THE UNIVERSITY OF MINNESOTA.

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# A REPORT

ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA:
MADE IN PURSUANCE OF AN ACT OF THE LEGISLATURE
OF THE STATE. APPROVED MARCH 1,
1872.

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THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.
N. H. WINCHELL, STATE GEOLOGIST.

1892—1896.

THE

# GEOLOGY OF MINNESOTA.

## VOL. III, PART II, OF THE FINAL REPORT.

## PALEONTOLOGY.

BY EDWARD O. ULRICH, WILBUR H. SCOFIELD,
JOHN M. CLARKE, NEWTON H. WINCHELL.

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1897.

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[NOTE. Each plate is accompanied by a full description.]

VOLUME III, PART II.

# INTRODUCTION TO VOL. III, PART II.

## THE LOWER SILURIAN DEPOSITS OF THE UPPER MISSISSIPPI PROVINCE: A CORRELATION OF THE STRATA WITH THOSE IN THE CINCINNATI, TENNESSEE, NEW YORK AND CANADIAN PROVINCES, AND THE STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION OF THE FOSSILS.

BY N. H. WINCHELL AND E. O. ULRICH.

### STRATIGRAPHIC DIVISIONS OF THE LOWER SILURIAN IN MINNESOTA.

The reader will see by reference to the table of stratigraphic designations in Part I of this volume (Introduction, pp. l and li) a list of the special names used in the greater part of this volume. As, however, the use of the various designations is not entirely uniform in the several chapters, and in order that the future student may have some guide in the study of these formations in the field, it is necessary to present an exact definition of the stratigraphy.

The published reports of the Minnesota survey have given stratigraphic sections at various places, but it has not been found possible heretofore to so adjust them as to show any close successional order, aside from that already given. The following might be considered as expressing an average composition of the Trenton division of these strata in southeastern Minnesota, taken in Olmsted county. It is essentially the same as that published in the first annual report, and takes into account only the lithologic character of the strata.

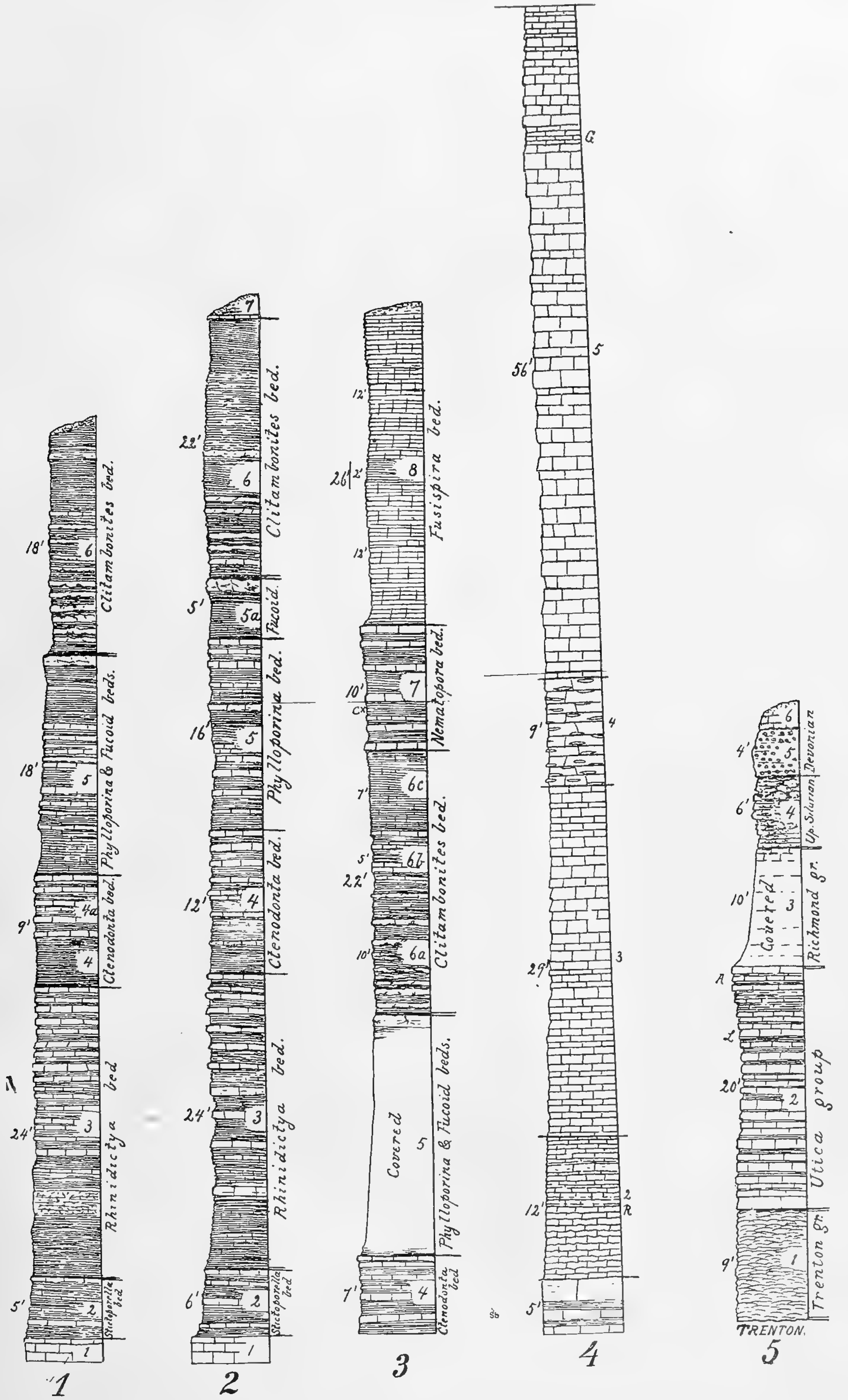
AVERAGE SECTION OF THE TRENTON PERIOD.

| | | | |
|---|---|---|---|
| 1 | Loose fragments | 4 feet. | |
| 2 | Magnesian limestone, buff | 30 feet, | 10 inches. |
| 3 | Slaty and argillaceous | 1 foot, | 6 inches. |
| 4 | Magnesian limestone, buff | 11 feet, | 6 inches. |
| 5 | Shaly limestone | 5 feet. | |
| 6 | Magnesian limestone, buff | 20 feet. | |
| 7 | Argillo-magnesian limestone with much interbedded shale (or shaly limestone). Lowest seen Receptaculites | 28 feet, | 4 inches. |
| 8 | Shales, with thin argillaceous sheets of limestone | 18 feet. | |
| 9 | Gray or earthy (bluish) limestone, with shaly partings | 37 feet. | |
| 10 | Alternating limestone and shale | 47 feet, | 6 inches. |
| 11 | Green shale | 42 feet. | |
| 12 | Compact limestone, buff on weathering, blue within, with interbedded shale | 22 feet. | |
| | Total | 267 feet, | 8 inches. |

Of the above the first nine numbers and a portion of the tenth may be considered as representing the Galena, of Iowa, Illinois and Wisconsin, though that will do violence to the lithologic criterion on which Profs. Hall and Whitney, as well as Moses Strong, determined the base of the Galena. But, as we will show further on, the shaly character of the lower part of the Galena in Minnesota is merely a local feature of the group similar to that which pertains more or less strongly also to the underlying divisions which we parallelize with the Black River and Birdseye limestones of New York. Nos. 1 to 6 represent the whole of the Maclurea bed, and 7, 8 and 9, the Fusispira bed, while the upper part of No. 10 is the Clitambonites bed. The lower part of No. 10 and the upper part of No. 11 represent the "Upper Blue" and "Upper Buff" limestones of the Wisconsin geologists and the Black River group of New York, while the lower part of No. 11, together with the whole of No. 12, corresponds with the "Lower Blue" and "Lower Buff" limestones of Chamberlin, the Birdseye limestone of New York geologists, and the Stones River group of Safford.

While a dependence upon lithologic characters in classifying the Lower Silurian strata of Minnesota is very liable to lead one into serious errors, the chances for overcoming the difficulties are greatly increased when the faunal characteristics of the various beds are minutely investigated and fully appreciated. This statement, however, is not to be understood as intimating that the lithologic characters are either entirely unreliable or useless in separating the beds. On the contrary, when judiciously employed in connection with the evidence afforded by the fossils, they are of great assistance in determining the age of the beds and in correlating even widely separated exposures of any of them. Familiarity with the beds shows that the shales and limestones of each have certain recognizable peculiarities, and there is something about the preservation and appearance of the fossils of each sufficiently distinctive to enable an expert in such matters to recognize, in at least nine cases out of ten, the bed and often the exact locality from which they were collected.

On the opposite page we present cuts of five actually measured continuous sections showing the character and thickness of Lower Silurian strata in Goodhue and Fillmore counties. None of the sections contain either the St. Peter sandstone or the lower part of the Stones River or Birdseye limestone, and only one (No. 5) contains strata above the Trenton. On another page, sections 6, 7 and 8 show the entire series of rocks, from the St. Peter sandstone up, seen in the three counties of Ramsey, Goodhue and Fillmore. These may be consulted to supplement sections 1 to 5, of which explanations follow.



Clitambonites bed.
Phylloporina & Fucoid beds.
Ctenodonta bed.
Rhinidictya bed
Stictoporella bed
Clitambonites bed.
Fucoid.
Phylloporina bed.
Ctenodonta bed.
Rhinidictya bed.
Stictoporella bed
Fusispira bed.
Nematopora bed.
Clitambonites bed.
Covered
Phylloporina & Fucoid beds.
Ctenodonta bed
Devonian
Up. Silurian
Covered
Richmond gr.
Utica group
Trenton gr.
TRENTON.
1
2
3
4
5

## EXPLANATION OF SECTIONS 1 TO 5.

*Nos. 1 and 2. Sections of Black River group shales with the upper portion of the Stones River group and the lower bed of the Trenton group. 1 was taken at a locality between five and six miles south of Cannon Falls, Goodhue county; 2 at a point about one mile east of the same town.*

1. Vanuxemia bed of Stones River group.

2. Stictoporella bed, consisting of soft shales and several layers of limestone. The latter are thin and largely made up of fossils, among them *Stictoporella frondifera*, *Pachydictya foliata*, *Homotrypa minnesotensis*, *Anolotichia impolita* and *Rhynchotrema minnesotensis*.

3. Rhinidictya bed, consisting in the lower part almost entirely of soft, greenish shales, holding very few fossils. In the upper half or two-thirds there are numerous, more or less irregular, subcrystalline limestone plates, largely made up of fossil remains, chiefly Bryozoa, with *Rhinidictya mutabilis* very abundant.

4 and 4*a*. Ctenodonta bed. In section 1 the lower four feet is a bed of dark shale in which no fossils were observed. The upper part contains five or six irregular layers of limestone, weathering red, which are filled with fossil shells, among them several species of *Ctenodonta*, *Crytodonta tenella*, *C. affinis*, *Plethocardia umbonata*, *Whitella scofieldi*, *Matheria rugosa*, and numerous Gastropoda and Cephalopoda The first layer contained, besides some of the species named, some plates of a large species of *Carabocrinus*, and in considerable abundance a slowly tapering tubular fossil, between one and two inches in length, that greatly resembles the *Salterella billingsi* which Safford regards as one of the most characteristic fossils of his "Central limestone" in Tennessee. In section 5, the bed is thicker and the lower portion is less sharply distinguished from the upper.

5 and 5*a*. Phylloporina and Fucoid beds. These consist almost entirely of soft and highly fossiliferous, greenish shales. The fossils occur mostly in bands, and where they are most abundant they are often consolidated into rough limestone layers, rarely exceeding three inches in thickness. Bryozoa are exceedingly abundant in the Phylloporina bed, and as a rule in an excellent state of preservation. Of the more striking and common forms we may mention *Phylloporina corticosa*, *Trigonodictya conciliatrix*, *Prasopora conoidea*, *Homotrypa tuberculata* and *Batostoma montuosum*. In the Fucoid bed the fossils occur more sparingly, and the Bryozoa are wanting almost entirely. At the top there is a rough layer of impure limestone, a foot or more in thickness, which may be recognized at once by its rusty hue. It is sometimes divided into two or three layers, and when it contains any fossils at all they are always imperfect.

6. This, the lowest or Clitambonites bed of the Trenton group, consists chiefly of yellowish shales. In the lower eight or ten feet there are numerous irregular or nodular layers of impure limestone. These are very fossiliferous, and it is in this portion that such characteristic species of the bed as *Clitambonites diversus*, *Strophomena scofieldi*, *Orthis meedsi*, *Prasopora insularis*, *Callopora ampla* and *Eridotrypa mutabilis* are nearly always to be found. Near the middle of the bed *Callopora goodhuensis* and a small variety of *Plectambonites sericea* are very abundant. The upper seven or eight feet consist entirely of shale, and in this portion fossils are exceedingly rare.

7. At the top of section 2, we recognized a small remnant of the Nematopora bed.

*Section 3, as exposed in an old road about two miles southeast from Cannon Falls.*

4. Ctenodonta bed.

5. Phylloporina and Fucoid beds, both covered except at the base and top.

6. Clitambonites bed. 6*a*, horizon of *Clitambonites diversus;* 6*b*, of *Callopora goodhuensis* 6*c*, unfossiliferous shales.

7. Nematopora bed. Drab to blue shales, including five or six layers of limestone, the latter very fossiliferous. *Orthis meedsi* var. *germana*, *Homotrypa similis*, *Pachydictya pumila*, *Rhinidictya minima*, *Nematopora ovalis* and *N. granosa* are both characteristic and common. At the point marked Cx some good specimens of *Clitambonites diversus* were obtained, while the shales immediately beneath it, when washed, afforded, beside the fossils above named, numerous minute Bryozoa of the genera *Arthroclema* and *Helopora*, and six species of Ostracoda.

8. Lower part of Fusispira bed, here consisting entirely of gray shales, quite unfossiliferous except between twelve and fourteen feet above the base where about a dozen good specimens of *Cyclospira bisulcata* were found.

*Section 4, showing the whole of the Fusispira bed and the upper part of the Nematopora bed; Prosser's ravine near Wykoff, Fillmore county.*

1. Nematopora bed. A layer of limestone two feet thick at the top. Obtained here *Orthis meedsi* var. *germana*, a variety of *O. borealis*, *Platystrophia biforata*, *Strophomena trentonensis*, *Rafinesquina alternata*, *Rhynchotrema increbescens*, and several undetermined Ostracoda and Bryzoa, the latter not well preserved.

2. Twelve feet of shelly or thin-bedded argillaceous limestone, the surface of the layers, in the lower half especially, being rough. Near the middle several large impressions of *Receptaculites oweni*, one quite fifteen inches in diameter, were noticed. Fossils are neither very plentiful nor well preserved in these layers.

3. Twenty-nine feet of rather thin-bedded, compact, bluish-gray, limestone, the purity of the limestone increasing from below upward. Contains numerous fossiliferous layers, the fossils being chiefly Brachiopoda of the family *Strophomenidæ*. Of other forms a fine new species of *Palæocrinus* deserves mention.

4. Nine feet of cherty limestone. Fossils abundant, *Orthis tricenaria*, *O. plicatella*, *Strophomena billingsi*, *Clitambonites diversus*, *Parastrophia hemiplicata*, and some branching monticuliporoids.

5. Fifty-six feet of fine-grained and subcrystalline limestones; some argillaceous layers, thinner than usual, in the upper twelve feet. About eleven feet beneath the top we find a layer full of graptolites, probably of the genus *Diplograptus*. Above this layer fossils are comparatively rare, but beneath it they are abundant though rather difficult to obtain perfect, since they must be broken out of the solid limestone. Among others we obtained here *Rafinesquina deltoidea*, *Plectambonites gibbosa*, *Zygospira uphami*, *Ambonychia bellistriata*, *Byssonychia intermedia*, *Clionychia undata*, *Ctenodonta intermedia*, *Cyrtodonta abrupta*, *C. germana*, *Endodesma cuneatum*, *E. compressum*, *Psiloconcha? minnesotensis*, *Eccyliopterus owenanus* *Fusispira inflata*, *F. nobilis*, *F. planulata*, *Trochonema robbinsi* and *Platymetopus robbinsi*.

Above No. 5 this ravine exposes about fifty feet of massive dolomitic limestones of the Maclurea bed and then about twenty feet of shaly layers belonging to the Utica group.

*Section 5, showing strata as seen in and near a small quarry, about two and a half miles north of Spring Valley, Minnesota.*

1. About nine feet of thin and unevenly bedded or laminated, bluish-gray, crinoidal limestone. The whole appears solid in a fresh exposure but breaks up under the weather. The crinoidal fragments have evidently been much rolled.

2. Twenty feet of even bedded, compact, gray limestone, in layers fifteen inches or less thick, the layers becoming too thin and argillaceous in the upper part for building purposes. Between the limestones there are bands of soft shale, the whole bed being composed of about one-third shale and two-thirds limestone. At the top several layers will be noticed containing the separated parts of *Asaphus* or *Isotelus maximus* in abundance. Six feet beneath the top a band of shale contains *Leptobolus occidentalis*, three species of *Lingula* and *Climacograptus typicalis* (?). Beneath this there is another band from which *Orthis testudinaria*, varieties *multisecta* and *emacerata*, and two discoidal species of Bryozoa were obtained in considerable abundance. The same layer afforded also *Triplecia ulrichi*, *Plectambonites praecosis* (Sardeson) and *Calymene callicephala* var. *mammillata*.

3. These are covered at this locality. About a mile east of Spring Valley they are exposed as thin bedded, arenaceous and argillaceous limestones; some of the layers are full of Brachiopoda and other fossils characterizing the Richmond group of the Cincinnati region.

4. Arenaceous strata, six feet thick, weathering into irregular lumps, some of which contain plates and columns of large crinoids or cystideans, and *Hindia sphærodalis*. Probably Upper Silurian.

5. Four feet of rather coarse sandstone, including here and there an abundant supply of small quartz pebbles.

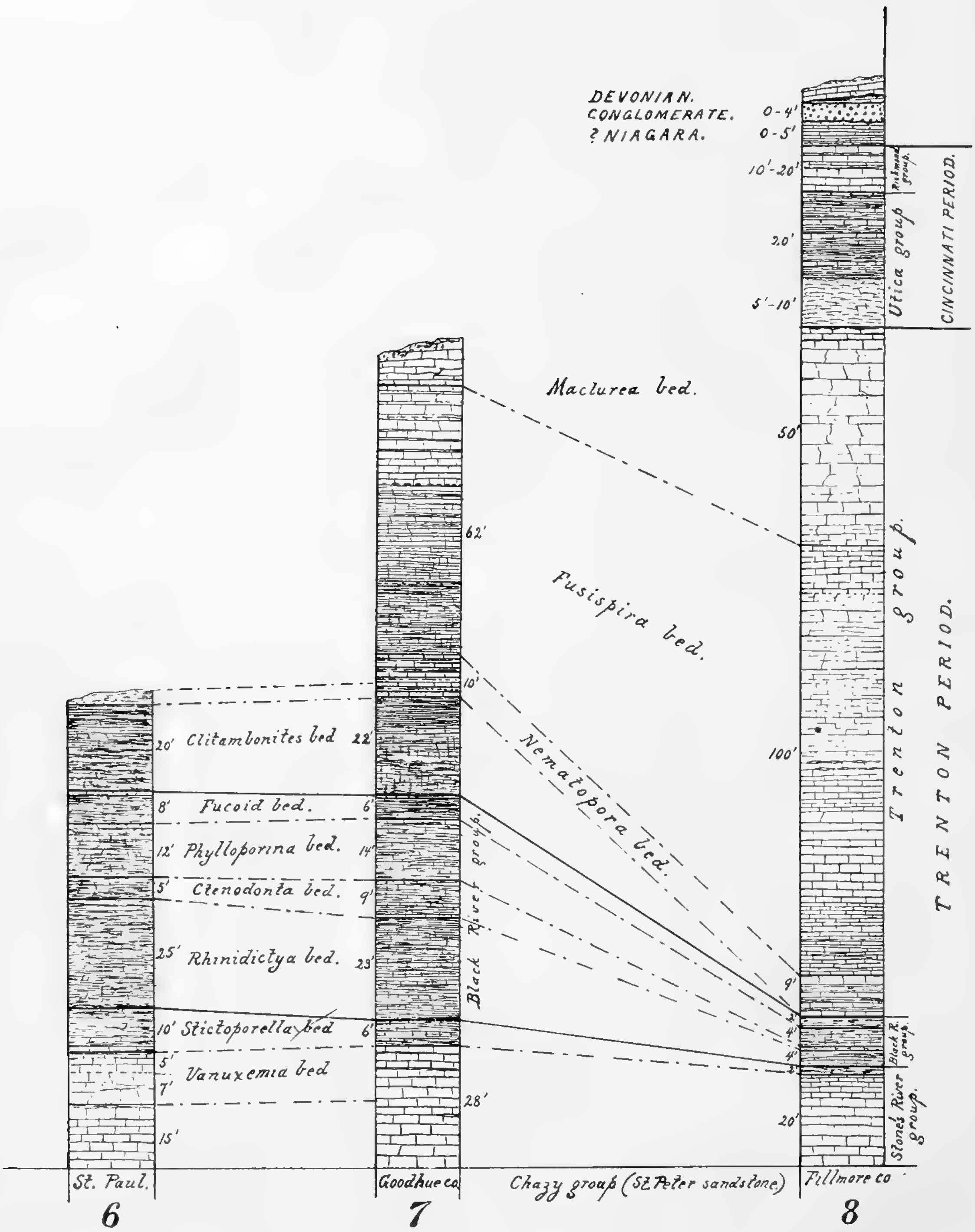
6. Above No. 5 the surface of the ground was strewn with irregular, porous lumps of yellow or buff, magnesian limestone of Devonian age.

## CORRELATION OF STRATA.

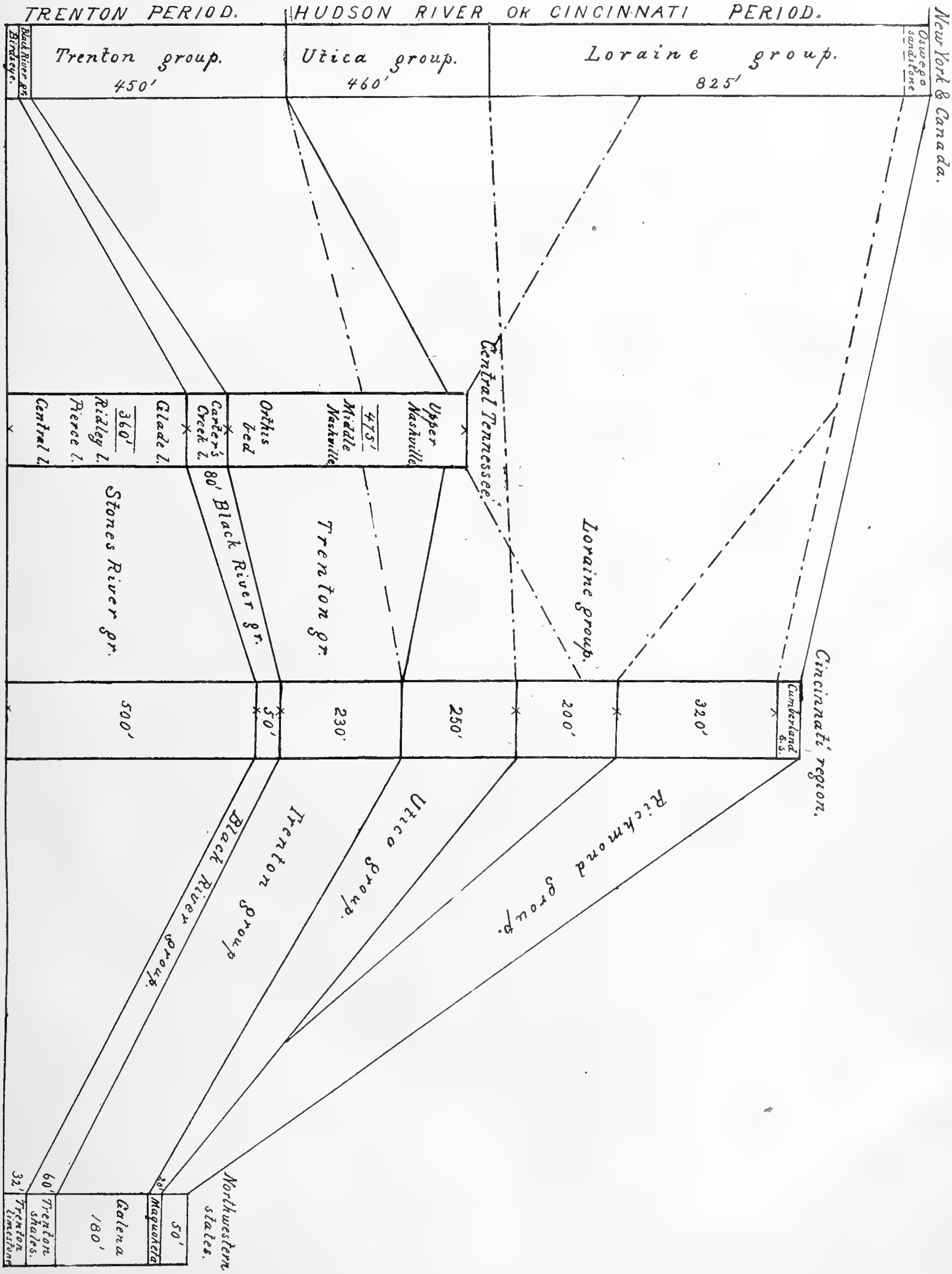
### TRENTON PERIOD.

#### *Chazy group.*

*St. Peter Sandstone.* A number of fossils have been found in this well known division of the Lower Silurian, but they are nearly all very ill preserved, the nature of the sediment being unfavorable. As they have not been included in this report, it may be well to say of them that, as far as their condition will admit of judgment, they are of types reminding one as much, perhaps, of species characterizing the Stones River group as of Chazy forms. It is, however, as a part of the latter group that the St. Peter is to be viewed.




Sections showing the thickness and character of strata of the Trenton and Hudson River periods at (6) St. Paul, and (7) Goodhue, and (8) Fillmore counties, Minnesota.




SECTION 9. Comparative stratigraphy of the Lower Silurian, New York, to Minnesota.

The St. Peter sandstone has a wide geographical distribution, being known by outcroppings in Canada, Michigan, Wisconsin, Minnesota, Iowa, Illinois and Missouri, and through deep borings in Indiana, Ohio and Kentucky. In the northwest it consists almost entirely of silica, but in the vicinity of Cincinnati, where it is the principal source of the "blue lick water" of the artesian wells, it contains a considerable amount of calcareous material.

*Stones River group.*

This name was proposed by Prof. J. M. Safford in 1851 (Amer. Jour. Sci. and Arts, 2d ser., vol. XII, p. 352) for the Lower Silurian strata of central Tennessee which in his "Geology of Tennessee," 1869, we find fully described under the names Central limestone, Pierce limestone, Ridley limestone, Glade limestone and Carter's Creek limestone. In the latter publication the group name is abandoned under the misapprehension that the limestones so designated are strictly equivalent to the Trenton group of New York. As we are confident that this was an error, we propose to resurrect the name. In our opinion the four lower members of the Stones River group as originally defined, are equivalent to the Birdseye limestone of New York and the "Lower Buff" and "Lower Blue" limestones of the Trenton, in Illinois, Wisconsin, Iowa and Minnesota. The group is strongly developed in Kentucky and from here it doubtless extends as an unbroken, though diminishing sheet, westward into Missouri and northward into Canada. According to the evidence now available it seems that in geographical distribution, thickness, and paleontological interest, the Stones River group is nearly or quite equal to the Trenton limestone itself.

Being thin and, according to report, not readily distinguished paleontologically from the overlying Black River limestone in Canada and New York, the Birdseye limestone, a name that we think must give way to the geographic designation proposed by Prof. Safford, has not been generally recognized. In Tennessee and the western and northwestern states the group has been almost universally regarded as representing part if not all of the Trenton limestone, while the Galena limestone, which is the exact equivalent of the Trenton limestone, was by most investigators believed to represent a local upper member of the Trenton, and by others the western equivalent of the Utica slate.

A careful and extended investigation of the stratigraphy and paleontology of the Trenton and Cincinnati periods, however, proves most conclusively that the generally accepted views of the equivalents of the Galena and other limestones resting on the St. Peter sandstone are incorrect, and that Prof. James Hall's early surmise respecting the presence in the northwest of strata representing the Birdseye and Black River limestones of New York is essentially correct.

As regards the Nashville group, which Prof. Safford, chiefly because of the presence of two fossils, *Cyrtolites ornatus* and *Byssonychia* (*Ambonychia*) *radiata*, in 1869, concluded to be the same as the Hudson River group of New York and Canada, it is, with the exception of a portion of the upper member, indubitably Trenton, and occupies the same interval which in the northwest is taken up by the Galena. The two fossils mentioned hold pecisely the same position in Kentucky, but here there can be no doubt concerning the age of the strata in which they are found since they lie beneath the base of the Utica. Again, as neither is strictly identical with the well-known Cincinnati or Hudson River types of the species, the important use to which they were put by Prof. Safford is, to say the least, unwarranted. Even if the supposed identity of the two shells and the Hudson River types to which they were referred had been corroborated or established by more recent investigations, the weight of the evidence thereby afforded must have been deemed insignificant as opposed to the abundant data upon which we base our conclusion that both the Galena and Nashville groups are strictly equivalent to the Trenton limestone of New York. Neither of the two species in question has yet been found in Minnesota, but a variety of the *Cyrtolites*, to which we give the new name *retrorsus*, occurs in the Black River shales in Fillmore county. We describe also a small variety of *C. ornatus* from the Clitambonites bed in Goodhue county, which corresponds very nearly in position with the Tennessee strata holding *C. retrorsus* Ulrich (*C. ornatus* Safford, not Hall).

We have not seen an entire exposure of the upper member of the Nashville group, and are therefore somewhat in doubt respecting its nature and position in the geological scale, but certain fossils in the collection of Prof. Safford cause us to suspect that it includes a few layers at the top representing portions of the Hudson River period. However this may turn out, we have no doubt whatever about the lower 70 feet of Safford's College Hill limestone (his section on p. 276, Geology of Tennessee, gives the whole a thickness of 120 feet) since that much at least is strictly equivalent to beds occurring near Frankfort, and other localities in Kentucky, at the top of the Trenton and always *below* the base of the Utica group.

*Divisions of the Stones River group recognized in the Upper Mississippi province.*

*Buff limestone.* This, the lowest portion of the group, rests apparently conformably upon the St. Peter sandstone. Its thickness in Minnesota, Wisconsin, Iowa and Illinois varies between twelve and twenty-two feet, the average thickness in Minnesota being about fifteen feet. At the base there is often a bed of green shale or an iron-stained layer of sandstone. The latter was noticed at Janesville, Wisconsin, there eighteen inches thick, while a combination of the two, varying both as to thickness and composition, has been observed at several points in Dodge and Olmsted counties in Minnesota. The limestone proper is compact, buff on weathering and bluish within. In Wisconsin it usually occurs in heavier beds than in Minnesota, and its fossils are not as well preserved there as here. The latter fact is probably due to the greater prevalence of clayey seams and the purer character of the limestone layers in Minnesota.

As to the fauna of this bed, it is not large in the way of species but individuals of some of them are often very abundant. This is true, especially of the region about

Minneapolis and St. Paul. Here we frequently meet with thin slabs, one s de of which may be filled with good specimens of a small variety of *Rhynchotrema minnesotensis*, *Orthis deflecta*, *Strophomena filitexta*, *Rafinesquina minnesotensis* and *Leperditia fabulites*. Perhaps ten or twelve other species have been observed in this bed at St. Paul and Minneapolis that may be considered as common, while all the others are rare. It is to be noticed also that very few, if any, of the common species are limited to the bed, but that nearly all of them are quite as abundant in the succeeding beds of limestone. For this reason no paleontological designation is proposed.

*Vanuxemia bed.* This designation is proposed for the upper part (about twelve feet) of the limestone series at St. Paul and Minneapolis. It is in part equivalent to the "Lower Blue limestone" of Wisconsin. The upper five feet are full of fossils, preserved, however, chiefly as empty molds and casts. Still, on the bed planes, Brachiopoda and other shells, as well as trilobites, are often very well preserved. *Leperditia fabulites*, *Rafinesquina minnesotensis*, *Orthis tricenaria*, *Clathrospira subconica*, *Trochonema beloitense*, *Lophospira conradana*, *L. serrulata*, and *Vanuxemia dixonensis* are very abundant, and the last four highly characteristic of the bed. *Vanuxemia obtusifrons*, *V. sardesoni*, *Maclurea depressa*, *Helicotoma umbilicata*, *Conradella triangularis*, and *Cyrtometopus scofieldi*, also are characteristic but much less common.

In giving "Formation and locality" of fossils described in this volume, these two limestone beds are, as a rule, not separately referred to. It is to be understood, therefore, that the designations "Trenton limestone" and "lower limestone of the Trenton formation," may mean either one or both beds.

*Stictoporella bed.* This term applies to the ten feet of shale and limestone ("lower third of the Trenton shales") resting on the Vanuxemia bed at St. Paul and Minneapolis. Here it is a well marked horizon, containing an abundant fauna of which Bryozoa are the principal element, no less than thirty-nine species of this class being represented. *Stictoporella frondifera*, *S. anguaris*, *Pachydictya frondosa* and *Anolotichia impolita* are always abundant and, as far as known, are to be found only in this bed. Among the interesting fossils is a fine new species of starfish, of which three specimens, the largest four inches across, were found at Minneapolis.

The great abundance of Bryozoa, and the fact that nineteen of the thirty-nine species pass on into succeeding beds might be considered as good evidence for uniting the Stictoporella bed with the next group rather than with the Stones River group. But this would be an error since it is clearly nothing more than the upper member of the Stones River group, which, in tracing it northwestward from Beloit and Janesville, Wisconsin, where it cannot be distinguished from the "Lower Blue limestone," gradually becomes more and more shaly. The conditions seem to have been eminently favorable for the development of bryozoan types, so it might be expected that many species would be ushered in, that, in this region, reached the hight of their development first in the upper part of the next bed. The same intimate faunal connection with the succeeding beds is exhibited also by some of the other classes of fossils. As shown in the list nearly 44 per cent (42 of 96) of its fauna pass on into the next bed or reappear in one or the other of the succeeding beds. If, however, we examine these species we notice that of the 42 forms which it holds in common with later divisions at least twelve species of Bryozoa, Brachiopoda and Trilobita range through three or more groups, and therefore ought not to be taken into account in determining the question under consideration. Deducting these the percentage of species passing upward is considerably reduced, while the remaining fauna is more in accordance with that of the preceding limestones. As it is, over half of the entire fauna is received from below.

In comparing the Stones River group as developed in Minnesota with equivalent rocks at other localities embraced within the limits of the Upper Mississippi province, we find that the lithologic characters change towards the east and south. Thus at Beloit, Wisconsin, and at Rockton, Illinois, the Lower Buff and Lower Blue limestones are more nearly alike in texture and composition than is the case farther west in those states. In the quarries at Rockton these beds as well as the Upper Buff limestone are enough alike to have been considered by Whitney and Worthen as the same as what the Wisconsin geologists have more recently distinguished as the Lower Buff. At Mineral Point, Wisconsin, and Dixon and Dunlieth, Illinois, the Lower Blue is a pure limestone and readily separated from the Lower Buff. In Minnesota, however, the strata equivalent to the Lower Buff are a purer limestone than usual in the northwest, while the strata which we parallelize with the Lower Blue are magnesian in the middle member (Vanuxemia bed), clayey in the lower, and an alternation of pure crystalline limestones and shales in the upper.

The Trenton period of the northwestern states may be divided into three regions in each of which the lithologic character of the various beds is approximately uniform, namely, the Minnesota area, the region included between the three towns of Dixon, Dunlieth and Mineral Point, and the third including the towns of Janesville, Beloit and Rockton. In the first, the period includes much shale, in the second, a good proportion is pure limestone, in the third, all the beds are more or less distinctly dolomitic. These lithologic areas, if we may so call them, of course merge gradually into each other, and probably are due to conditions depending upon the distance of each area from the Lower Silurian shore line.

Of Wisconsin sections of the group of strata under consideration, the one which, so far as known to us, offers the greatest resemblance to the St. Paul section, occurs near Benton, Wisconsin. Here the "Lower Blue limestone" is terminated above by two beds corresponding in position and fossils, and fairly well also as regards composition, to the Vanuxemia and Stictoporella beds.

In central Kentucky the rocks which belong to this group form precipitous bluffs, often over two hundred feet in hight, along the Kentucky river from Frankfort to and beyond High Bridge. Nearly the whole of this section consists of massive dove-colored limestones, exceedingly like and unquestionably equivalent to the Birdseye limestone of New York. The base of the group is not exposed in Kentucky so that we have only the evidence of deep borings to show that it is underlaid by the St. Peter sandstone. For the same reason we cannot give the entire thickness of the group in Kentucky. About 325 feet of it are exposed at High Bridge, but judging from certain fossils which occur at the base of the section at that point, we believe that no less than fifty feet more are covered. Indeed, there may be much more since the fossils in question are characteristic species of the Ridley limestone of Tennessee, and if the underlying limestones have as great a thickness in Kentucky as in that state, which, considering the fact that the beds equivalent to the Glade limestone are much thicker at High Bridge than in Tennessee, is highly probable, the covered portion of the group equals quite a hundred feet. The upper part sometimes contains much shale and is highly fossiliferous, many of the species being identical with those which occur in the upper beds of the group in the Minnesota region. *Tetradium cellulosum* Hall sp., perhaps the most characteristic fossil of the Birdseye in New York, is very abundant in this portion of the group at High Bridge and Frankfort.

The typical Tennessee section consists of from 300 to 340 feet of alternating thin and heavy bedded, light blue and dove-colored compact limestones, the texture very much like that of the Upper Blue limestone ("Glass rock") at Dixon, Ill., and Mineral Point, Wis., and not greatly different from occasional layers found in the Lower Buff at Minneapolis. The lowest member (Central limestone) is thick bedded and decidedly cherty, and some of the layers are full of silicified fossils in a good state of preservation. *Salterella billingsi* and *Leperditia fabulites*, the latter, perhaps, the most characteristic fossil of the group, occur in great abundance. Other fossils having an interest in this connection are *Pterotheca alternata*, *Gonioceras occidentalis*, *Ctenodonta gibberula*, *Bucania emmonsi*, *Lophospira perangulata*, *Liospira abrupta*, *Solenospira prisca*, and *Ceraurus pleurexanthemus*.

The next bed (Pierce limestone) is chiefly remarkable for the wonderful profusion of its Bryozoan fauna, some of the thin layers being completely covered with bifoliate forms. The "Ridley limestone" is heavily bedded again, and contains a rather peculiar fauna, much of it, especially among the Bryozoa, new to science. *Orthis subæquata*, *Rafinesquina minnesotensis* and *Phylloporina sublaxa* are not uncommon. The "Glade limestone," with a maximum thickness of 120 feet, consists of thin or flaggy layers and some shale. It is highly fossiliferous and contains many species that are characteristic of the group in Minnesota.

*Black River group.*

This group, though never very thick (usually from 20 to 100 feet) is still widely distributed, being recognizable in Canada, New York, Vermont, Pennsylvania, Tennessee, Kentucky and in the northwest. In Canada and the eastern states it is usually a heavy bedded limestone, and so it is also in Tennessee, Kentucky, Illinois and Wisconsin, but in Minnesota it consists almost entirely of greenish shales. The Tennessee and Kentucky strata which we place here have been called "Carter's Creek limestone" by Prof. Safford. In Kentucky the group is less than 50 feet thick, but in Tennessee it is as much as 100 feet. The rocks contain considerable chert and the fossils are nearly always silicified. Characteristic fossils are *Tetradium columnare*, *Columnaria halli*, *C. carterensis*, *Streptelasma profundum*, *Raphistomina lapicida*, *Stromatocerium rugosum*, *Triptoceras planodorsatum*, *Actinoceras bigsbyi*, *Orthoceras arcuoliratum*, *O. lesueuri*, *T. planoconvexum*, *Orthis pectinella*, *Receptaculites occidentalis*, and *Camarocladia rugosa* (Ulrich).*

In Wisconsin and Illinois the group is represented by the "Upper Buff" and "Upper Blue limestones." The average thickness of the two beds here is probably less than 40 feet. They are well exposed in the quarries at Rockton, Illinois, where the upper member carries fossils clearly indicating the Phylloporina and Fucoid beds of the Minnesota section. We collected here, namely, *Orthis pectinella*, *O. testudinaria*, *Strophomena trentonensis*, *Agelacrinus marginatus*, *Bythotrypa laxata*, *Rafinesquina inquassa*, *Arthropora bifurcata*, *Prasopora conoidea* and *Bythopora alcicornis*. In the Upper Buff, which we correlate with the Rhinidictya and Ctenodonta beds of Minnesota, we saw *Streptelasma profundum*, *Pachydictya occidentalis*. *Phylloporina reticulata*, *Rhinidictya mutabilis*, *Cyrtodonta cingulata*, *Vanuxemia niota* and *Cyrtoceras corniculum*. Numerous other Cephalopoda occur in this bed but they have not been identified in Minnesota. At Beloit and other localities in Wisconsin the Upper Buff contains some chert.

The strata representing the Black River group in Minnesota are peculiar in consisting almost entirely of shales. They are also more fossiliferous than elsewhere, and the fauna taken as a whole is unusual in two respects. Namely, it includes a large number of Bryozoa which are wanting entirely in other regions, while the Cephalopoda, for which the group is noted, are here represented by relatively small species only. Another remarkable feature is the rapid reduction in volume between Cannon Falls and localities in Fillmore county. (See sections 6, 7 and 8). This is so marked that we are almost justified in assuming that the entire group failed a few miles east of Fountain. Unfortunately, this cannot be proved since the strata of the Trenton period have all been removed in that direction. While the Stones River group may still have continued without material interruption across the Mississippi valley, at the southern end of the state, the Black River group probably did not do so, and we are inclined to believe that the latter, as well as the succeeding Silurian and Devonian strata of southern Minnesota and northern Iowa, were deposited in a bay.

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* The last of these fossils is the large "fucoid" that is so extremely abundant and characteristic of the Fucoid bed in Minnesota. In Mercer county, Kentucky, it occurs at an exactly equivalent horizon, *i. e.*, in a thin bed of shale near the top of the Black River limestone. The fossil seems to us to be a cast of a branching sponge similar to the *Camarocladia dichotoma* described by Ulrich and Everett from the sponge layer of the Stones River group at Dixon, Illinois. *C. rugosa* is a much larger species, its flexuous compressed branches varying from 5 to over 12 mm. in width. The bifurcations vary greatly, being sometimes very close, at other times far apart. As a rule the specimens show little structure, appearing as mere stony flattened branches with more or less obscure transverse and oblique furrows. The most complete specimens are covered with an irregular network composed of coarse nodulose threads often exhibiting a longitudinal arrangement. Generally the network remains on one side of the branches only. When removed entirely the stems are seen to be composed of two elements: (1) a siphuncle-like, subcylindrical rod, with annulations and constrictions 3 to 6 mm. apart, and (2) a series of oblique septa-like partitions—generally two to each annulation—clasping the annulated rod so as to leave about one-third of its circumference exposed to view. Not infrequently the rod changes suddenly from one side of the branch to the other. In an unbranched fragment before us this occurs twice in the space of 40 mm. The best specimens were found in Goodhue county.

The Black River shales of Minnesota (Trenton shales of this volume—particularly those parts which are distinguished as middle and upper thirds) may conveniently be divided into four beds as follows:

*Rhinidictya bed.* This bed is usually referred to in the following descriptions as the "middle third of the Trenton shales." It consists of dark green, soft shale, not over 5 feet thick in Fillmore county, and between 20 and 25 feet in Goodhue and Ramsey counties. (See sections 1, 2, 6, 7 and 8). It is very fossiliferous, particularly in the upper half, where the fossils, Bryozoa mainly, occur in thin calcareous layers in great quantity and variety. *Rhinidictya mutabilis* is exceedingly abundant, as is also *Batostoma winchelli*, while no less than 25 of the 57 species of Bryozoa may be said to be common. Excepting the Mollusca, which occur as casts of the interior, the fossils are in an excellent state of preservation.

*Ctenodonta bed.* At St. Paul this bed is scarcely distinguishable from the Rhinidictya bed, several of the leading Bryozoa being quite abundant in it. However, in Goodhue county, where the bed is from 6 to 10 feet thick, Bryozoa are almost entirely absent while the Mollusca occur in great numbers. No less than 43 Lamellibranchiata have been found here and over half of the number are restricted to this bed. The Gastropoda are almost equally numerous while the Cephalopoda are, as far as number of species is concerned, nearly as well represented here as in any other division of the Lower Silurian in Minnesota. The bed contains considerable iron and in Goodhue county can always be recognized by the red or brown color of the fossils and weathered slabs. The latter frequently become oölitic exteriorly, the grains being concretions of limonite of lenticular form. *Ctenodonta socialis, C. scofieldi, C. compressa, C. planodorsata, Lyrodesma acuminatum, Matheria rugosa, Whitella scofieldi, Cyrtoceras corniculum, Archinacella deleta, Raphistoma peracuta, Lophospira oweni,* and *L. spironema*, are some of the characteristic fossils. Under the descriptions of some of the Lamellibranchiata this bed is distinguished as the "upper part of the middle third of the Trenton shales." The name Ctenodonta bed is used only in the chapter on Gastropoda.

*Phylloporina bed.* This bed has a thickness of from 10 to 15 feet in Ramsey and Goodhue counties, but it is much thinner in Fillmore county. It much resembles the Rhinidictya bed, and like it contains a great number of Bryozoa, but instead of the bifoliate forms it is the monticuliporoids that predominate here. *Homotrypa subramosa* is very abundant at most localities, as are also *Prasopora simulatrix, P. conoidea* and *Batostoma montuosum*, but the most distinctive and easily recognized fossil is the *Phylloporina corticosa*. Of four Echinodermata one, *Agelacrinus marginatus*, occurs in the "Upper Blue" in Wisconsin, and at the base of the Trenton in Kentucky. Lamellibranchiata, Gastropoda, Cephalopoda and Trilobita are rare, but the Ostracoda are well represented and some of the species are abundant. In the descriptions of the fossils this bed is not separated from the following, the designation "upper third of the Trenton shales" applying to either one or both.

*Fucoid* or *Orthis pectinella bed.* This bed is scarcely recognizable in Fillmore county, but at St. Paul and in Goodhue county it is a well marked horizon. It is full of one of the so-called fucoids, the *Camarocladia rugosa,* a fossil which we regard as the cast of a branching sponge. (See foot note, p. xcv.) It is very characteristic of the bed in Minnesota and occurs in the same group in Kentucky. Other characteristic fossils of the bed are *Orthis pectinella* and *Strophomena septata.* In Minnesota the bed is generally terminated above by a roughly bedded, rusty, semi-crystalline layer, one to three feet in thickness. The rest of the bed, with the occasional exception of one or two thin limestone layers, consists entirely of blue shales similar to those of the preceding beds, excepting that it is largely made up of comminuted fragments of organic remains.

The Fucoid bed may in a measure be considered as a passage from the Black River group to the Trenton group. On both paleontological and lithological grounds, however, we are satisfied that it is really a part of the former. The rather limited fauna is more clearly related to the Black River than to the Trenton and it was not till its close that any marked lithological change took place. In Minnesota, it is true, the strata following are at first still shaly, but instead of the preceding blue and green colors, we now have a yellowish or gray tinge, while the prevailing fossils, excepting several Branchiopoda, are nearly all distinct. In Wisconsin and Illinois the two groups are just as easily separated, while in Tennessee and Kentucky, no one could fail in separating the Orthis bed from the Carter's Creek limestone. Paleontologically there is always a decided break between the two groups. This is, perhaps, least in eastern Canada where the Black River group is also lithologically much like the Trenton limestone.

In the eastern states and Canada the Black River group is remarkable for the abundance and great size of the Cephalopoda. In other regions, however, this class of fossils is not so strongly represented, although the group everywhere presents some of the leading species—less of them in Minnesota than anywhere else. But in Wisconsin and Illinois the "Upper Buff limestone" again contains more Cephalopoda than anything else, although most of the species occur also in the underlying "Lower Blue limestone". Still, this seems to be the case with the Cephalopoda not only in Wisconsin but in Canada, Kentucky and Tennessee as well. The summary tables immediately following the list of fossils show that of the 296 species found in the Black River group of Minnesota, 189 are restricted to the group, 72 occur also in the Stones River group, and 58 pass into the following groups.

### *Trenton group.* (*Galena limestone and shales. Nashville group.*)

When the Lower Silurian faunas of Canada, the eastern states and of Kentucky and Tennessee are compared with those which characterize the various divisions of the Lower Silurian in the northwest, it seems strange that it has not been recognized heretofore that the Galena limestone, instead of being a local upper member of the Trenton or the equivalent of the Utica slate, is really equal to the whole of the Trenton group in New

York and Canada. That this is a fact, is, we think, shown beyond any question whatever by the summary tables following the list of fossils. As given there no less than 107, or 87 per cent. of the 123 species common to the Galena of the northwest and one or more of the four other regions compared, occur elsewhere in the Trenton group. This percentage is increased to nearly 95 per cent., if we consider only the species that are restricted to the group in the northwest, since of 76 of such species 72 occur elsewhere in the Trenton group. That the Galena is a distinct group by itself is we think again shown conclusively by summary table No. 1. This gives a total of 305 species, of which 227, or about 74 per cent., are restricted to the group.

The Trenton group everywhere is a limestone, usually thin bedded and with more or less of shale in the lower part, and thick bedded and coarser textured in the upper. Sometimes, as at Frankfort and Covington, Ky., and Nashville, Tenn., there is some shale also near or at the extreme top. In the eastern states the lower part is black, the upper dark gray; south of the Ohio river both divisions are of lighter shades, the lower part being dark gray or blue, the upper a light gray or dove-color and when shaly a darker gray or blue; in the northwest the whole may be of various shades of buff, or the lower half may be in parts yellowish, grayish or with faint blue or greenish tints.

In the northwest, if the group is traced from southern Wisconsin into Illinois and then around the supposed upper Mississippi barrier into Iowa and Minnesota, a gradual change in the lithologic characters of the group will be noticed. In the first locality the Trenton or Galena is a dolomitic limestone throughout, in Illinois it sustains very little if any change, but in Iowa, as for instance at Decorah, the basal part is decidedly shaly and contains some layers of nearly pure limestone. In Fillmore county, Minnesota, the pure limestone has increased very materially in thickness, over 100 feet being of this character at Wykoff, leaving only about 50 feet at the top (the Maclurea bed) retaining the dolomitic feature that pertains to the whole of the group in southern Wisconsin. In following the group through Olmsted county into Goodhue we observe that now the lime also is gradually replaced (from the bottom upward) by more and more of argillaceous material, so that in the last county, between the post offices of Hader and Holden, only about 20 feet at the top of the Fusispira bed is still a pure limestone. Only a few feet of the Maclurea bed is left in Goodhue county and this seems to be essentially of the same character as in Fillmore county. North of Goodhue county all of the Trenton, save the lowest member (Clitambonites bed) has been swept away, so we cannot say positively that the Maclurea bed, like the Fusispira bed, was eventually also replaced by shales.

In Minnesota the group is divisible into three or four beds as follows:

*Clitambonites bed.* This division (see sections 1, 2 and 3) consists of yellowish, light green or drab shales, with more or less of thin, indurated clay or impure limestone layers in the lower two-thirds. At the top there is a bed of light shale without hard layers, five to ten feet in thickness, in which fossils are very scarce. In the remainder, however, fossils are exceedingly plentiful, and, excepting the Mollusca, very well preserved. The whole bed is from 15 to 22 feet thick at St. Paul and in Goodhue county. Like the preceding shales of the Black River group it thins rapidly in a southeastern direction from Goodhue county, being very thin in Olmsted county and scarcely, if at all, represented in the southern part of Fillmore county.

The lower eight feet at St. Paul contains great numbers of *Zygospira recurvirostra* and *Rhychotrema increbescens*, while *Pachydictya elegans* is abundant and characteristic of this portion. Taking the bed as a whole the Bryoza make up a large part of its fossils, 10 of the 36 species being also restricted to it. Next come the Gastropoda with 29 species, the Brachiopoda with 23, and the Lamellibranchiata with 13. The principal characteristic fossils are *Callopora ampla*, *C. goodhuensis*, *Prasopora insularis*, *Eridotrypa mutabilis*, *Strophomena scofieldi*, *Orthis meedsi*, *Clitambonites diversa*, *Vanuxemia hayniana*, *Tetranota bidorsata* and *Arges wesenbergensis* var. *paulianus*. A small variety of *Plectambonites sericea* (*minnesotensis* Sardeson) is also very abundant. *Receptaculites oweni* is occasionally met with in the uppermost layers of this bed at St. Paul. In the description of the species this bed is always called the Galena shales. That term, however, is not entirely restricted to the Clitambonites bed but occasionally includes also the lower part of the next bed.

*Fusispira bed.* This is by far the most important of the three or four beds of the Trenton in Minnesota. Outcrops are numerous in Fillmore, Olmsted, Dodge and Goodhue counties, and fossils, most of them well preserved, are abundant in many of the layers. As already pointed out, the lithologic character of the bed varies considerably at different localities in the counties mentioned. (See sections 3, 4, 7 and 8.) The lower portion only is fairly constant, consisting, wherever this part has been observed, of soft shales and four or five, often irregular or lenticular, layers of crystalline limestone, varying in thickness from one to ten inches. These layers are crowded with fossils (mostly Bryozoa and Brachiopoda) many of which are restricted to the horizon. Being a persistent and easily recognized stratum it should have been separated and given a distinct name, but several reasons, chief among them the fact that we could not satisfy ourselves respecting the upper limit, have caused us to refer it provisionally to the Fusispira bed. Dr. Sardeson has, we believe, included it in his Camarella bed, which he gives a thickness of 30 feet.* He does not mention the limestone layers that occur at intervals in the lower 10 or 12 feet, and which lie directly upon the Clitambonites bed, but characterizes the bed according to the crumbling argillaceous limestones resting on them and which contain *Parastrophia hemiplicata* and *Cyclospira bisulcata*. The latter, as will be shown presently, does not deserve to be separated from the next series of strata which Dr. Sardeson calls the "Lingulasma bed," nor can we, for the reason given, justly restrict the use of the name Camarella bed to the 10 or 12 feet of strata immediately following the Clitambonites bed. Really, Dr. Sardeson's name must be thrown out altogether for the simple reason that, according to the investigations of Winchell and Schuchert, and those recently published by Hall and Clarke,† one of his supposed Camarellas proves to belong to the new genus *Parastrophia*, H. & C.,‡ while the other is the type of another new genus

* It is possible that we are mistaken and that Dr. Sardeson really regards the bed as the upper member of his Orthisina bed (Clitambonites bed of this book). Again it is possible that thelayers in question were entirely overlooked by him. (For abstracts of Sardeson's papers see pp. xlvi and xlvii of the Introduction to part I of this volume.)

† Palæontology of New York, vol. VIII, pt. 2, fasc. i and ii, 1893.

‡ The species of this genus are referred provisionally to *Anastrophia* in this volume, pp. 382, 383.

and is now called *Cyclospira bisulcata.* This leaves the genus *Camarella* without any known representative in the Silurian rocks of Minnesota.

This lower division of the Fusispira bed is referred to occasionally in the description of the fossils as the "Nematopora bed" or as the "top" or "upper portion of the Galena shales," but in most cases the fossils are credited simply to the Galena shales.* Fossils are abundant, some of them extremely so. Common forms are plates of *Glytocystites* sp. undet., *Helopora mucronata, Arthroclema armatum, Nematopora ovalis, N. granosa, Pachydictya pumila, Rhinidictya minima, Homotrypa similis, Mesotrypa discoidea, Orthis mcedsi* var. *germana, Clitambonites diversus, Schmidtella subæqualis, Halliella labiosa* and *Tetradella lunatifera.* If a distinct name is desired for this horizon, that of Nematopora bed would be appropriate since this genus is represented here by four species and is unknown in all the other beds.

Above the Nematopora horizon we have a series of strata for which the name Fusispira bed is proposed and to which the name should eventually be restricted. As has been stated already the lower portion of the bed has been separated by Dr. Sardeson as the "Camarella bed" while the upper portion he named "Lingulasma bed." The first of Dr Sardeson's names we have shown to be untenable, the second is objectionable because it is based upon a fossil that is very rare and in the opinion of the writers probably not distinct from the *Lingulasma schucherti* which is a rather widely distributed fossil of the Cincinnati period. We doubt also our right to extend the application of the name to strata which Dr. Sardeson holds to be distinct. Our name is based upon the occurrence here of at least nine species of *Fusispira,* four of which seem to be restricted to the bed, while two occur also in the Clitambonites bed and the others continue into the lower part of the Maclurea bed.

In Fillmore county, as may be seen from section 4, (pl. xxxv), the Fusispira bed consists of a continuous series of thin bedded and more or less pure limestones little short of 100 feet in thickness. Nearly every foot of the bed as exposed in Prosser's ravine near Wykoff is fossiliferous, and some of the layers are crowded with shells. In tracing the bed through Olmsted and Dodge into Goodhue county the lower part becomes gradually more and more argillaceous (see sections 3 and 7), the fossils at the same time becoming less abundant and finally exceedingly rare or wanting entirely.

The Mantorville quarry layers, which we place in the lower part of the bed, are peculiar in reassuming the magnesian character which had been lost before the bed entered Minnesota. The rock here is a firm and durable limestone in courses varying from three to thirty-six inches in thickness. All the fossils except the inarticulate brachiopods and graptolites occur as casts. We collected here the following species: *Lingula iowensis, L. hurlbuti, L.* n. sp., *Schizotreta pelopea, Strophomena trilobata,*

* It is unfortunate that the subdivision of the Lower Silurian strata Minnesota could not be carried out before this volume went to press. It would have prevented some naccuracies, though we would doubtless have fallen into others and in the end perhaps have produced more confusion than prevails now with the provisional nomenclature which was adopted by agreement among the several authors who have contributed to the work. Although we had a working conception of the various subdivisions, it was not till the close of the field season of 1892 that they were fully understood and characterized so as to be recognized at once by their fossils and lithological peculiarities. By this time, however, nearly 400 pages of the volume had been printed, and it is in this portion that most of the errors and ambiguities occur.

*Rafinesquina delloidea, Plectambonites gibbosa, Cyclospira bisulcata, Pleurocystites squamosa, Receptaculites oweni* and *Murchisonia bellicincta,* all of which may be considered as characteristic of the lower half of the Fusispira bed.

To the northward at Berne, also in Dodge county, the Mantorville layers are more argillaceous and much less firm, while the fossils generally retain their shells. About six miles north of Kenyon (Goodhue county) the same layers are exposed in a bluff near the headwaters of a tributary of the Cannon river. Here, however, they are so thin and soft that they are quite unfit for building purposes. Immediately beneath them this bluff presents also a good exposure of the Nematopora horizon. About three miles south of Cannon Falls a good section of the greater part of the bed is exposed on a hill-side and in large cuts along the road to Hader P. O. Here we have, resting on the Nematopora layers, nearly 50 feet of shaly and sometimes apparently arenaceous strata in which after a careful search not a single good fossil was observed. Above them are about 20 feet of thin bedded fossiliferous limestones, which doubtless are equivalent to the layers quarried at Hader. The latter are at or near the top of the bed and contain a considerable fauna. Some fine specimens of *Fusispira inflata* (Meek & Worthen, sp.) were obtained here.

*Maclurea bed.* We adopt this name from Dr. Sardeson's section. It is an easily recognized bed of buff magnesian limestone, averaging about 50 feet in thickness in Olmsted and Fillmore counties. This entire bed is exposed in Prosser's ravine near Wykoff (see section 4) and the lower layers are quarried at Stewartville and other localities in the state. The bed resists decomposition very well and as a rule forms bold bluffs. The fossils occur chiefly in the lower half, and consist almost exclusively of large Gastropoda, of which *Maclurea crassa, Maclurina cuneata, M. manitobensis,* and *Lophospira augustina* are sometimes abundant and always characteristic. At the top of the bed several hard though porous layers are usually present forming a durable cap when they have not been weathered into rough prominences. Above these, or taking their place, we have noticed at several points in Fillmore county, notably, at a small quarry about two and a half miles north of Spring Valley, from five to ten feet of unevenly laminated bluish-gray, crinoidal limestone, presenting unmistakable evidence of disturbance at the close of the period. This layer corresponds with current formed limestones occurring quite generally at the top of the Trenton in Kentucky and Tennessee, and will be further considered in our general remarks on the Lower Silurian.

## THE HUDSON RIVER OR CINCINNATI PERIOD.

Under this term we include all the rocks lying between the top of the Trenton and the base of the Upper Silurian. Space is wanting, nor are we fully prepared to give all our reasons for preferring the term Cincinnati for the period instead of Hudson River group or period, Hudson terrane, or that oldest name of them all, the "Gray Sandstones and Shales of Salmon River" as described and named by Conrad in 1837, in his first report on the geology of the third district of New York. For the present it must be sufficient to say that our preference is dominated by a sense of its utility and fitness. There is no other locality on the continent that deserves so well to be considered the typical locality for the series of strata in question as the region about Cincinnati, Ohio. All the groups into which the period may be divided are well represented there, and when it comes to their faunas and the facilities for collecting fossils, there is no other region in America where the fossils are so plentiful and so easy to obtain. Throughout this volume, however, and in all the Minnesota reports the term Hudson River has been used, and it is only from a sense of consistency that it is placed first in our title.

Only a brief account of the subdivisions of this important series of rocks will be attempted here, the point of chief interest to students of northwestern geology being the determination of the exact equivalents of the two Minnesota divisions of the formation in the Cincinnati section.

The strata of the Cincinnati period as exposed in Ohio, Indiana and Kentucky, are divisible into three groups, having about the same geological value as the Chazy, Stones River, Black River, and Trenton groups of the Trenton period, and the Medina, Clinton and Niagara groups of the Niagara period. These three divisions correspond very nearly with the Lower, Middle, and Upper Hudson of the Kentucky geologists, and the Eden shales, Hill Quarry beds, and Lebanon beds of Prof. Edward Orton in Vol. I, Geology of Ohio.

At Cincinnati we begin the period with the Utica group, which here consists of over 250 feet of grayish and blue calcareous shales and marls, in which many layers of more or less crystalline limestone, from one to twenty inches thick, are included.* The lower 15 or 20 feet of this division are of a darker color than the succeeding shales, being greenish gray or drab rather than light blue. It is this portion that agrees best in all respects with the Utica of New York and Canada, and it was so determined by Prof. James Hall as early as 1842. The gray shales contain more or less abundantly such widely distributed and characteristic Utica fossils as *Triarthrus becki, Primitiella unicornis, Leptobolus insignis, Lingula daphne, Dicranograptus ramosus, Diplograptus spinulosus, D. putillus, Dendrograptus simplex* and *D. tenuiramosus*. Of these, the last three, as well as many other species, continue into the main body of the shaly strata of the group. Throughout, fossils, Bryozoa especially, occur in greater abundance, variety and perfection than at any other known locality for the Utica. At the top the shales pass rather gradually into the "Hill Quarry beds."

The latter, for which we propose to use the name Lorraine group, are clearly equivalent to the greater part of the New York strata which Emmons included under that name.† At the base of the division, which at Cincinnati comprises about 200 feet of strata, there are some arenaceous layers that on weathering frequently preserve the fossils as casts.

* At Cincinnati, as may be seen opposite the city in the Kentucky bank of the river between the towns of West Covington and Ludlow, the Utica rests on at least 50 feet of limestones and shales belonging to the Trenton group. The latter terminate above with a heavy current-formed crinoidal layer, which includes large pebbles and disturbed masses of the underlying limestone layers and exhibits other evidences of unconformity by erosion between the two periods.

† We refer particularly to Emmons' Lorraine sandstone, the greater part, if not all, of his Lorraine shales, which Walcott in 1879 referred to the Utica, being probably equivalent to the upper part of the Utica at Cincinnati.

Above these there are numerous layers of crystalline limestone, three to ten inches in thickness, separated by relatively thin bands of shale. In the upper 60 or 70 feet the bedding is more irregular and the limestone layers thinner and generally argillaceous, unfitting them for building purposes. Fossils are well preserved and exceedingly plentiful, and among them may be recognized nearly ever species that has been described from the equivalent beds in New York. Perhaps 300 species of fossils are known from the Cincinnati exposure of the Lorraine group and of these at least two-thirds are limited to the group, which is, considering the very similar lithological characters of the preceding and succeeding beds, a surprisingly large percentage.

Resting on the Lorraine there is a series of alternating thin bedded shales and limestones and in some localities finally a sandstone, in all quite 350 feet thick in southwestern Ohio and southeastern Indiana. Almost the entire series is excellently exposed at Richmond, Indiana, so that the name Richmond group which we propose to apply to the series is eminently appropriate.* East and southeast of Oxford in Ohio, the whole group consists of thin bedded limestones and shales, but at Richmond the upper part shows an increase of arenaceous matter while the uppermost layers of shale have become harder and include one or two heavy beds of impure limestone. Southward from this locality in Ripley and Jefferson counties (Indiana) the heavy layers are increased. In the last county their texture is very compact and the color a drab or dove reminding one in both respects very greatly of some beds of the Trenton period. In Indiana and Ohio this upper part of the group is, as a rule, not very fossiliferous, but when the bed is traced over into Kentucky it becomes a veritable coral reef reaching from Jefferson county (Ky.) to and beyond Marion county. The rock in this distance has changed some, being in the last county of a yellowish color and finely arenaceous texture, the whole giving way very readily under the weather so that the surface is sometimes thickly strewn with masses of *Columnaria*, *Tetradium*, *Labechia* and *Beatricea*.

Near the southern border of Kentucky, at Burksville, this upper member is a true sandstone which Prof. Shaler has called the Cumberland sandstone. But it assumes very nearly that character locally also near the Ohio river, as in Oldham county where over 30 feet of it consists of greenish arenaceous shales and fine grained thin bedded sandstones. Linney was probably correct in correlating this bed with the Oswego sandstone of New York.

An interesting paleontological fact is the recurrence in the Richmond group, either as identical or closely related forms, of numerous species that, while they are all wanting in the Utica and Lorraine groups, are common fossils of one or the other of the groups of the Trenton period. Of these we may mention *Labechia ohioensis* Nicholson, which is scarcely distinct from the Trenton *Stromatopora pustulosa* of Stafford; *Streptelasma rustica* Billings, which is very similar to *S. corniculum* of the Trenton; *Orthis subquadrata* Hall, *Leperditia cæcigena* Miller, *Isochilina subnodosa* Ulrich and *Columnaria alveolata* Goldfuss are also

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* Prof. Orton's name "Lebanon" would have been adopted had his name not been used before for a division of the Trenton period by Prof. Safford. The Richmond exposures besides are larger and more characteristic of the group than those near Lebanon, Ohio.

upper Trenton species, while *C. halli* Nicholson, of which the typical form occurs in the Stones River and Black River groups, recurs here as well as at the top of the Trenton in slightly modified forms. Then we have varieties of *Tetradium minus* Safford and *Protarea vetusta* Hall, two Trenton species; while the following Trenton types, *Strophomena filitexta, S. trentonensis, S. trilobata* and *Rhynchotrema increbescens* are represented respectively by *S. neglecta, S. rugosa, S. nutans* and *R. capax.* And all these species, moreover belong to the predominant fossils of the group. Still, of the total number of species known from the group (over 300) nearly three-fourths are restricted to it.

Only two of the groups of the Cincinnati period are represented in Minnesota, viz: the lower and the upper, and both by but a small thickness. The Lorraine group thins rapidly in a northwestward direction from Cincinnati, and probably runs out altogether before reaching Kankakee, Illinois, where the volume of the whole period is less than 250 feet; and much the greater part of this seems to belong to the Richmond group.

The Utica group also is probably wanting entirely in the northeastern corner of Illinois, but in the northwestern corner at Savannah, where the whole period is little less than 100 feet thick, the lower 50 feet belong to this group, while the upper represents the Richmond group. From a paper by Prof. J. F. James* it appears that the Cincinnati period occasionally exceeds 100 feet in thickness in Iowa, but on the whole it diminishes slowly northward from the latitude of Savannah.

The Utica group in the Northwest seems to be a relatively deep sea deposit, and, in Iowa in particular, probably represents, so far as time is concerned, not only the Utica but the Lorraine of the Cincinnati region as well, without however at any time receiving any of the characteristic fauna of the latter.

The Lorraine deposits and fauna of the Cincinnati province were derived from the east-northeast and for some reason (perhaps deep water) did not extend into the northern Mississippi province. At the beginning of the Richmond group the Cincinnati province received an incursion of northwestern species like *Hyolithes parviusculus* and *Coleolus iowensis* James.

In Minnesota the Utica group (see section 8) rests on the unevenly laminated, bluish-gray, crinoidal limestone, which forms the top of the Trenton, and consists of 20 feet or more of layers of impure, evenly bedded, compact gray limestone, varying from 2 to 12 inches in thickness, separated by thin seams of shale. In the upper part of this bed the limestone layers are prevailingly thinner than in the lower part, and contain an abundance of small specimens of *Asaphus megistos.* The interbedded shales contain *Plectambonites sericea, Orthis testudinaria,* varieties *multisecta* and *emacerata, Triplecia ulrichi* and a number of undetermined Bryozoa, while about 14 feet above the crinoidal limestone one of the layers furnished numerous specimens of several species of *Lingula, Leptobolus occidentalis* and *Diplograptus putillus.*

The above describes the beds and fauna of the group as it is exposed in the vicinity of Spring Valley. Farther south, between Granger, Minn., and Graf, Iowa, the fossiliferous

* American Geologist. vol. 5, no. 6; 1890.

bed becomes thicker and more argillaceous, taking it as a whole, and contains molluscan species of the genera *Ctenodonta*, *Clidophorus* and *Orthoceras* in increasing abundance.

Resting upon the Utica we find in Fillmore county from 10 to perhaps 25 feet of more or less thin bedded argillaceous and siliceous limestones belonging to the Richmond group. Some of the layers are full of fine fossils, chiefly Brachiopoda, and these are often silicified, in which condition they have been collected by hundreds near Spring Valley. With very few exceptions, all the fossils that have been found in these layers occur also in the Richmond group of Illinois, Indiana and Ohio.

The strata of this group in Fillmore county are quickly decomposed and covered with soil, so that satisfactory natural exposures are rare. The fossils may sometimes be picked out of the worn soil of old fields but a more abundant supply was obtained in the cuttings along the railroad between Wykoff and Spring Valley. A few of the characteristic species are *Orthis subquadrata*, *O. proavita*, *O. testudinaria* (large variety), *O. whitfieldi*, *Rafinesquina kingi* Whitfield sp., *Rhynchonella capax*, *Strophomena neglecta*, *Balostoma variabile*, *Ctenodonta similis*, *C. recurva* and *Streptelasma rusticum*.

Overlying the fossiliferous layers of the Richmond group, may be seen in two places near Spring Valley, one about two and one-half miles north, the other one mile east of the town, about six feet of sandy layers weathering into irregular lumps and thin shells. Some of these contained fragments of large crinoids or cystids, and from the loose material we obtained several fine examples of *Hindia sphæroidalis*, a common Upper Silurian fossil; also spicules of *Hyalostelia solivaga* which occurs nearly everywhere in connection with the *Hindia*. Though these six feet are probably to be regarded as Upper Silurian the passage lithologically from the Richmond group is exceedingly gradual.

Succeeding the foregoing bed and followed with not very strong evidences of unconformity by Devonian strata, is a sandstone four feet thick which here and there contains large numbers of small quartz pebbles, varying between one and ten mm. in diameter This sandstone we assume to belong to the Oriskany of New York.

## Tabulation of the Lower Silurian Species of Minnesota and General Remarks Introductory to Same.

In the following tables the student will find the names of all the species known to occur in the Minnesota strata of the Trenton and Hudson River periods, excepting the St. Peter sandstone. To these are added a number that are likely to be found within the limits of the state but are as yet known to occur only in the neighboring states of Wisconsin, Illinois and Iowa. With these the total number of forms catalogued is 809. Species described in the volume from other regions are not included in the list since they have no bearing at present upon the points which the tables are intended to bring out. These tables show also the stratigraphic and geographic distribution of the species, while the summary tables which follow the list show how the faunas of the various stratigraphic divisions compare with each other and with those recognized in the Cincinnati, Tennessee, New York and Canadian Lower Silurian regions.

The total number of species and varieties in the Lower Silurian, belonging to the classes studied, which have been discussed in the volume, is eight hundred and eighty-one, and of these six hundred and ninety-three have been identified in the state, and ninety have been obtained from other states, and are likely to be found in Minnesota. They are distributed as follows:

*Sponges.* 11 species, of which one only has been found in Canada.

*Graptolites.* 3 species, all of which have been found in New York and Canada.

*Corals.* 10 species, of which 4 have been found in New York and Canada.

*Bryozoans.* 162 species, of which 15 are in New York and Canada, and 17 have not been found in Minnesota. The 19 large genera, *i. e.*, those containing four or more species are the following:

| | | | |
|---|---|---|---|
| Stomatopora | 4 species. | Monticulipora | 5 species. |
| Rhinidictya | 9 species. | Atactoporella | 4 species. |
| Pachydictya | 7 species. | Homotrypella | 6 species. |
| Escharopora | 4 species. | Homotrypa | 8 species. |
| Stictoporella | 6 species. | Prasopora | 8 species. |
| Helopora | 7 species. | Mesotrypa | 5 species. |
| Arthroclema | 5 species. | Callopora | 9 species. |
| Nematopora | 4 species. | Batostoma | 8 species. |
| Phylloporina | 4 species. | Monotrypa | 4 species. |
| Leptotrypa | 4 species. | | |

Of this total 9 species have not yet been found in Minnesota, leaving 102 species in 19 genera, which are known to occur within the state. The other 30 genera, of which one (*Heterotrypa*) does not occur in the state so far as known, contain 51 species.

*Brachiopods.* 81 species, of which 20 species (and 2 varieties) occur in New York, and 33 species (and 4 varieties) occur in Canada. There is a total of 40 species common to Minnesota, New York and Canada. Of the 81 species considered, 8 are not found in the state, making a total of 73 species of known Lower Silurian brachiopods. The large genera, having each four or more species, are:

| | | | |
|---|---|---|---|
| Lingula | 12 species. | Strophomena | 12 species. |
| Orthis | 17 species. | | |

Of these 3 are not found in Minnesota, leaving 38 species in 3 genera. The other 24 genera contain 40 species. Two of these (*Schizambon* and *Rhynchonella*) have not been found in the state.

*Lamellibranchs.* 131 species, of which 18 are not found in Minnesota, 7 are in New York (and Penn.), and 5 in Canada. Nine species are common to Minnesota, New York and Canada.

The large genera, *i. e.*, those containing 4 or more species, are the following:

| | | | |
|---|---|---|---|
| Ambonychia | 4 species. | Cyrtodonta | 16 species. |
| Clionychia | 5 species. | Vanuxemia | 15 species. |
| Modiolopsis | 11 species. | Whitella | 12 species. |
| Orthodesma | 4 species. | Ctenodonta | 26 species. |
| Endodesma | 5 species. | Technophorus | 4 species. |

Of these 15 are not found in Minnesota, leaving 87 species of Minnesota lamellibranchs in 10 genera. The total number of genera is 27. The other 17 genera contain 29 species.

*Gastropods.* 287 species, contained in 46 genera, of which 149 species and 41 genera have been found in Minnesota. 30 of the Minnesota species occur in New York or Canada. The large genera, containing 4 or more species, are as follows:

| | | | |
|---|---|---|---|
| Archinacella | 13 species. | Liospira | 13 species. |
| Scenella | 7 species. | Eotomaria | 6 species. |
| Cyrtolites | 7 species. | Hormotoma | 10 species. |
| Protowarthia | 8 species. | Helicotoma | 10 species. |
| Tetranota | 6 species. | Maclurea | 7 species. |
| Bucania | 18 species. | Trochonema | 13 species. |
| Salpingostoma | 4 species. | Eunema | 6 species. |
| Conradella | 10 species. | Gyronema | 4 species. |
| Bellerophon | 11 species. | Cyclonema | 11 species. |
| Carinaropsis | 6 species. | Holopea | 11 species. |
| Raphistomina | 4 species. | Subulites | 9 species. |
| Lophospira | 38 species. | Fusispira | 10 species. |

Of the 242 species contained in the above 24 large genera, 125 species and all the genera are represented in Minnesota. 45 species are contained in 22 smaller genera; of these 24 species and 17 genera are represented in Minnesota.

*Cephalopods.* 49 species, all occurring in Minnesota. 15 of these have been found in New York or Canada. 38 species are contained in 5 large genera, and 11 in 8 smaller genera, making 13 genera in all. The large genera, containing 4 or more species, are:

| | | | |
|---|---|---|---|
| Cameroceras | 4 species. | Cyrtoceras | 11 species. |
| Triptoceras | 5 species. | Orthoceras | 12 species. |
| Oncoceras | 6 species. | | |

*Ostracods.* 67 species, of which 5 have not been found in Minnesota. Only one of these has been reported from New York and Canada. The 8 large genera, having 4 or more species, are the following:

| | | | |
|---|---|---|---|
| Leperditella | 5 species. | Primitia | 9 species. |
| Schmidtella | 6 species. | Eurychilina | 5 species. |
| Aparchites | 7 species. | Dicranella | 4 species. |
| Primitiella | 5 species. | Bythocypris | 4 species. |

Of these genera two have not their full complement in Minnesota (*Leperditella*, and *Bythocypris*, each 3 in Minn.), leaving 42 species in the state contained in 8 genera, and 36 species contained in 6 large genera. The total genera of ostracods are 22. The other 14 genera contain 22 species.

*Trilobites.* 40 species, of which 8 have not yet been found in Minnesota. Of the 32 species, 17 have been found in New York and 7 have been reported from Canada. There are 20 species of trilobites which are common to Minnesota, New York and Canada. Only two genera contain as many as 4 species, viz.: *Isotelus*, 4, and *Pterygometopus*, 4; but one species of the latter is absent from Minnesota. The total number of genera is 24, but three of these have not been found in Minnesota.

In the descriptive portions of the volume, excepting the last chapter (Gastropoda), temporary stratigraphic designations are generally employed in assigning the fossils to their respective geologic horizons. Thus the limestones of the Stones River group are in most cases not distinguished, the species of the Bluff limestone and of the Vanuxemia bed being as a rule referred to the Trenton limestone or, more exactly, to the "lower limestone of the Trenton formation." As we have said in discussing these beds on page xcii, their faunas are not greatly different. Still as the fossils from each are readily recognized in Minnesota by their modes of preservation,—those of the lower bed retain their shells while those of the Vanuxemia bed as a rule are casts merely—we have carefully separated the species which, so far, appear to be characteristic of each.

The greenish shales lying between the Vanuxemia bed and the yellowish or grayish shales of the Clitambonites bed were divided into three unequal parts or thirds, "lower, middle and upper thirds of the Trenton shales," corresponding in a general way with the Stictoporella, Rhinidictya and Phylloporina beds. The Ctenodonta bed is occasionally referred to as the "upper part of the middle third of the Trenton shales," while the Fucoid bed is sometimes called the "Orthis pectinella horizon."

The "Prasopora insularis horizon" is the same as the Clitambonites bed, and it is this bed that is usually meant when the text refers a fossil to the "Galena shales," though that term frequently also includes more or less of the Fusispira bed. As a rule, however, the shales of the latter bed are distinguished as the "upper part of the Galena shales." On the other hand, limestone deposits of the Fusispira bed in Fillmore county, the equivalents, of which in Goodhue county are referred to as Galena shales, are included with the rest of the Fusispira bed in the term "middle Galena." In accordance with the sense of the last term, the Galena or Trenton group was divided into three lithologic divisions, the Galena shales, the middle Galena, a portion consisting principally of pure limestone, and the upper Galena or Maclurea bed, a magnesian limestone.

The Maclurea bed alone maintains the typical dolomitic character of the Galena, but it diminishes in thickness from south to north, and may not have extended beyond Goodhue county. The lithologic changes in the strata have caused a slight overlapping in the designations of the special horizons. Thus the "Middle Galena," in speaking of localities in Goodhue county, refers to the solid upper part of the Fusispira bed, while it refers to the whole of the bed when Fillmore county localities are mentioned.

It is to be remembered that the Galena shale is merely a lithologic phase moving northward from county to county, and that it does not represent accurately any time interval in the Trenton at large. If studied only in the region between Cannon Falls and Berne the upper part of the shales would probably be separated as a distinct bed, as indeed was done by Sardeson who called it "Camarella bed." But as this merges gradually into the rest of the Fusispira bed, both lithologically and faunally, there is very little reason, if any, for the sub-division.

Occasionally reference is made in the volume to the *Anastrophia bed*, and the *Upper Clitambonites horizon.* These refer to shales in Goodhue county immediately over the Nematopora bed. It is the same horizon as the *Platystrophia beds* in Fillmore county, as that term is used in the 19th annual report.

In general, taking the whole area in which these Trenton formations are found in Minnesota, there may be said to be three grand lithologic features alternating, from below upward, as follows: Limestone, shale, limestone. Hitherto it has been customary to place in the Galena the upper limestone and in the Trenton the lower limestone, leaving the intervening shales in an unascertained relation. It is, however, now clear that the Galena alone is strictly equivalent to the Trenton limestone of New York, while the green shales beneath the Clitambonites bed and the limestone beneath these are to be correlated respectively with the Black River and Stones River or Birdseye limestones. The lower limestone, therefore, should no longer be spoken of as the Trenton limestone except in a broad sense, while the name Galena, if retained at all in this connection, should henceforth be used only as expressing a lithologic phase of the Trenton group and not as a distinct geologic horizon.

That the Galena is simply a lithologic phase, the prevalence of which was known to become reduced in passing from Iowa northward into Minnesota, was recognized in some of the earlier reports of the survey. It fades out gradually, and shales and shaly limestone take its place. There seems to be no other horizontal lithologic change than that which can be attributed to varying conditions of the same oceanic expanse dependent on nearness or remoteness from the ancient shore line. The present surface strike of these formations in southern Minnesota is northerly, and in Lower Silurian time, as well as now, that must have been toward the ancient land area of the region. Nothing, therefore, could have been more natural than that the limestone phase should be replaced, at the same horizon, passing northward, by a lithologic phase embracing more and more of shale. The Black River formation is affected in the same way. Shale beds occupy the stratigraphic position of limestones in Iowa and Wisconsin. So far, then, as the nature of the sediments may affect the distribution of the oceanic life of the Lower Silurian in the upper Mississippi valley, deep sea species would be crowded out more and more on approaching the latitude of the falls of St. Anthony. Such vertical oscillations as may have taken place in the bed of the ocean apparently were felt uniformily over the whole region, and they may be supposed to have been the prime cause of the grand vertical changes in the nature of the rock. These two components in the cause of faunal variation in the Lower Silurian rocks must both be admitted to have had their legitimate effects, but they operated differently. While a natural vertical succession of forms would be brought about by the action of one, in any certain locality, by the action of the other a lateral variation was caused. This lateral variation introduces such irregularity that it is plainly impossible to construct a stratigraphical scheme for the whole area, and consequently, it is difficult to assign all of the species uniformly to definite stratigraphic limits. This is true of those species that are easily affected by changed environment, and to a certain extent it is necessarily true of all the species concerned.

Two formations of the Hudson River period are recognized in southern Minnesota, namely, the Utica and Richmond groups. As a rule the two divisions are not distinguished in giving the "formation and locality" of the species found in them, but the fossils are mostly referred simply to the Hudson River formation.

Now, whatever stratigraphical terms are employed in our provisional efforts to fix the horizons of the fossils here described, it is to be understood that the position and range assigned to each in the following list is in accordance with our latest and best information. Continued investigations in the field and laboratory have enabled us to correct some errors and given us more definite knowledge concerning the geologic and geographic distribution of the species. We do not, of course, wish to intimate that the list is in any wise permanent or reliable in all parts, yet we are confident that the changes which may be necessitated by future discoveries will not materially affect the conclusions which we have drawn from the facts brought out by the tables. Now and then the vertical range of a species may be extended, but such defections will be more than equalized by the new discoveries that are continually rewarding the efforts of the collector.

The geologic position and range of each species found in Minnesota is indicated by the letter x in one or more columns. Species occurring in the upper Mississippi province, but not yet discovered within the limits of the state of Minnesota, are distinguished in the columns by a dagger (†) instead of by the letter x. The number of these might have been largely increased but it was thought sufficient for our purpose to include only those which we may reasonably expect to find in the state.

In the column devoted to the Fusispira and Nematopora beds, those species which are restricted to the latter division are indicated by the letter n instead of by the letter x. The letter f in the Phylloporina and Fucoid beds' column distinguishes the few forms that are particularly characteristic of the Fucoid bed.

Finally, in the columns showing occurrence of species in other regions, the following abbreviations are used: Cincinnati region, R for Richmond group, L for Lorraine group, U for Utica group, T for Trenton group, B for Black River group, and S for Stones River group; Central Tennessee, T for Trenton group (Nashville group of Safford), B for Black River group (Carter's Creek limestone), S for Stones River group (Glade, Ridley, Pierce and Central limestones of Safford); New York and Canada, H for Hudson River group, U for Utica group, T for Trenton group, B and S for Black River and Stones River or Birdseye limestone, and C for Chazy group. In Canada the Black River and Birdseye are not separated, hence, in this column the letter B stands for either one or both.

| PORIFERA, CŒLENTERATA, AND BRYOZOA. | Page. | Trenton Period. | | | | | | | | | Hudson or Cincinnati Period. | | Cincinnati region. | Tennessee. | New York. | Canada. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stones River Group. | | | Black River Group. | | | Trenton Group. | | | | | | | | |
| | | "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Utica group. | Richmond group. | | | | |
| Receptaculites oweni Hall | 57 | | | | | | | x | x | x | | | | | | |
| Receptaculites sp. undet | | | | | | | | | | | | x | | | | |
| Ischadites iowensis Owen | 64 | | | | | | | ? | x | ? | | | | | | T |
| Rauffella filosa Ulrich | 75 | | | | x | x | x | | | | | | | | | |
| Rauffella palmipes Ulrich | 76 | | | | x | | | | | | | | | | | |
| Heterospongia subramosa Ulr | 79 | | | | | | | | | | | x | L R | | | |
| Hindia inæqualis Ulrich | | | x | † | | | | | | | | | | | | |
| Hindia parva Ulrich | 79 | | | | | | x | x | | | | | T | T | | |
| Cylindrocœlia minnesotensis Ulr | 78 | | | | x | x | x | | | | | | | | | |
| Brachiospongia (?) robbinsi Ulrich | | | | | | | | | x | | | | | | | |
| Calathium (?) clavatum Ulrich | | | | | | | | | x | | | | | | | |
| Calathium (?) hexagonalis Ulrich | | | | | | | | | | | | x | | | | |
| Camarocladia dichotoma U. & E. | | | x | † | | | | | | | | | | | | |
| Camarocladia fruticosa Ulrich | | | x | | | | | | | | | | | | | |
| Camarocladia rugosa Ulrich | | | | | | | f | | | | | | B | | | |
| Solenopora compacta Billings | 80 | | | | | | x | | | | | | S B T R | T | | B |
| Diplograptus pristis ? Hall | 81 | | | | | | | | | | x | | ?U | | U H | U H |
| Diplograptus putillus Hall | 82 | | | | | | | | | | x | | U | | | |
| Climacograptus typicalis Hall | 82 | | | | | | | | x | | | | T U | | H | |
| Lichenaria typa, n. sp | 83 | | | | x | | x | | | | | | | | | B |
| Lichenaria minor, n. sp. | 84 | | | | | | | x | | | | | | | | |
| Columnaria halli Nicholson | 85 | | | x | x | | | | | | | | S B R | S B | B | B |
| Streptelasma profundum Conrad | 88 | x | x | x | x | x | x | | | | | | S B | S B | S B | B |
| Streptelasma parasiticum, n. sp | 89 | x | | | x | | | | | | | | | | | |
| Streptelasma breve, n. sp | 92 | | x | | | | | | | | | | | | | |
| Streptelasma corniculum Hall | 90 | | | | | | | x | x | | | | | | T | T |
| Streptelasma rusticum Billings | 93 | | | | | | | | | | | x | R | | | H |
| Protarea vetusta Hall | 94 | | | | | | | x | | | | | | | T | T |
| Protarea vetusta var | | | | | | | | | | | | x | R | | | |
| Tetradium minus var | | | | | | | | | | | | x | R | | | |
| Aulopora (?) trentonensis, n. sp | 95 | | | ? | x | | | | | | | | | | | |
| BRYOZOA. | | | | | | | | | | | | | | | | |
| Vinella repens Ulrich | 114 | | | | | | x | | | | | | | | | |
| Stomatopora proutana Miller | 117 | | | x | x | | x | x | n | | | † | T U L R | | | |
| Stomatopora inflata Hall | 117 | | | | | | x | | | | | | L | | T | T |
| Stomatopora turgida Ulrich | 118 | | | | | | | | | | | † | | | | |
| Proboscina tumulosa, n. sp | 119 | | | | | | x | | | | | | | | | |
| Berenicea minnesotensis Ulrich | 120 | | | x | x | | | | | | | | | | | |
| Diastoporina flabellata Ulrich | 122 | | | | | | | ? | n | | | | | | | |
| Mitoclema (?) mundulum Ulrich | 123 | | | | | | | | n | | | | | | | |
| Rhinidictya mutabilis Ulrich | 125 | | | x | x | x | x | x | n | | | | T | S T | | |
| Rhinidictya mutabilis var. major Ulr | 127 | | | | x | x | x | | | | | | | | | |
| Rhinidictya mutabilis var. senilis, n. var. | 127 | | | | x | | | | | | | | | | | |
| Rhinidictya paupera Ulrich | 129 | | | | | | x | | | | | | | | | |
| Rhinidictya neglecta, n. sp | 130 | | | | | | ? | | | | | | T | | | |
| Rhinidictya exigua Ulrich | 131 | | | x | x | | x | | | | | | | | | |
| Rhinidictya minima Ulrich | 132 | | | | | | | | n | | | | | | | |
| Rhinidictya minima var. modesta, n. var. | 133 | | | | | | | | n | | | | | | | |
| Rhinidictya fidelis Ulrich | 134 | | | x | | | | | | | | | | | | |
| Rhinidictya trentonensis Ulrich | 135 | | x | x | | | | | | | | | | S | | |
| Rhinidictya nicholsoni Ulrich | | | x | | | | | | | | | | S | S | | |
| Rhinidictya grandis, n. sp. | 136 | | † | † | | | | | | | | | S | | | |
| Rhinidictya pediculata, n. sp | 137 | x | x | | | | | | | | | | S | | | |
| Eurydictya multipora (? Hall sp.) | 139 | | | | | | x | | | | | | T | T | | |
| Phyllodictya frondosa Ulrich | 142 | | | ? | x | | | | | | | | S B | | | |
| Phyllodictya varia, n. sp | 144 | | | | x | | | | | | | | | | | |
| Pachydictya foliata Ulrich | 149 | | | x | | | | | | | | | S | S | | |
| Pachydictya occidentalis Ulrich | 151 | | | | | | x | | | | | | | | | |
| Pachydictya fimbriata Ulrich | 152 | | | | x | x | ? | | | | | | | S | | |
| Pachydictya elegans, n. sp | 154 | | | | | | | x | | | | | | | | |
| Pachydictya acuta Hall | 155 | | | | | | ? | x | x | | | | T | T | T | T |
| Pachydictya pumila Ulrich | 157 | | | | | | ? | | n | | | | | | T | |
| Pachydictya magnipora Ulrich | | | | | | | | | x | | | | | | | T |

| BRYOZOA. | Page. | Trenton Period. Stones River Group. "Lower Buff." | Trenton Period. Stones River Group. Vanuxemia bed. | Trenton Period. Stones River Group. Stictoporella bed. | Trenton Period. Black River Group. Rhinidictya bed. | Trenton Period. Black River Group. Ctenodonta bed. | Trenton Period. Black River Group. Fucoid and Phylloporina beds. | Trenton Period. Trenton Group. Clitambonites bed. | Trenton Period. Trenton Group. Fusispira and Nematopora beds. | Trenton Period. Trenton Group. Maclurea bed. | Hudson or Cincinnati Period. Utica group. | Hudson or Cincinnati Period. Richmond group. | Cincinnati region. | Tennessee. | New York. | Canada. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trigonodictya conciliatrix Ulrich | 160 | | | | | | x | | | | | | | | | |
| Escharopora angularis, n. sp | 168 | x | x | x | | | | | | | | | S | S | | |
| Escharopora subrecta Ulrich | 168 | | | ? | x | | | | | | | | | | | |
| Escharopora recta ? Hall | | | | | | | | x | n | | | | | | T | T |
| Escharopora confluens, n. sp | 171 | | | | x | | | | | | | | | S | | |
| Escharopora (?) limitaris, n. sp | 172 | | | x | x | | | | | | | | | | | |
| Phænopora incipiens, n. sp | 174 | | | | | | | x | | | | | | | T | T |
| Phænopora wilmingtonensis, n. sp | 175 | | | | | | | | | | | † | | | | |
| Arthropora simplex Ulrich | 177 | | | x | x | | | | | | | | | | | |
| Arthropora bifurcata, n. sp | 178 | | | | | | x | x | | | | | T | | | |
| Arthropora reversa, n. sp | 178 | | | | | | | x | | | | | | | | |
| Stictoporella rigida Ulrich | 180 | | | | | | x | | | | | | | | | |
| Stictoporella dumosa, n. sp | 181 | | | | | | x | | | | | | | | | |
| Stictoporella angularis Ulrich | 182 | | | x | | | | | | | | | | | | |
| Stictoporella " var. intermedia, n. var. | 183 | | | x | | | | | | | | | | | | |
| Stictoporella frondifera Ulrich | 183 | | | x | | | | | | | | | | | | |
| Stictoporella cribrosa Ulrich | 184 | | | | x | x | | | | | | | | | | |
| Arthrostylus conjunctus Ulrich | 188 | | | | | | x | | | | | | ? T | | | |
| Arthrostylus obliquus Ulrich | 188 | | | x | | | | | | | | | | | | |
| Helopora divaricata Ulrich | 191 | | | x | | | | | | | | | | | | |
| Helopora alternata Ulrich | 192 | | | | x | | | | | | | | | | | |
| Helopora mucronata Ulrich | 193 | | | | | | | x | n | | | | | | | |
| Helopora quadrata, n. sp | 193 | | | | | | | | n | | | | | | | |
| Helopora elegans, n. sp | 194 | | | | | | | | | | | † | R | | | |
| Helopora harrisi James | 195 | | | | | | | | | | | † | R | | | |
| Helopora sp. undet | 196 | | | | | | | | n | | | | | | | |
| Arthroclema striatum, n. sp | 198 | | | | x | | | | | | | | | | | |
| Arthroclema cornutum Ulrich | 200 | | | | x | | | | | | | | | | | |
| Arthroclema armatum Ulrich | 201 | | | | | | | | n | | | | | | | |
| Arthroclema pulchellum Billings | | | | | | | x | x | | | | | | | | T |
| Arthroclema sp. undet (1) | 203 | | | | x | | | | | | | | | | | |
| Nematopora ovalis Ulrich | 204 | | | | | | | | n | | | | | | | |
| Nematopora granosa Ulrich | 205 | | | | | | | | n | | | | | | | |
| Nematopora delicatula Ulrich | 206 | | | | | | | | n | | | | | | | |
| Nematopora conferta Ulrich | 206 | | | | | | | | n | | | | | | | |
| Phylloporina sublaxa Ulrich | 209 | x | | | | | | | | | | | S | S | | |
| Phylloporina reticulata Hall | 210 | | | x | x | | | | n | | | | T | | T | T |
| Phylloporina halli Ulrich | 211 | | | | | | x | | | | | | | | | |
| Phylloporina corticosa Ulrich | 212 | | | | | | x | | | | | | | | | |
| Monticulipora wetherbyi Ulrich | 218 | x | | | | | | | | | | | S | | | |
| Monticulipora incompta, n. sp | 219 | | | | x | | | | | | | | | | | |
| Monticulipora grandis Ulrich | 219 | | | x | | | | | x | | | | | | | |
| Monticulipora arborea, n. sp | 220 | | | | | | | x | ? | | | | T | | | |
| Monticulipora cannonensis, n. sp | 221 | | | | | | | x | | | | | | | | |
| Atactoporella typicalis var. præcipta, n. var | 223 | | | | x | | | | | | | | | | | |
| Atactoporella insueta, n. sp | 224 | | | | x | | | | | | | | | | | |
| Atactoporella crassa, n. sp | 225 | | | | | | | x | | | | | | | | |
| Atactoporella ramosa, n. sp | 226 | | | | | | x | | | | | | | | | |
| Homotrypella instabilis Ulrich | 229 | | | | x | | | | | | | | | | | |
| Homotrypella multiporata, n. sp | 230 | | | | x | | | | | | | | | | | |
| Homotrypella subgracilis, n. sp | 230 | | | | x | | | | | | | | | | | |
| Homotrypella ovata, n. sp | 231 | | | | x | | | x | | | | | | | | |
| Homotrypella mundula, n. sp | 232 | | | | | | | x | ? | | | | | | | |
| Homotrypella gracilis Nicholson | | | | | | | | | | | | x | L R | | | |
| Homotrypella rustica, n. sp | 234 | | | | | | | | | | | x | R | | | |
| Homotrypa minnesotensis Ulrich | 235 | | | x | | | x | | | | | | | | | |
| Homotrypa exilis Ulrich | 236 | | | x | | | | | | | | | | | | |
| Homotrypa separata, n. sp | 237 | | | x | | | | | | | | | S | | | |
| Homotrypa intercalaris, n. sp | 238 | | | | x | | | | | | | | | | | |
| Homotrypa subramosa Ulrich | 239 | | | | x | | x | | | | | | | | | |
| Homotrypa " var. insignis Ulrich | 240 | | | | | | | x | | | | | | | | |
| Homotrypa tuberculata, n. sp | 240 | | | | | | x | | | | | | | | | |
| Homotrypa similis Foord | 242 | | | | | | | x | n | | | | | | | T |

| BRYOZOA. | Page. | Trenton Period. | | | | | | | | | Hudson or Cincinnati Period. | | Cincinnati region. | Tennessee. | New York. | Canada. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stones River Group. | | | Black River Group. | | | Trenton Group. | | | | | | | | |
| | | "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Utica group. | Richmond group. | | | | |
| Homotrypa callosa, n. sp. | 243 | | | | | | | x | n | | | | T | | | |
| Prasopora simulatrix Ulrich | 245 | | | | | | x | | x | | | | T | T | T | T |
| Prasopora contigua Ulrich | 249 | | | | | | x | ? | | | | | | | | |
| Prasopora conoidea Ulrich | 249 | | | | | | x | | | | | | | | | |
| Prasopora selwyni Nicholson | 250 | | | | | | | | x | | | | | | | T |
| Prasopora insularis, n. sp. | 251 | | | | | | | x | | | | | | | | |
| Prasopora affinis Foord | 253 | | | | | | | | n | | | | | | | T |
| Prasopora oculata Foord | 252 | | | | | | | | n | | | | | | | T |
| Prasopora lenticularis, n. sp. | 253 | | | | | | x | | | | | | | | | |
| Aspidopora parasitica Ulrich | 255 | | | x | x | | | | | | | | | | | |
| Aspidopora elegantula, n. sp. | 256 | | | | | | | x | | | | | | | | |
| Mesotrypa infida Ulrich | 258 | | | | x | | | | | | | | | | | |
| Mesotrypa (?) spinosa, n. sp. | 259 | | | | x | | | | | | | | | | | |
| Mesotrypa quebecensis Ami | 259 | | | | | | | ? | x | | | | T | | T | T |
| Mesotrypa discoidea, n. sp. | 260 | | | | | | | | x | | | | | | | |
| Mesotrypa (?) rotunda, n. sp. | 262 | | | | | | | | x | | | | | | | |
| Bythopora herricki Ulrich | 263 | | | | x | | | | | | | | | | | |
| Bythopora alcicornis, n. sp. | 264 | | | | | | x | | | | | | | | | |
| Eridotrypa mutabilis, n. sp. | 265 | | | | | | | x | x | | | | T | T | | T |
| Eridotrypa mutabilis var. minor, n. var. | 266 | | | | | | x | x | | | | | | | | |
| Eridotrypa exigua, n. sp. | 266 | | | | | | | | n | | | | | | T | |
| Heterotrypa prolifica Ulrich | 268 | | | | | | | | | | | † | R | | | |
| Heterotrypa singularis Ulrich | 268 | | | | | | | | | | | † | R | | | |
| Dekayella prænuntia, n. sp. | 270 | | | | x | | | | | | | | | | | |
| Dekayella " var. simplex, n. var. | 271 | | | x | x | | | | | | | | | | | |
| Dekayella " var. nævigera, n. var. | 271 | | | x | | | | | | | | | | | | |
| Dekayella " var. echinata, n. var. | 271 | | | | x | x | x | | | | | | | | | |
| Dekayella " var. multipora, n. var | 272 | | | | x | | | | | | | | | | | |
| Dekayia trentonensis Ulrich | 274 | | | | | | x | x | | | | | T | | | |
| Callopora angularis, n. sp. | 277 | | | x | | | | | | | | | | | | |
| Callopora incontroversa Ulrich | 278 | | | x | | | | | | | | | | | | |
| Callopora undulata Ulrich | 279 | | | | x | x | | | | | | | | | | |
| Callopora multitabulata Ulrich | 280 | | | | x | | x | x | ? | | | | T | T | | |
| Callopora ampla, n. sp. | 281 | | | | x | | x | x | | | | | | | | |
| Callopora goodhuensis, n. sp. | 282 | | | | | | | x | | | | | | | | |
| Callopora dumalis, n. sp. | 282 | | | | | | x | x | | | | | | | | |
| Callopora pulchella, n. sp. | 283 | | | | | | x | | | | | | | | | |
| Callopora pulchella var. persimilis, n. var | 284 | | | | | | x | | | | | | | | | |
| Callopora crenulata, n. sp. | 284 | | | | | | x | x | | | | | | | | |
| Diplotrypa limitaris, n. sp. | 286 | | | | | | | | x | | | | | | | |
| Diplotrypa neglecta, n. sp. | 287 | | | | | | | | x | | | | | | | |
| Batostoma fertile Ulrich | 290 | | | x | | | | | | | | | | | | |
| Batostoma magnopora, n. sp. | 291 | | | | x | | | | | | | | | | | |
| Batostoma varium, n. sp. | 292 | | | | x | x | | | | | | | | | | |
| Batostoma montuosum, n. sp. | 293 | | | | | | x | | | | | | | | | |
| Batostoma humile, n. sp. | 294 | | | | | | | x | | | | | ?T | | | |
| Batostoma winchelli Ulrich | 295 | | | | x | | | | | | | | | | | |
| Batostoma minnesotense, n. sp. | 297 | | | | x | | | | | | | | | | | |
| Batostoma (?) decipiens, n. sp. | 298 | | | x | x | | | | | | | | | | | |
| Hemiphragma irrasum Ulrich | 299 | | | x | x | | x | x | | | | | | | | |
| Hemiphragma ottawense Foord | 300 | | | | | | | | n | | | | | | | T |
| Hemiphragma tenuimurale, n. sp. | 301 | | | | | | | x | n | | | | | | | |
| Hemiphragma imperfectum Ulrich | | | | | | | | | | | | † | | | | |
| Stromatotrypa ovata, n. sp. | 302 | | | x | x | | | | | | | | | | | |
| Monotrypa magna, n. sp. | 304 | x | † | † | | | | | | | | | | S | | |
| Monotrypa intabulata, n. sp. | 305 | | | | | | | | x | | | | | | | |
| Monotrypa nodosa, n. sp. | 306 | | | | | | | | | | | † | | | | |
| Monotrypa cumulata, n. sp. | 307 | | | | | | | | x | | | | | | | T |
| Trematopora (?) primigenia Ulrich | 309 | | | | x | | | | | | | | | | | |
| Trematopora (?) " var. ornata Ulrich | 310 | | | | x | | | | | | | | | | | |
| Trematopora (?) " var. spinosa, n. var | 310 | | | | x | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stones River Group. | | | Black River Group. | | | Trenton Group. | | | | | | | | |
| | | "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Utica group. | Richmond group. | | | | |
| Constellaria varia, n. sp. | 311 | | | | | | | | n | | | | | | | |
| Stellipora antheloidea Hall | | | | | | | x | | | | | | | | | |
| Nicholsonella laminata, n. sp | 315 | | | | x | | | | | | | | | | | |
| Nicholsonella ponderosa (?) Ulrich | 316 | | | x | x | | | | | | | | | | | |
| Leptotrypa hexagonalis Ulrich | 317 | x | x | | | | | | | | | | | | | |
| Leptotrypa informis, n. sp. | 317 | | | x | ? | | | | | | | | | | | |
| Leptotrypa claviformis, n. sp | 319 | | | | x | x | x | | | | | | | | | |
| Leptotrypa acervulosa, n. sp. | 318 | | | | | | | x | | | | | T | | | |
| Spatiopora labeculosa, n. sp. | 320 | | | | x | | | | | | | | | | | |
| Spatiopora iowensis, n. sp | 321 | | | | | | | | | | x | | | | | |
| Crepipora subæquata, n. sp | 322 | | | | | | x | | | | | | | | | |
| Crepipora perampla, n. sp. | 323 | ? x | | | | | | | | | | | | | | |
| Bythotrypa laxata Ulrich | 325 | | | x | x | | x | | x | | | | | | | |
| Anolotichia impolita Ulrich | 327 | | | x | | | | | | | | | | S | | |
| Ceramoporella distincta Ulrich | 328 | | | x | | | | | | | | | T U L R | | | |
| Ceramoporella inclusa, n. sp. | 329 | | | x | x | | x | | | | | | | | | |
| Ceramoporella interporosa Ulrich | 330 | | | | | | | x | | | | | T U L | | | |
| Diamesopora trentonensis, n. sp. | 330 | | | | | | x | | n | | | | | | T | T |
| Ceramophylla frondosa, n. sp | 331 | | | | | | x | | | | | | | | | |
| BRACHIOPODA. | | | | | | | | | | | | | | | | |
| Lingula elderi Whitfield | 339 | | x | x | | | | ? | | | | | | | | |
| Lingula eva Billings | 341 | | | | x | | | | | | | | | | | B |
| Lingula philomela Billings | 342 | | | | | | | | | | x | | | | | T |
| Lingula riciniformis Hall | 343 | | | | | | | x | | | | | | | T | T |
| Lingula " var. galenensis W. & S | 344 | | | | | | | | x | | | | | | | |
| Lingula modesta Ulrich | 344 | | | | | | | | | | x | | T U L | | | |
| Lingula clathrata, n. sp. | 345 | | | | x | | | | | | | | | | | |
| Lingula coburgensis ? Billings | 346 | x | | | | | | | | | | | | | | T |
| Lingula iowensis Owen | 349 | | | | | | | ? | x | | | | | | | |
| Lingula beltrami, n. sp. | 351 | | | | | | | | | | x | | | | | |
| Lingula n. sp. (? canadensis Billings) | 352 | | | | | | | | x | | | | | | | |
| L. (Glossina) deflecta W. & S. | 348 | | | | | | | | x | | x | | | | | |
| L. (Glossina) hurlbuti N. H. Winchell | 347 | | | | | | | | x | | | | | | | |
| Lingulasma schucherti Ulrich | 353 | | | | | | | | | | x | x | | | | |
| Lingulasma galenensis W. & S. | 354 | | | | | | | | x | | ? | | | | | |
| Dinobolus (?) parvus Whitfield | 356 | | | | | | | | x | | | | | | | |
| Siphonotreta (?) minnesotensis Hall | 358 | | x | | | | | | | | | | | | | |
| Leptobolus occidentalis Hall | 360 | | | | | | | | | | x | | | | | U |
| Orbiculoidea lamellosa ? Hall | 358 | | | | | | | | | | | x | | | T | T |
| Schizotreta pelopia Billings | 365 | | | | | | | | x | | | x | | | T | T |
| Schizotreta minutula, n. sp | 366 | | | | | | | | | | x | | | | | |
| Trematis huronensis? Billings | 368 | | x | x | x | | | | | | | | | | | B T |
| Trematis ottawensis Billings | 369 | | | | | | | x | | | | | T | | | T |
| Schizocrania filosa Hall | 370 | | | | x | | ? | | | | | | T U L | | T U | T U |
| Crania setigera Hall | 372 | x | x | x | x | x | | | | | | | | | | |
| Crania granulosa N. H. Winchell | 373 | x | | | | | | | | | | | | | | |
| Crania trentonensis Hall | 374 | | | | | | | x | | | | | | | T | |
| Craniella (?) ulrichi Hall | 375 | | | | x | | | x | | | | | | | | |
| Pholidops trentonensis var. minor, n. var. | 376 | | | | | x | | x | | | | | | | T | |
| Clitambonites diversus Shaler | 379 | | | | | | | x | x | | | | | | | T H Ant |
| Clitambonites " var. altissimus, n. var. | 381 | | | | | | | | x | | | | | | | |
| Scenidium anthonensis Sardeson | 381 | x | | | | | x | | | | | | | S | | |
| Parastrophia hemiplicata Hall | 382 | | | | | | | | x | | | | | | T | T |
| Parastrophia " var. rotunda, n. var. | 383 | | | | | | | | x | | | | | | | |
| Parastrophia scofieldi, n. sp | 383 | | | | | | | | x | | | | | | | |
| Strophomena incurvata Shepard | 385 | x | x | x | x | x | x | ? | | | | | S B T | S | T | B T |
| Strophomena neglecta James | 388 | | | | | | | | | | | † | R | | | |
| Strophomena " var. acuta, n. var. | 388 | | | | | | | | | | | x | | | | |
| Strophomena trentonensis, n. sp | 389 | | | | | | x | x | | | | | T | T | T | T |
| Strophomena septata, n. sp | 390 | | | | | | x | | | | | | | | | |
| Strophomena rugosa Blainville | 390 | | | | | | | | | | | x | R | | H | H |
| Strophomena " var. subtenta Hall. | 393 | | | | | | | | | | | x | R | | | |
| Strophomena planodorsata W. & S. | 393 | | | | | | | | | | | x | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stones River Group. | | | Black River Group. | | | Trenton Group. | | | | | | | | |
| | | "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Utica group. | Richmond group. | | | | |
| Strophomena winchelli Hall | 394 | | † | † | | | | | | | | | | | | B ?T |
| Strophomena trilobata Owen | 395 | | | | | | | | x | | | | | | | |
| Strophomena fluctuosa Billings | 395 | | | | | | | | | | ? | x | | | | T H |
| Strophomena billingsi, n. sp | 397 | | | | | | | x | | | | | | | | T |
| Strophomena scofieldi W. & S. | 398 | | | | | | | x | | | | | | | | |
| Strophomena emaciata W. & S. | 399 | | | | | | | x | | | | | | | | |
| Rafinesquina minnesotensis N. H. Winch. | 401 | x | x | | | | | | | | | | S | S | | B |
| Rafinesquina " var. inquassa Sardeson. | 403 | | | | x | | x | | | | | | | | | |
| Rafinesquina deltoidea Conrad | 403 | | | | | | ? | | x | | | | | | T | T |
| Rafinesquina alternata Conrad | 405 | | | | | | x | x | x | | | † | BTULR | T H | T H | Ch to H |
| Rafinesquina " var. loxorhytis ? Meek. | 407 | | | | | | | | | | | x | L R | | | |
| Triplecia ulrichi, n. sp | 409 | | | | | | | | | | x | | | | | |
| Leptæna charlottæ W. & S. | 410 | | | | x | x | | | | | | | | | | |
| Leptæna unicostata M. & W. | 411 | | | | | | | | | | ? | x | | | | |
| Plectambonites sericea Sowerby | 414 | x | | x | x | x | x | x | x | | x | x | S to R | S to H | T U H | B to H |
| Plectambonites præcosis Sardeson sp. | | | | | | | | | | | x | | | | | |
| Plectambonites gibbosa W. & S. | 416 | | | | | | | | x | | | | | | | |
| Orthis tricenaria Conrad | 418 | x | x | x | x | x | x | x | x | | | | S B T | S B | T | B T |
| O. (Dinorthis) deflecta Conrad | 422 | x | x | | | | | | | | | | S | S | T | B T |
| O. (Dinorthis) pectinella Emmons | 424 | | | | | | f | | | | | | B T | | T | B T |
| O. (Dinorthis) " var. sweeneyi N. H. W. | 426 | | | | | | f | | | | | | | | | |
| O. (Dinorthis) meedsi W. & S. | 427 | | | | | | | x | | | | | | | | |
| O. (Dinorthis) " var. germana W. & S. | 428 | | | | | | | | n | | | | | | | |
| O. (Dinorthis) subquadrata Hall | 428 | | | | | | | | | | | x | T R | | | T H |
| O. (Dinorthis) proavita W. & S. | 431 | | | | | | | | | | | x | | | | |
| O. (Hebertella) borealis Billings | 433 | | | | | | | | x | | | | T | T | | Ch T |
| O. (Hebertella) bellarugosa Conrad | 434 | x | x | | x | | x | | x | | | | B | S B | | B T |
| O. (Hebertella) insculpta Hall | 435 | | | | | | | | | | | x | R | | | |
| O. (Plectorthis) plicatella Hall | 436 | | | | | | | x | x | | | | T L | | T | B T |
| O. (Plectorthis) whitfieldi N. H. Winch. | 437 | | | | | | | | | | | x | | | | |
| O. (Dalmanella) hamburgensis ? Walcott | 440 | | | | | | x | | | | | | | | | |
| O. (Dalmanella) testudinaria Dalman | 441 | | | | | | x | x | x | | x | x | B B R | T H | B to H | B to H |
| O. (Dalmanella) tersa Sardeson | | | | | | | | | | | | x | | | | |
| O. (Dalmanella) subæquata Conrad | 446 | x | x | x | | | | | | | | | S | S | | B T |
| O. (Dalmanella) " var. conradi N. H. W. | 449 | x | x | | | | | | | | | | | | | |
| O. (Dalmanella) " var. perveta Conrad. | 450 | | x | x | x | | | | | | | | S | S | | B |
| O. (Dalmanella) " var. gibbosa Billings. | 451 | | | x | | | | | | | | | | | | B T |
| O. (Dalmanella) " var. circularis N.H.W. | 452 | | | | | | x | | | | | | B | | | |
| Platystrophia biforata Schlotheim | 455 | | | | | | | x | x | | | x | T to R | T H | T H | Ch to H |
| Platystrophia crassa James | 458 | | | | | | | | | | | x | L R | | | |
| Rhynchotrema minnesotensis Sardeson | | x | x | x | x | | | | | | | | | | | |
| Rhynchotrema ainsliei N. H. Winchell | 459 | | | x | x | | | | | | | | | | | |
| Rhynchotrema inæquivalvis Castelnau | 459 | | | | | | x | x | x | | | | | T | T | B T |
| Rhynchotrema " var. laticostata W. & S. | 461 | | | | | | | x | | | | | T | | T | |
| Rhynchotrema capax Conrad | 463 | | | | | | | | ? | | | x | R | | | H |
| Rhynchonella (?) anticostiensis Billings. | 464 | | | | | | | | | | | † | | | | H |
| Rhynchonella (?) neenah Whitfield | 465 | | | | | | | | | | | † | | | | |
| Zygospira recurvirostra Hall | 466 | | x | x | x | x | x | x | x | | | | S B T | S T | T | B T |
| Zygospira modesta Say | 467 | | | | | | | | | | x | x | U L R | H | U H | U H |
| Zygospira uphami W. & S. | 468 | | | | | | | | x | | | | | | | |
| Zygospira (Hallina) nicolleti W. & S. | 469 | x | x | | | | | | | | | | | | | |
| Cyclospira bisulcata Emmons | 470 | | | | | | | | x | | | | | | T | T |
| LAMELLIBRANCHIATA. | | | | | | | | | | | | | | | | |
| Ambonychia planistriata Hall | 491 | x | ? | | | | | | | | | | | | | |
| Ambonychia bellistriata Hall | 492 | | | | | | | | x | | | | | | T | T |
| Ambonychia affinis, n. sp | 492 | | | | | | | | x | | | | | | | |
| Ambonychia amygdalina Hall | 493 | | | | | | | | x | | | | | | T | T |
| Clionychia lamellosa Hall | 494 | | x | | | | | | | | | | | S | | |
| Clionychia nitida, n. sp | 495 | x | | | | | | | | | | | | S | | |
| Clionychia erecta Hall | 496 | | x | | | | | | | | | | | | | |
| Clionychia rhomboidea Ulrich | 496 | x | | | | | | | | | | | | | | |
| Clionychia undata Emmons | 497 | | | | | | | | x | | | | | | T | T |
| Byssonychia intermedia M. & W. | 499 | | | | | | | | x | ? | | | | | T |

| LAMELLIBRANCHIATA. | Page. | Trenton Period. | | | | | | | | | Hudson or Cincinnati Period. | | Cincinnati region. | Tennessee. | New York. | Canada. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stones River Group. | | | Black River Group. | | | Trenton Group. | | | | | | | | |
| | | "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Utica group. | Richmond group. | | | | |
| Byssonychia tenuistriata, n. sp. | 500 | | | | | | | | | | | x | R | | | |
| Modiolpsis similis Ulrich | 504 | | | | | x | | | | | | | | | | |
| Mediolopsis oweni, n. sp. | 506 | | | | | | | | x | | | | | | | |
| Modiolopsis arguta, n. sp. | 506 | | | | x | x | | | | | | | | | | |
| Modiolopsis nana, n. sp. | 507 | | | | | | | x | | | | | | | | |
| Modiolopsis mytiloides Hall | 508 | | | | | | | | x | | | | | | T | B T |
| Modiolopsis chatfieldensis, n. sp. | 508 | | | | | x | | | | | | | | | | |
| Modiolopsis obsoleta, n. sp. | 509 | | | | | x | | | | | | | | | | |
| Modiolopsis concava Ulrich | 509 | | | | | x | | | | | | | | | | |
| Modiolopsis concentrica H. & W. | 510 | | | | | | | | | | | ? | R | | | |
| Modiolopsis excellens, n. sp. | 511 | | | | | | | | | | | x | | | | |
| Eurymya plana Hall. | 512 | | x | | | | | | | | | | | | | |
| Whiteavesia modioliformis M. & W. | 515 | † | † | | | | | | | | | | | | | |
| Whiteavesia subcarinata, n. sp. | 516 | | | | | | | | x | | | | | | | |
| Orthodesma minnesotense Ulrich | 517 | | | | x | x | | | | | | | | | | |
| Orthodesma schucherti, n. sp. | 518 | | | | | | | | x | | | | | | | |
| Orthodesma subnasutum M. & W. | 518 | | | | | | | | ? | † | | | | | | |
| Orthodesma canaliculatum, n. sp. | 520 | | | | | | | | | | | x | R | | | |
| Modiolodon patulus, n. sp. | 521 | | | | | | | | x | | | | T | | | |
| Modiolodon patulus, var. undescribed | | | | | | | x | | | | | | | | | |
| Modiolodon (?) gibbus, n. sp. | 522 | | | | | | x | | | | | | | | | |
| Colpomya demissa, n. sp. | 524 | | | | | x | | | | | | | | | | |
| Aristerella nitidula, n. sp. | 524 | | | | | x | | | | | | | | | | |
| Endodesma cuneatum, n. sp. | 526 | | | | | | | | x | | | | | | | |
| Endodesma postlatum, n. sp. | 527 | | | | | | | | x | | | | | | | |
| Endodesma orthonotum M. & W. | 527 | | † | † | | | | | | | | | | | | |
| Endodesma undosum, n. sp. | 529 | | | | | † | | | | | | | | | | |
| Endodesma compressum, n. sp. | 529 | | | | | | | | x | | | | | | | |
| Psiloconcha minnesotensis, n. sp. | 531 | | | | | | | | x | | | | | | | |
| Prolobella striatula, n. sp. | 532 | | | | | | | | x | | | | | | | |
| Cyrtodonta huronensis Billings (=*C. subovata* Ulrich.) | 536 | x | x | | x | x | | | | | | | S B T | | | B T |
| Cyrtodonta janesvillensis, n. sp. | 537 | | † | | | | | | | | | | | | | |
| Cyrtodonta ampla, n. sp. | 538 | x | | | | | | | | | | | | | | |
| Cyrtodonta billingsi, n. sp. | 538 | x | † | | | | | | | | | | S | | | |
| Cyrtodonta obliqua M. & W. | 540 | | | | | | | | † | | | | | | | |
| Cyrtodonta affinis, n. sp. | 540 | | | | | x | | | | | | | | | | |
| Cyrtodonta affinis var. fillmorensis, n. var. | 540 | | | | | | | | x | | | | | | | |
| Cyrtodonta parva, n. sp. | 541 | | | | | | | | x | | | | | | | |
| Cyrtodonta rotulata, n. sp. | 541 | | | | ? | x | | | | | | | B | | | |
| Cyrtodonta obesa, n. sp. | 542 | | | | ? | ? | | | | | | | B | | | |
| Cyrtodonta gibbera, n. sp. | 542 | | | | | | | | x | | | | | | | |
| Cyrtodonta glabella Ulrich | 543 | | x | x | x | x | | | | | | | | | | |
| Cyrtodonta persimilis, n. sp. | 544 | x | x | | | | | | | | | | | | | |
| Cyrtodonta oviformis Ulrich | 544 | | † | | | | | | | | | | | | | |
| Cyrtodonta cingulata Ulrich | 545 | | | | x | x | | | | | | | | | | |
| Cyrtodonta tenells Ulrich | 546 | | | | | x | | | | | | | | | | |
| Cyrtodonta grandis Ulrich | 547 | | | | | | | x | x | | | | T | | | |
| Cyrtodonta grandis var. germana Ulrich. | 547 | | | | | | | x | x | | | | T | | | |
| Cyrtodonta grandis var. luculenta Sard. | 547 | | | | | | | | | | ? | x | | | | |
| Vanuxemia dixonensis M. & W. | 550 | | x | | | | | | | | | | | | | |
| Vanuxemia dixonensis var. insueta, n. var | 551 | | x | | | | | | | | | | | | | |
| Vanuxemia rotundata Hall | 552 | | x | | | | | | | | | | | | | |
| Vanuxemia suberecta, n. sp. | 553 | | | | | † | | | | | | | | | | |
| Vanuxemia rectirostris Hall | | † | † | | | | | | | | | | | | | |
| Vanuxemia media, n. sp. | 553 | x | | | | | | | | | | | | | | |
| Vanuxemia crassa, n. sp. | 553 | | | | ? | x | | | | | | | | | | |
| Vanuxemia obtusifrons Ulrich | 554 | | x | | | | | | | | | | | | | |
| Vanuxemia sardesoni Ulrich | 555 | | x | | | | | | | | | | | | | |
| Vanuxemia umbonata, n. sp. | 556 | | | | | x | | | | | | | B | | | |
| Vanuxemia terminalis Ulrich | 556 | x | | | | | | | | | | | | | | |
| Vanuxemia hayniana Safford | 557 | | | | | | | x | | | | | T | T | | |
| Vanuxemia subrotunda, n. sp. | 559 | | | | | x | | | | | | | | | | |

| LAMELLIBRANCHIATA. | Page. | Trenton Period. Stones River Group. | | | Trenton Period. Black River Group. | | | Trenton Period. Trenton Group. | | | Hudson or Cincinnati Period. | | Cincinnati region. | Tennessee. | New York. | Canada. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Utica group. | Richmond group. | | | | |
| Vanuxemia abrupta, n. sp. | 560 | | | | | | | | x | | | | | | | |
| Vanuxemia niota Hall | 560 | | † | | | † | | | | | | | | | | |
| Vanuxemia wortheni, n. sp | 561 | | | | | | | | † | ? | | | | | | |
| Vanuxemia decipiens, n. sp | 562 | x | ? | | | | | | | | | | | | | |
| Matheria rugosa Ulrich | 563 | | | | | x | | | | | | | | | | |
| Whitella obliquata Ulrich | 565 | | | | | | | | | | | x | R | | | |
| Whitella quadrangularis Whitfield | 566 | | | | | | | | | | | x | R | | | |
| Whitella sterlingensis M. & W. | 567 | | | | | | | | | | | x | ? R | | | |
| Whitella compressa Ulrich | 568 | | | | x | x | | | | | | | | | | |
| Whitella concentrica Ulrich | 569 | | | | x | x | | | | | | | | | | |
| Whitella rugatina, n. sp | 569 | | | | x | x | | | | | | | | | | |
| Whitella megambona Whitfield | 570 | x | | | | | | | | | | | | | | |
| Whitella scofieldi Ulrich | 571 | | | | | x | | | | | | | | | | |
| Whitella truncata Ulrich | 572 | | | | | | | | x | | | | | | | |
| Whitella subcarinata, n. sp | 572 | | | | | | | | x | | | | | | | |
| Whitella ventricosa Hall | 573 | | | | | | | | ? | | | | | | T | T |
| Whitella præcipta Ulrich | 574 | | | | | | | x | x | | | | | | | |
| Plethocardia umbonata Ulrich | 576 | | | | | x | | | | | | | B | | | |
| Plethocardia suberecta Ulrich | 577 | | | | | | | x | | | | | | | | |
| Ctenodonta nasuta Hall | 584 | | x | † | | x | | | | | | | | S B | T | B T |
| Ctenodonta nasuta var. robusta, n var. | 585 | | † | | | ? | | | | | | | | | | B |
| Ctenodonta subnasuta, n. sp | 585 | | | | | | | x | | | | | | | | T |
| Ctenodonta oviformis, n. sp | 586 | | | | | | | x | | | | | | | | |
| Ctenodonta cuneiformis, n. sp | 587 | | | | | x | | | | | | | | | | |
| Ctenodonta gibberula, Salter | 587 | | x | | | † | | | | | | | | S | | B |
| Ctenodonta carinata, n. sp | 589 | | | | | | | | x | | | | | | | |
| Ctenodonta planodorsata Ulrich | 589 | | | | | x | | | | | | | | | | |
| Ctenodonta longa, n. sp | 590 | | | | | x | | | | | | | | | | |
| Ctenodonta logani Salter | 591 | | | | | † | | | | | | | | | | |
| Ctenodonta nitida Ulrich | 592 | | | | x | x | | | | | | | | | | |
| Ctenodonta medialis, n. sp | 593 | | | | | x | | ? | | | | | | | | |
| Ctenodonta scofieldi, n. sp | 593 | | | | | x | | ? | | | | | | | | |
| Ctenodonta socialis, n. sp | 594 | | | | | x | | | | | | | S T | | | |
| Ctenodonta fecunda Hall | 595 | | | | | | | | | | x | | | | | |
| Ctenodonta calvini, n. sp | 596 | | | | | | | | | | † | | | | | |
| Ctenodonta albertina, n. sp | 598 | | | | | | | | | | | ? | R | | | |
| Ctenodonta filistriata, n. sp | 599 | | | | | | | | | | x | | U | | | |
| Ctenodonta simulatrix, n. sp | 600 | | | | | | | | | | | x | | | | |
| Ctenodonta compressa Ulrich | 600 | | ? | | | x | | | | | | | | | | |
| Ctenodonta astartiformis Salter | 601 | | | | | | x | | | | | | B | B | | B |
| Ctenodonta intermedia Ulrich | 601 | | | | | | | | x | | | | | | | |
| Ctenodonta alta Hall | 602 | | | | | | | | x | | | | | | | |
| Ctenodonta recurva Ulrich | 603 | | | | | | | | | | | x | R | | | |
| Ctenodonta similis Ulrich | 604 | | | | | | | | | | | x | R | | | |
| Ctenodonta obliqua Hall | 604 | | | | | | | | | | † | | U L R | | | |
| Ctenodonta hamburgensis Walcott | 605 | | | | | x | | | | | | | | | | |
| Clidophorus consuetus Ulrich | 606 | | | | | | | | x | | | | | | | |
| Clidophorus neglectus Hall | 607 | | | | | | | | | | † | | ? U | | | |
| Lyrodesma acuminatum, n. sp | 609 | | | | | x | | | | | | | | | | |
| Lyrodesma cannonense, n. sp | 610 | | | | | | | x | | | | | | | | |
| Lyrodesma major Ulrich | 611 | | | | | | | | | | | x | L R | | | |
| Technophorus subacutus Ulrich | 614 | ? | | x | | | | | | | | | | | | |
| Technophorus extenuatus Ulrich | 614 | | | | x | x | | | | | | | | | | |
| Technophorus filistriatus Ulrich | 615 | | | | | x | | | | | | | | | | |
| Technophorus divaricatus Ulrich | 616 | | | | | | x | | | | | | | | | |
| Allodesma subellipticum Ulrich | 617 | | | | | | | x | | | | | | | | |
| Rhytimya sinuata, n. sp | 619 | | | | | | | | x | | | | | | | |
| Cuneamya truncatula, n. sp | 622 | | | | | | | | x | | | | | | | |
| Cuneamya oblonga, n. sp | 623 | | | | | | | | | † | | | | | | |
| Sphenolium parallelum, n. sp | 624 | | † | † | | | | | | | | | | | | |
| Sphenolium striatum, n. sp | 624 | | | | | | | | x | | | | | | | |
| Saffordia ventralis, n. sp | 626 | | | | | | | | | | | x | | | | |
| Saffordia sulcodorsata Ulrich | 626 | | | | | | | | | | | x | | | | |
| Saffordia modesta Ulrich | 627 | | | | | | | ? | x | | | | | | | |

| GASTROPODA. | Page. | Trenton Period. Stones River Group. "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Black River Group. Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Trenton Group. Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Hudson or Cincinnati Period. Utica group. | Richmond group. | Cincinnati region. | Tennessee. | New York. | Canada. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GASTROPODA. | | | | | | | | | | | | | | | | |
| Tryblidium modestum, n. sp. | 826 | | | | | x | | | | | | | | | | |
| Helcionopsis subcarinata, n. sp. | 827 | | | | | | | x | | | | | | | | |
| Archinacella powersi, n. sp. | 829 | | x | | | | | | | | | | | | | |
| Archinacella depressa, n. sp. | 830 | | x | | | | | | | | | | | | | |
| Archinacella perovalis Whitfield | 830 | | x | | | | | | | | | | | | | |
| Archinacella deleta Sardeson | 831 | | | | x | x | | | | | | | | | | |
| Archinacella valida Sardeson | 832 | | | | | | | x | | | | | | | | |
| Archinacella semicarinata, n. sp. | 833 | | | | | | | x | x | | | | | | | |
| Archinacella simulatrix, n. sp. | 833 | | | | | | x | | | | | | T | | | |
| Archinacella subrotunda, n. sp. | 834 | | | | | x | | | | | | | | | | |
| Archinacella instabilis var. incurva, n. var | 835 | | | | | x | | | | | | | | | | |
| Archinacella rotunda, n. sp. | 835 | | | | | | | | | | x | | | | | |
| Palæacmæa humilis, n. sp. | 837 | | x | | | x | | | | | | | | | | |
| Scenella superba Billings | 838 | ? | x | | | | | | | | | | | | | B |
| Scenella magnifica, n. sp. | 839 | ? | x | | | | | | | | | | | | | |
| Scenella beloitensis, n. sp. | 839 | | x | | | | | | | | | | | | | |
| Scenella compressa, n. sp. | 840 | | x | | | | | | | | | | | | | |
| Scenella affinis, n. sp. | 840 | | | | | x | | x | x | | | | | | | |
| Scenella obtusa Sardeson | 841 | | | | x | | | | | | | | | | | |
| Scenella radialis, n. sp. | 841 | | | | | | | x | | | | | | | | |
| Stenotheca exserta Sardeson | 842 | | x | | | | | | | | | | | | | |
| Cyrtolites ornatus var. minor, n. var. | 860 | | | | | | | x | | | | | | | | |
| Cyrtolites retrorsus var. fillmorensis, n. var | 862 | | | | | x | | | | | | | | | | |
| Cyrtolites carinatus S. A. Miller | 862 | | | | | | | | | | ? | | U | | | |
| Cyrtolites disjunctus, n. sp. | 864 | | | | | | | | | | | x | | | | |
| Cyrtolites dilatatus, n. sp. | 865 | | | | | x | | | | | | | | | | |
| Protowarthia rectangularis, n. sp. | 868 | | x | | | | | | | | | | | | | |
| Protowarthia pervoluta, n. sp. | 871 | | | | x | x | | | | | | | B T | | | |
| Protowarthia cancellata Hall | 872 | | | | x | x | x | x | x | | x | x | B T U L R | T | U L | T U L |
| Protowarthia concinna, n. sp. | 874 | | | | | | | | | | | x | | | | |
| Tetranota bidorsata Hall | 877 | | | | | | | x | ? | | | | B T | S B T | T | B T |
| Tetranota bidorsata var. minor, n. var. | 878 | | | | | x | | | | | | | | | | |
| Tetranota sexcarinata, n. sp. | 878 | | x | | | | | | x | | | | | S | | |
| Tetranota macra, n. sp. | 879 | | x | | | | | | | | | | | | | |
| Tetranota obsoleta, n. sp. | 880 | | x | | | x | | | x | | | | B U | | | |
| Tetranota wisconsinensis Whitfield | 881 | | x | | | | | | | | | | | | | |
| Kokenia costalis, n. sp. | 882 | | | | | | | x | | | | | | | | |
| Bucania halli, n. sp. | 886 | | x | | | | | | | | | | B | | | |
| Bucania minnesotensis, n. sp. | 887 | | x | | | | | | | | | | | | | |
| Bucania emmonsi, n. sp. | 887 | | x | | ? | x | | | | | | | | S | | |
| Bucania elliptica, n. sp. | 888 | | | | | | | | x | | | | B T | | | |
| Bucania sublata, n. sp. | 888 | | x | | | x | | | x | | | | T | | | |
| Bucania lindsleyi Safford | 889 | | | | | | | ? | | | | | | T | | |
| Bucania, sp. undescribed | | | | | | | | | x | | | | T | | | |
| Salpingostoma buelli Whitfield | 900 | | x | | | | | | | | | | S B (var) | | | |
| Salpingostoma sculptilis, n. sp. | 902 | | | | | | | | x | | | | | | | |
| Salpingostoma imbricata, n. sp. | 902 | | | | | | | | | | | x | | | | |
| Conradella fimbriata, n. sp. | 907 | | x | ? | | | | | | | | | | | | |
| Conradella triangularis, n. sp. | 908 | | x | | | | | | | | | | | S | | |
| Conradella obliqua, n. sp. | 906 | | | | x | x | | | | | | | | | | |
| Conradella dyeri Hall | 909 | | | | | | | | | | | x | R | | | |
| Conradella dyeri, var. cellulosa, n. var. | 910 | | | | | | | x | | | | | | | | |
| Oxydiscus subacutus, n. sp. | 913 | | | | | | | | ? | | | | T | | | |
| Bellerophon troosti Safford | 915 | | | | | | | | ? | | | | T | T | | |
| Bellerophon platystoma M. & W. | 918 | | | | | | | x | x | | | | | | | |
| Bellerophon similis, n. sp. | 919 | | | | | | | x | x | | | | | | | |
| Carinaropsis acuta, n. sp. | 928 | | | | x | x | | | | | | | | | | |
| Carinaropsis minima, n. sp. | 929 | | | | | x | | | | | | | | | | |
| Carinaropsis phalera Sardeson | 928 | | | | x | x | | | | | | | | | | |
| Pterotheca attenuata Hall | | | x | | | x | | | | | | | S B | S B | | |

PLEASE insert the following corrections on pages cxix and cxx of part 2 of volume 3 of the FINAL REPORT of the *Geological and Natural History Survey of Minnesota.*

## Page cxix.

For Lophospira parangulata var. acuminata n. var. read Lophospira *acuminata*, n. sp., p. 993.

For Lophospira (?) major read Hormotoma (?) major Hall, p. 1018.

After Liospira abrupta insert Liospira modesta, n. sp. Ctenodonta bed.

After Hormotoma gracilis insert Hormotoma gracilis var. goodhuensis, n. var. p. 1015. Ctenodonta bed.

After Cœlocaulus œhlerti insert Cœlocaulus neglectus n. sp., p. 1020, Clitambonites bed.

After Ophiletina sublaxa insert var. sequens, n. var., p. 1031. Fusispira bed.

## Page cxx.

Add Maclurina subrotunda Whitfield, p. 1043. Maclurea bed.

For Trochonema varians read Trochonema vagrans, n. sp. p. 1049.

Insert (Eunema) between generic and specific names of Trochonema salteri and Trochonema robbinsi.

For Trochonema sp. read Trochonema (Eunema) simile n. sp., p. 1053.

" Trochonema liratum read Gyronema liratum n. sp.

" Trochonema pulchellum read Gyronema pulchellum, n. sp.

" Trochonema semicarinatum read Gyronema semicarinatum Salter.

" Trochnema percarinatum Hall read Gyronema duplicatum, n. sp., p. 1055.

" Cyclonema textilis read Strophostylus textilis n. sp., p. 1064.

Holopea pyrene is from the Fusispira bed.

For Holopea subundata read Holopea paludiniformis Hall, p. 1067. Clitambonites bed and in the Trenton of New York.

Subulites conradi occurs also in the Black River group in Canada.

Add Subulites regularis n. sp., p. 1072. Stones River group in Minnesota, Kentucky and Tennessee, and Black River group in Canada.

For Fusispira vittata Hall, read Fusispira angusta, n. sp., p. 1079.

" Fusispira vittata var. vaticina read Fusispira angusta var. subplana, n. var., p. 1079.

| New York. | Canada. |
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Conradella
Conradella
Conradella
Conradella
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Oxydiscus
Bellerópho
Bellerópho
Bellerópho
Carinarops
Carinarops
Carinarops
Pterotheca

| GASTROPODA. | Page. | Trenton Period. Stones River Group. "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Black River Group. Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Trenton Group. Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Hudson or Cincinnati Period. Utica group. | Richmond group. | Cincinnati region. | Tennessee. | New York. | Canada. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pterotheca, sp. undetermined | | | | | | | | | x | | | | | | | |
| Pterotheca. sp. undescribed | | | x | | | | | | | | | | | | | |
| Hyolithes baconi Whitfield | | x | x | | | | | | | | | | S | | | |
| Hyolithes, sp. undescribed | | | | | | | x | | | | | | | | | |
| Hyolithes, sp. undescribed | | | | | | | x | | | | | | | | | |
| Conularia quadrata Walcott | | | x | | x | x | | | | | | | S | | T | |
| Conularia, sp. undescribed | | | | | | | | | x | | | | T | | | |
| Conularia trentonensis Hall | | | | | | | | | | | x | | T U | | TU | T U |
| Raphistoma peracutum, n. sp | 940 | | | | | x | | ? | | | | | | | | |
| Raphistomina rugata, n. sp | 944 | | | | | | | x | | | | | | | | |
| Omospira alexandra Billings | 946 | | | | | † | | | | | | | B T | | | B T |
| Lophospira bicincta Hall | 964 | | x | x | | x | | | x | | | | S B | S | T | B T |
| Lophospira obliqua, n. sp | 965 | | | | | | | x | x | | | x | S B T | | | |
| Lophospira concinnula, n. sp | 966 | | | | x | x | | | | | | | S T | | | |
| Lophospira fillmorensis, n. sp | 967 | | | | | | | | x | | | | | | | |
| Lophospira conradana, n. sp | 979 | | x | | | | | | | | | | | | | |
| Lophospira helicteres var. wisconsinensis, n. var | 971 | | x | | | | | | | | | | | | | |
| Lophospira quadrisulcata, n. sp | 967 | | | | | | | | | | | x | | | | |
| Lophospira spironema, n. sp | 983 | | | | | x | | | | | | | | | | |
| Lophospira serrulata Salter | 968 | | x | | | | | | | | | | | B | | B |
| Lophospira perangulata Hall | 972 | | x | | | | | | | | | | S | S | S | B |
| Lophospira perangulata var. acuminata. n. var | | | | | | | | | | | | x | R | | | |
| Lophospira elevata, n. sp | 977 | | | | | | | | x | | | | T | T | | |
| Lophospira peracuta, n. sp | 976 | | | | x | x | | | | | | | | S | | |
| Lophospira medialis, n. sp | 973 | | | | | | | x | x | | | | T | T | | |
| Lophospira perforata, n. sp | 984 | | | | | | | | x | ?x | | | | | | |
| Lophospira oweni, n. sp | 980 | | | | x | x | | | | | | | B U | | | |
| Lophospira pulchella, n. sp | 982 | | | | | x | | | | | | x | T L | | | |
| Lophospira sumnerensis Safford | 978 | | | | | | | | x | | | | T | T | | |
| Lophospira augustina Billings | 987 | | | | | | | | | x | | | | | | Quebec |
| Lophospira augustina var. minnesotensis, n. var | 988 | | | | | | | | | x | | | | | | |
| Lophospira (?) major Hall | | | | | | | | | ? | x | | | | | | |
| Liospira micula Hall | 994 | | | | | | | | | | x | x | T U L R | | | |
| Liospira abrupta, n. sp | 995 | | ? | | | ? | | | | | | | S T | S | | |
| Liospira americana Billings | 996 | | ? | | | | | x | x | | | | S T | S B T | T | B T |
| Liospira vitruvia Billings | 995 | | x | | | | | x | x | | | | | S | T | B T |
| Liospira progne Billings | 996 | | | | | | | | x | | | | B T | S T | | B T |
| Liospira angustata, n. sp | 997 | | x | | | | | | x | | | | | | | |
| Eotomaria dryope Billings | 1003 | | x | | | | | | | | | | | B | | B |
| Eotomaria vicina, n. sp | 1003 | | x | | | | | | | | | | | | | |
| Eotomaria supracingulata Billings | 1004 | | x | | | x | | | | | | | | | | B ? T |
| Clathrospira subconica Hall | 1006 | x | x | | ? | ? | | | | | | | S T L R | S B T | T | B T H |
| Clathrospira conica, n. sp | 1008 | | | | x | x | | x | x | | | | B T L | | | |
| Clathrospira convexa, n. sp | 1007 | | x | | | | | | | | | | | | | |
| Plethospira semele Hall | 1010 | | | | | | | | | | x | | | | | |
| Hormotoma gracilis Hall | 1014 | | | | | | x | | | | x | x | T | | T H | T H |
| Hormotoma gracilis var. angustata Hall | 1015 | | x | | | | | | | | | | S U | S | S | B |
| Hormotoma gracilis var. multivolvis, n. var | 1015 | | | | | | | | | | | x | | | | |
| Hormotoma subangulata, n. sp | 1016 | | | | x | x | | | | | | | | | | |
| Hormotoma salteri, n. sp | 1016 | | | | | | | | x | | | | T | T | | B |
| Hormotoma conferta, n. sp | | | | | | | | | x | | | | | | | |
| Hormotoma bellicincta Hall | 1017 | | | | | | | | x | | | | T | | T | T |
| Cœlocaulus œhlerti, n. sp | 1020 | | | | | | | | ? | x | | | | | | |
| Solenospira prisca (?) Billings | 1022 | | x | | | | | | | | | | S | S | | Cal. |
| Solenospira pagoda Salter | 1022 | | | | | | x | | | | | | | | | B |
| Ophiletina sublaxa, n. sp | 1030 | | x | ?x | | | | | | | | | | S | | |
| Ophiletina angularis, n. sp | 1031 | | | | | | x | | | | | | | | | |
| Eccyliopterus owenanus M. & W. | 1032 | | | | | | | | x | | | | | | | |
| Eccyliopterus beloitensis, n. sp | 1032 | | x | | | | | | | | | | | | | |
| Helicotoma planulata var. robusta, n. var | 1033 | | x | | | | | | | | | | | | | |

| | | Trenton Period. | | | | | | | | | Hudson or Cincinnati Period. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stones River Group. | | | Black River Group. | | | Trenton Group. | | | | | | | | |
| GASTROPODA. | Page. | "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Utica group. | Richmond group. | Cincinnati region. | Tennessee. | New York. | Canada. |
| Helicotoma umbilicata, n. sp. | 1034 | | x | | | | | | | | | | | | | |
| Eccyliomphalus undulatus Hall | 1036 | | x | | | | | | | | | | | S | | |
| Eccyliomphalus subrotundus, n. sp. | 1037 | | | | | | | | x | | | | | | | |
| Maclurea bigsbyi Hall | 1039 | | x | | | | | | | | | | ? S | S | | |
| Maclurea nitida, n. sp. | 1040 | | x | ? | | | | | | | | | | | | |
| Maclurea depressa, n. sp. | 1040 | | x | | | | | | | | | | ? S | | | |
| Maclurea patula, n. sp. | | | | | | | | | | x | | | | | | |
| Maclurea patula var. macra, n. var. | | | | | | | | | x | | | | | | | |
| Maclurina cuneata Whitfield | 1041 | | | | | | | | | x | | | | | | |
| Maclurina manitobensis Whiteaves | 1041 | | | | | | | | | x | | | | | | |
| Trochonema umbilicatum Hall | 1047 | | x | | | | | x | x | x | | | S T ? L | S B | S B T H | B T U H |
| Trochonema beachi Whitfield | 1048 | | x | x | | | | | | | | | B | | | |
| Trochonema beloitense Whitfield | 1048 | | x | | | | | | | | | | | | | |
| Trochonema rugosum, n. sp. | | | x | | | | | | | | | | | | | |
| Trochonema fragile, n. sp. | 1050 | | | | | | | x | x | | | | | | | |
| Trochonema subcrassum, n. sp. | 1051 | | | | | | | | x | | | | T | | | |
| Trochonema varians, n. sp. | | | x | | | | | | | | | | | | | |
| Trochonema retrorsum, n. sp. | 1051 | | | | | x | | | | | | | | | | |
| Trochonema altum, n. sp. | 1052 | | | | | | | | x | | | | | | | |
| Trochonema salteri, n. sp. | 1053 | | | | | | | x | x | | | | | | | |
| Trochonema sp. | | | | | | x | | | x | | | | | | | |
| Trochonema robbinsi, n. sp. | 1053 | | | | | | | | x | | | | | | | |
| Trochonema niota Hall | 1052 | | ? | | | † | | | | | | | | | | |
| Trochonema liratum, n. sp. | 1056 | | x | | | | | | | | | | | | | |
| Trochonema pulchellum, n. sp. | 1054 | | | | x | x | | | | | | | B | | | |
| Trochonema semicarinatum Salter | 1055 | | | | | | x | | | | | | | | | B |
| Trochonema percarinatum Hall | | | x | | | | | ? | | | | | | | T | |
| Cyclonema textilis, n. sp. | | | | | | x | | x | | | | | T | | | |
| Cyclonema varicosum Hall | 1060 | | | | | | | | x | | | | T L | T | | |
| Holopea insignis, n. sp. | 1065 | | x | | | | | | | | | | | | | |
| Holopea concinnula, n. sp. | 1066 | | x | | | | | | | | | | | | | |
| Holopea appressa, n. sp. | 1065 | | | | | | | x | | | | | T | | | |
| Holopea excelsa, n. sp. | 1066 | | | | | | | | x | | | | | | | |
| Holopea pyrene Billings | 1067 | | | | | | | x | | | | | | | | B |
| Holopea subundata, n. sp. | | | | | | | | | x | | | | ? T | | | |
| Holopea rotunda, n. sp. | 1066 | | x | | | | | | | | | | | T | | |
| Holopea ampla, n. sp. | 1065 | | x | | | | | | | | | | | | | |
| Holopea similis, n. sp. | 1066 | | | | | x | | | x | | | | L | | | |
| Holopea supraplana, n. sp. | 1068 | | | | | | | | x | | | | | | | |
| Platyceras (?) wisconsinensis, n. sp. | 1068 | | x | | | | | | | | | | | | | |
| Platyceras (?) depressum, n. sp. | 1069 | | | | | x | | | | | | | | | | |
| Subulites conradi, n. sp. | 1071 | | x | | | | | | | | | | | | | |
| Subulites dixonensis, n. sp. | 1071 | | x | ? | | | | | | | | | | | | |
| Subulites regularis, n. sp. | 1072 | | x | | | | | | | | | | S | | | |
| Subulites beloitensis, n. sp. | 1072 | | † | | | | | | | | | | | | | |
| Subulites spicula, n. sp. | 1073 | | x | | x | x | | | | | | | S | | | |
| Subulites pergracilis, n. sp. | 1072 | | | | | | | | x | | | | | | | |
| Cyrtospira wykoffensis, n. sp. | 1074 | | | | | | | | x | | | | | | | |
| Fusispira schucherti, n. sp. | 1076 | | | | | † | | | | | | | | | | |
| Fusispira nobilis, n. sp. | 1078 | | | | | | | | x | | | | | | | |
| Fusispira convexa, n. sp. | 1077 | | | | | | | x | ? | | | | | | T | |
| Fusispira subbrevis, n. sp. | 1076 | | | | | | | | x | x | | | | | | |
| Fusispira inflata M. & W. | 1075 | | | | | | | | x | ? | | | | | | |
| Fusispira inflata var. ventricosa Hall | 1075 | | | | | | | | x | x | | | | | | |
| Fusispira intermedia, n. sp. | 1076 | | | | | | | | | x | | | | | | |
| Fusispira subfusiformis Hall | 1077 | | | | | | | | x | | | | T | | T | T |
| Fusispira planulata, n. sp. | 1078 | | | | | | | | x | | | | | | | |
| Fusispira vittata Hall | | | | | | | | x | x | | | | T | | T | |
| Fusispira vittata var. vaticina, n. var. | | | | | | | | x | x | | | | | | | |
| Fusispira elongata (?) Hall | | | | | | | | | x | | | | | | | T |
| Meekospira subconica, n. sp. | 1080 | | | | | | | | | | | x | | | | |

| CEPHALOPODA AND OSTRACODA. | Page. | Trenton Period. Stones River Group. "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Black River Group. Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Trenton Group. Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Hudson or Cincinnati Period. Utica group. | Richmond group. | Cincinnati region. | Tennessee. | New York. | Canada. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CEPHALOPODA. | | | | | | | | | | | | | | | | |
| Nanno aulema, n. sp | 770 | | | | | x | ? | | | | | | | | | |
| Cyrtocerina (?) schoolcrafti, n. sp | 774 | | | | | | x | | | | | | | | | |
| Cameroceras proteiforme Hall | 777 | x | x | | | | | | x | | | | S B T U L | S | T | B T |
| Cameroceras hennepini, n. sp | 779 | | | | | | | | x | | | | | | | |
| Cameroceras, sp | 780 | x | x | | | | | | | | | | | | | |
| Cameroceras, sp. nov | 780 | x | x | | | | | | | | | | | | | |
| Actinoceras bigsbyi Stokes | 781 | | x | | | x | | ? | x | | | | S B | S B T | | T |
| Actinoceras beloitense Whitfield | 782 | | ?† | | | ?† | | | | | | | | | | |
| Actinoceras remotiseptum Hall | 782 | x | ? | | | | | | | | | | | | T | |
| Orthoceras nicolleti, n. sp | 784 | x | ? | | | | | | | | | | | | | |
| Orthoceras anellus Conrad | 784 | | | | | x | | | | | | | B | | T | B T |
| Orthoceras perroti, n. sp | 785 | | | | | | | | | | | x | ? R | | | |
| Orthoceras lesueuri, n. sp | 785 | | x | | | | | | | | | | S B | | | |
| Orthoceras bilineatum Hall | 786 | | x | | | x | | | | | | | B | T | T | B T |
| Orthoceras olorus Hall | 788 | | x | | | | | | x | | | | S | | T | |
| Orthoceras tenuistriatum Hall | 788 | x | ? | | | | | | | | | | | | | |
| Orthoceras sociale Hall | 789 | | | | | | | | x | | x | x | U ? L | | | |
| Orthoceras beltrami, n. sp | 789 | | | | | | | x | | | | | | | | |
| Orthoceras multicameratum Emmons | 789 | | x | x | x | | | | x | | | | S | | S | |
| Orthoceras junceum Hall | 790 | | x | | | x | ? | x | | | | | S B T | | T | T |
| Orthoceras cf. amplicameratum Hall | 790 | | | | | | | | x | | | | | T | T | B T |
| Triptoceras planoconvexum Hall | 791 | | x | | | | | | x | | | | S B | | | |
| Triptoceras planodorsatum Whitfield | 792 | | x | | | | | | | | | | | | | |
| Triptoceras oweni, n. sp | 792 | | x | | | | | | | | | | B | | | |
| Triptoceras, sp. (?) | 793 | | | | | | | | x | | | | | | | |
| Triptoceras lambi Whiteaves | 793 | | | | | | | | | x | | | | | | |
| Gonioceras anceps Hall | 794 | | x | | | | | | | | | | | S | B | B |
| Gonioceras occidentale Hall | 795 | | † | † | | | | | | | | | | S | | |
| Poterioceras apertum Whiteaves | 796 | | | | | | | | x | | | | | | | T |
| Clinoceras mumiæforme Whitfield | 797 | | x | | | ? | | | | | | | S | | | |
| Oncoceras exiguum Billings | 798 | | | | | | | ? | x | | | | | | | T |
| Oncoceras minnesotense, n. sp | 798 | | | | | | | | x | | | | | | | |
| Oncoceras lycus Hall | 799 | | x | | | | | | | | | | | | | |
| Oncoceras carveri, n. sp | 801 | | x | | | | | | | | | | | | | |
| Oncoceras douglassi, n. sp | 801 | | | | | | | | x | | | | | | | |
| Oncoceras pandion Hall | 802 | | x | | | | | | | | | | | | | |
| Cyrtoceras neleus Hall | 804 | | x | | | | | | | | | | | | | |
| Cyrtoceras bondi (?) Safford | | | x | | | | | | | | | | S B | S | | |
| Cyrtoceras hallianum d'Orbigny | 805 | | | | | x | x | | | | | | | | T | T |
| Cyrtoceras billingsi Salter | 806 | | x | | | | | | | | | | S | | | B |
| Cyrtoceras houghtoni, n. sp | 807 | | x | | | | | | | | | | | | | |
| Cyrtoceras featherstonhaughi, n. sp | 807 | ?x | | | | | | | | | | | | | | |
| Cyrtoceras minneapolis, n. sp | 808 | | x | | | | | | | | | | | | | |
| Cyrtoceras corniculum Hall | 809 | | | | | x | | | | | | | | | | |
| Cyrtoceras norwoodi, n. sp | 809 | | | | | † | | | | | | | | | | |
| Cyrtoceras shumardi, n. sp | 810 | | x | | | | | | | | | | | | | |
| Cyrtoceras scofieldi, n. sp | 810 | | † | | | | | | | | | | | | | |
| Gyroceras duplicostatum Whitfield | 811 | | † | | | | | | | | | | | | | |
| Eurostomites undatus var. occidentalis Hall | 811 | | x | | | | | | | | | | | | B | |
| OSTRACODA. | | | | | | | | | | | | | | | | |
| Leperditia fabulites Conrad | 634 | x | x | † | | | | | | | | | S | S | S | B ? T |
| Leperditella canalis, n. sp | 637 | x | x | | | | | | | | | | | | | |
| Leperditella persimilis, n. sp | 637 | | | | x | | | | | | | | | | | |
| Leperditella macra, n. sp | 638 | | | | x | | | | | | | | | | | |
| Leperditella germana Ulrich | 638 | | † | † | | | | | | | | | | | | |
| Leperditella (?) dorsicornis Ulrich | 639 | | | | | | | | | | | † | | | | |
| Schmidtella crassimarginata Ulrich | 640 | | † | † | | | | | | | | | S | | | |
| Schmidtella affinis, n. sp | 641 | | | | | | | x | n | | | | | | | |
| Schmidtella umbonata, n. sp | 641 | | | | | | x | | | | | | | | | |
| Schmidtella incompta, n. sp | 642 | | | | x | | | | | | | | | | | |
| Schmidtella incompta var. subæqualis, n. var | 642 | | | | | | | | n | | | | | | | |
| Schmidtella brevis, n. sp | 642 | | | | x | | | | | | | | | | | |

| | | Trenton Period. | | | | | | | | | Hudson or Cincinnati Period. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stones River Group. | | | Black River Group. | | | Trenton Group. | | | | | | | | |
| OSTRACODA AND TRILOBITA. | Page. | "Lower Buff." | Vanuxemia bed. | Stictoporella bed. | Rhinidictya bed. | Ctenodonta bed. | Fucoid and Phylloporina beds. | Clitambonites bed. | Fusispira and Nematopora beds. | Maclurea bed. | Utica group. | Richmond group. | Cincinnati region. | Tennessee. | New York. | Canada. |
| Schmidtella subrotunda, n. sp. | 643 | | | x | | | | | | | | | | | | |
| Aparchites ellipticus, n. sp. | 644 | | | | x | | | ? | | | | | | | | |
| Aparchites granilabiatus Ulrich | 644 | | | | | | x | | | | | | | | | |
| Aparchites neglectus, n. sp. | 645 | | | x | ? | | | | | | | | | | | B |
| Aparchites millepunctatus Ulrich | 645 | | | | x | | | | | | | | | | | |
| Aparchites fimbriatus Ulrich | 645 | | | | | | | | | | | x | | | | |
| Aparchites arrectus, n. sp. | 646 | | | | | | x | | | | | | | | | |
| Aparchites chatfieldensis, n. sp. | 646 | | | | | x | | | | | | | | | | |
| Aparchites minutissimus var. trentonensis, n. var. | 646 | | | | x | | | | n | | | | | | | |
| Primitiella constricta, n. sp. | 647 | x | ? | x | | | | | | | | | S | | | |
| Primitiella limbata, n. sp. | 648 | | | x | | | | | | | | | | | | |
| Primitiella simulans, n. sp. | 648 | | | | x | | | | | | | | | | | |
| Primitiella fillmorensis, n. sp. | 649 | | | | x | | | | | | | | | | | |
| Primitiella unicornis Ulrich | 649 | | | | | | | | | | ? | | T U | | | |
| Primitia minutissima, n. sp. | 651 | | | x | x | | | | | | | | | | | |
| Primitia uphami, n. sp. | 651 | | | | | | | x | | | | | | | | |
| Primitia mammata, n. sp. | 652 | | | | x | | | | | | | | | | | |
| Primitia santi-pauli, n. sp. | 652 | | | | | | x | | | | | | | | | |
| Primitia micula, n. sp. | 653 | | | | | | | x | | | | | | | | |
| Primitia celata, n. sp. | 653 | | | | x | | | | | | | | | | | |
| Primitia duplicata, n. sp. | 654 | | | | x | | | | | | | | | | | |
| Primitia tumidula, n. sp. | 655 | | | | | | | | | | x | | | | | |
| Primitia gibbera, n. sp. | 655 | | | | | | | | | | x | | | | | |
| Halliella labiosa, n. sp. | 656 | | | | | | | | n | | | | | | | |
| Beyrichia initialis, n. sp. | 658 | | | | x | | | | | | | | | | | |
| Eurychilina reticulata Ulrich | 660 | x | x | x | x | x | x | | | | | | | | | |
| Eurychilina " var. incurva, n. var. | 661 | | | | | | x | | | | | | | | | |
| Eurychilina subradiata Ulrich | 661 | | x | x | | | | | | | | | S | S | | |
| Eurychilina ventrosa, n. sp. | 662 | | | | | | | | n | | | | | | | |
| Eurychilina (?) subæquata, n. sp. | 663 | | | | | | x | | | | | | | | | |
| Eurychilina (?) symmetrica, n. sp. | 663 | | | | | | x | | | | | | | | | |
| Dicranella bicornis, n. sp. | 665 | | | x | x | | | | | | | | | | | |
| Dicranella spinosa, n. sp. | 665 | | | | x | | | | | | | | | | | |
| Dicranella marginata, n. sp. | 666 | | | | x | | | | | | | | | | | |
| Dicranella (?) simplex, n. sp. | 666 | | | | x | | | | | | | | | | | |
| Jonesella obscura, n. sp. | 668 | | | | | | | x | | | | | | | | |
| Bollia subæquata, n. sp. | 669 | | | | | | | x | | | | | | | | |
| Bollia unguloidea, n. sp. | 669 | | | | | | | x | n | | | | | | | |
| Drepanella bilateralis, n. sp. | 671 | | | | | | x | | | | | | | | | |
| Drepanella macra Ulrich | 670 | | † | † | | | | | | | | | | S | | |
| Drepanella bigeneris, n. sp. | 672 | x | | | | | | | | | | | | | | |
| Dilobella typa, n. sp. | 673 | | | | | | x | | | | | | | | | |
| Ctenobolbina fulcrata, n. sp. | 674 | | | | | | x | | | | | | | | | |
| Ctenobolbina crassa Ulrich | 675 | | | | | | x | | | | | | | | | |
| Ctenobolbina ciliata var. emaciata Ulrich | 673 | | | | | | | | | | | † | R | | | |
| Ceratopsis chambersi Miller | 676 | | | | x | x | x | | | | x | | T U | | | |
| Ceratopsis " var. robusta, n. var. | 677 | | | | | | | | | | | x | R | | | |
| Tetradella quadrilirata H. & W. | 679 | | | | x | x | x | | | | | | S R | | | |
| Tetradella lunatifera Ulrich | 680 | | | | | | | | n | | | | R | | | H |
| Moorea angularis, n. sp. | 682 | | | | x | | | | | | | | | | | |
| Moorea punctata, n. sp. | 682 | | | | | | x | | | | | | | | | |
| Moorea (?) perplexa, n. sp. | 683 | | | | x | | | | | | | | | | | |
| Macronotella scofieldi, n. sp. | 684 | x | | | | | | | | | | | S | | | |
| Cytherella (?) subrotunda, n. sp. | 685 | | | x | | | | | | | | | | | | |
| Cytherella (?) rugosa Jones | 686 | | | | | | | | n | | | | | | | B |
| Cytherella " var. arcta, n. var. | 686 | | | | | | | | n | | | | | | | |
| Bythocypris cylindrica Hall | 687 | | | | | | | x | | | | | T U | | | U |
| Bythocypris (?) curta, n. sp. | 689 | | | | x | | | | | | | | | | | |
| Bythocypris granti, n. sp. | 689 | | | | x | | | | | | | | | | | |
| Bythocypris (?) robusta, n. sp. | 690 | | † | † | | | | | | | | | | | | |
| Krausella inæqualis, n. sp. | 692 | | † | † | | | | | | | | | | | | |
| Krausella arcuata, n. sp. | 692 | | † | x | | | | | | | | | S | S | | |
| TRILOBITA. | | | | | | | | | | | | | | | | |
| Calymmene callicephala Green | 699 | | | | | | | x | x | | x | x | T to R | T H | T U H | T U H |
| Isotelus gigas Dekay | 701 | | | | | | | | x | | x | | T to R | T H | T U H | Ch to H |
| Isotelus maximus Locke | 701 | | | | | | | x | x | | x | x | T to R | T H | T U H | T U H |
| Isotelus canalis Conrad | 707 | x | x | | | | | | | | | | | S | Ch to T | Cal Ch T |

| TRILOBITA, ECHINODERMATA, ETC. | Page. | Trenton Period. Stones River Group. "Lower Buff." | Trenton Period. Stones River Group. Vanuxemia bed. | Trenton Period. Stones River Group. Stictoporella bed. | Trenton Period. Black River Group. Rhinidictya bed. | Trenton Period. Black River Group. Ctenodonta bed. | Trenton Period. Black River Group. Fucoid and Phylloporina beds. | Trenton Period. Trenton Group. Clitambonites bed. | Trenton Period. Trenton Group. Fusispira and Nematopora beds. | Trenton Period. Trenton Group. Maclurea bed. | Hudson or Cincinnati Period. Utica group. | Hudson or Cincinnati Period. Richmond group. | Cincinnati region. | Tennessee. | New York. | Canada. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Isotelus susæ Whitfield | 708 | | | | | | | | | | | x | | | | |
| Ptychopyga ulrich, n. sp | 709 | x | x | | | | | | | | | | | | | |
| Nileus vigilans M. & W. | 712 | x | x | | x | | | | x | | | | | | | |
| Illænus americanus Billings | 714 | | | | | | | x | x | | | | | | T | T |
| Illænus cf. indeterminatus Walcott | 716 | | † | † | | | | | | | | | | | B | |
| Thaleops ovata Conrad | 716 | x | x | | | | | | | | | | S | S | | B |
| Bumastus trentonensis Emmons | 718 | x | x | | x | | | | x | | | | S | | B T | B T |
| Bumastus orbicaudatus Billings | 722 | | | | | | | | x | | | | | | | ?H |
| Bathyurus extans Hall | 722 | x | | | | | | | | | | | S | | S | B |
| Bathyurus spiniger Hall | 723 | | † | † | | | | | | | | | S | | ? T | B T |
| Bathyurus schucherti, n. sp | 724 | x | | | | | | | | | | | | | | |
| Bronteus lunatus Billings | 725 | | | | | | | | x | | | | | | | T |
| Dalmanites achates Billings | 726 | | | | | | | | x | | | | | | T | T |
| Pterygometopus intermedius Walcott | 727 | x | † | x | x | | | | | | | | S | | | |
| Pterygometopus schmidti, n. sp | 729 | x | | | | | | ? | x | | | | | S | | |
| Pterygometopus callicephalus Hall | 731 | x | x | x | x | x | x | x | x | | | | S T | S B T | T | |
| Ceraurus pleurexanthemus Green | 734 | x | x | † | x | x | x | x | x | | | | S T | S | T | B to H |
| Cyrtometopus scofieldi, n. sp | 735 | | x | | | | | | | | | | | S | | |
| Encrinurus vannulus, n. sp | 739 | x | † | † | | | | | | | | | | | | |
| ? Encrinurus raricostatus Walcott | 740 | | † | † | | | | | | | | | | S | | |
| Encrinurus cristatus, n. sp | 741 | | | | | | | | | | | x | | | | |
| Cybele winchelli, n. sp | 742 | | | | | | | | ? | | | | | | | |
| Odontopleura parvula Walcott | 744 | | | | | | | x | | | | | | | T | |
| Arges wesenbergensis var. paulianus, n. var | 744 | | | | | | | x | | | | | | | | |
| Platymetopus cucullus M. & W. | 746 | | | | | | | | x | | | | | | | |
| Platymetopus robbinsi Ulrich | 747 | | | | | | | | x | | | | | | | |
| Platymetopus bicornis Ulrich | 748 | | | | | | | | | | | x | | | | |
| Proetus cf. parviusculus Hall | 754 | | | | | | | x | | | | | T | | | T |
| Harpina minnesotensis, n. sp | 755 | | | | | | | | x | | | | | | | |
| Harpina cf. H. ottawensis Billings | 757 | | | | | | | | x | | | | | | | T |
| Harpina rutrellum, n. sp | 757 | | | | | | | ? x | ? x | | | | | | | |
| Cyphaspis (?) galenensis, n. sp | 759 | | | | | | | x | | | | | | | | |
| ECHINODERMATA and other fossils not described in this volume. | | | | | | | | | | | | | | | | |
| Dendrocrinus n. sp | | | | | | | x | | | | | | | | | |
| Dendrocrinus n. sp | | | | | | | | | | | | | | | | |
| Dendrocrinus n. sp | | | | | | | | | x | | | | | | | |
| Dendrocrinus n. sp | | | | | | | | | x | | | | | | | |
| Dendrocrinus n. sp | | | † | † | | | | | | | | | | | | |
| Merocrinus laxus Ulrich | | | | | x | | | | | | | | | | | |
| Palæocrinus articulosus Ulrich | | | | | | | | | x | | | | | | | |
| Glyptocrinus | | | | | | | x | | | | | | | | | |
| Porocrinus | | | | | x | | | | | | | | | | | |
| Carabocrinus magnificus Ulrich | | | | | x | x | | | | | | | | | | |
| Carabocrinus | | | | | | | | | | | | x | | | | |
| Carabocrinus | | | | | | | | | | | | x | | | | |
| Cremacrinus punctatus Ulrich | | | | | x | | | | | | | | | | | |
| Pleurocystites squamosus Billings | | | | | | | | | x | | | | ? B T | | | T |
| Pleurocystites angulatus Ulrich | | | | | | | | | x | | | | | | | |
| Pleurocystites abnormis Ulrich | | | | | | | | | x | | | | | | | |
| Eurycystites granosus Ulrich | | | | | x | x | | | | | | | | | | |
| Glyptocsytites grandis Ulrich | | ? | † | † | | | | | | | | | | | | |
| Glyptocystites, sp. undet | | | | | | | | | n | | | | | | | |
| Paleaster | | | | | | | x | | | | | | | | | |
| New starfish | | | | x | | | | | | | | | | | | |
| New starfish | | | | | | | | | | | | † | | | | |
| Edrioaster bigsbyi Billings | | | | | | | | | x | | | | | | | T |
| Agelacrinus | | | | | x | | | | | | | | | | | |
| Agelacrinus | | | | | | | x | | | | | | | | | |
| Lichenocrinus crateriformis Hall and varieties | | x | x | x | x | | x | x | x | | | | T U | | | |
| Lichenocrinus affinis Miller | | | | | | | | | | | | x | R | | | |
| Cyclocystoides | | | † | † | | | | | | | | | | | | |
| Pasceolus globosus Billings | | | | | | | | x | | | | | T | | | T |
| Lycrophycus ottawaensis Billings | | | | | | | | x | | | | | | | | T |
| Serpulites dissolutus Billings | | x | x | | | | | | | | | | T U L | | | B T |
| Cornulites, n. sp | | | | | | | | | | | | x | | | | |
| Cornulites, sp. undet | | | | | x | x | x | x | | | | | T | | | |
| Ortonia, sp. undesc | | | | | x | x | x | | | | | | | | | |

*Table showing number of species found in each of the beds, groups and periods of the Lower Silurian in Minnesota, number of same received from below and passing up, and number restricted to each.*

<table>
<tr><th rowspan="3" colspan="2"></th><th colspan="9">Trenton period.</th><th colspan="2">Hudson River or Cincinnati period.</th></tr>
<tr><th colspan="3">Stones River group.</th><th colspan="3">Black River group.</th><th colspan="3">Trenton group.</th><th rowspan="2">Utica group.</th><th rowspan="2">Richmond group.</th></tr>
<tr><th>Lower Buff.</th><th>Vanuxemia bed.</th><th>Stictoporella bed.</th><th>Rhinidictya bed.</th><th>Ctenodonta bed.</th><th>Phylloporina bed.</th><th>Clitambonit's bed.</th><th>Fusispira bed.</th><th>Maclurea bed.</th></tr>
<tr><td rowspan="3">Cœlenterata: in beds.</td><td>Number of species............</td><td>2</td><td>5</td><td>5</td><td>8</td><td>3</td><td>7</td><td>6</td><td>6</td><td>2</td><td></td><td></td></tr>
<tr><td>Received from below and passing up......................</td><td>? | 2</td><td>1 | 3</td><td>3 | 3</td><td>4 | 4</td><td>3 | 3</td><td>4 | 1</td><td>1 | 3</td><td>3 | 2</td><td>2 | 0</td><td></td><td></td></tr>
<tr><td>Number of species restricted to beds.....................</td><td>0</td><td>2</td><td>0</td><td>1</td><td>0</td><td>2</td><td>2</td><td>3</td><td>0</td><td></td><td></td></tr>
<tr><td rowspan="3">Cœlenterata: in groups.</td><td>Number of species............</td><td></td><td>8</td><td></td><td></td><td>11</td><td></td><td></td><td>9</td><td></td><td>2</td><td>6</td></tr>
<tr><td>Received from below and passing up......................</td><td></td><td>? | 4</td><td></td><td></td><td>4 | 1</td><td></td><td></td><td>1 | 0</td><td></td><td>0 | 0</td><td>0 | 0</td></tr>
<tr><td>Number of species restricted to groups...................</td><td></td><td>4</td><td></td><td></td><td>6</td><td></td><td></td><td>8</td><td></td><td>2</td><td>6</td></tr>
<tr><td rowspan="3">Bryozoa: in beds.</td><td>Number of species............</td><td>7</td><td>7</td><td>39</td><td>57</td><td>8</td><td>48</td><td>36</td><td>43</td><td>0</td><td></td><td></td></tr>
<tr><td>Received from below and passing up...........  ........</td><td>? | 4</td><td>4 | 4</td><td>4 | 19</td><td>17 | 18</td><td>8 | 5</td><td>14 | 18</td><td>12 | 15</td><td>19 | 1</td><td>0 | 0</td><td></td><td></td></tr>
<tr><td>Number of species restricted to beds.....................</td><td>3</td><td>1</td><td>16</td><td>27</td><td>0</td><td>21</td><td>10</td><td>24</td><td>0</td><td></td><td></td></tr>
<tr><td rowspan="3">Bryozoa: in groups.</td><td>Number of species...........</td><td></td><td>45</td><td></td><td></td><td>91</td><td></td><td></td><td>65</td><td></td><td>1</td><td>11</td></tr>
<tr><td>Received from below and passing up.....................</td><td></td><td>? | 21</td><td></td><td></td><td>21 | 19</td><td></td><td></td><td>20 | 1</td><td></td><td>0 | 0</td><td>1 | 0</td></tr>
<tr><td>Number of species restricted to groups...... ............</td><td></td><td>24</td><td></td><td></td><td>56</td><td></td><td></td><td>45</td><td></td><td>1</td><td>10</td></tr>
<tr><td rowspan="3">Brachiopoda: in beds.</td><td>Number of species............</td><td>14</td><td>16</td><td>13</td><td>16</td><td>7</td><td>18</td><td>23</td><td>30</td><td>0</td><td></td><td></td></tr>
<tr><td>Received from below and passing up.....................</td><td>? | 11</td><td>10 | 11</td><td>11 | 9</td><td>10 | 10</td><td>7 | 5</td><td>9 | 10</td><td>10 | 10</td><td>12 | 8</td><td>0 | 0</td><td></td><td></td></tr>
<tr><td>Number of species restricted to beds.....................</td><td>3</td><td>1</td><td>1</td><td>2</td><td>0</td><td>5</td><td>8</td><td>14</td><td>0</td><td></td><td></td></tr>
<tr><td rowspan="3">Brachiopoda: in groups.</td><td>Number of species............</td><td></td><td>22</td><td></td><td></td><td>28</td><td></td><td></td><td>43</td><td></td><td>15</td><td>25</td></tr>
<tr><td>Received from below and passing up......................</td><td></td><td>? | 12</td><td></td><td></td><td>11 | 12</td><td></td><td></td><td>13 | 7</td><td></td><td>4 | 6</td><td>10 | 0</td></tr>
<tr><td>Number of species restricted to groups.. ................</td><td></td><td>10</td><td></td><td></td><td>11</td><td></td><td></td><td>24</td><td></td><td>7</td><td>15</td></tr>
<tr><td rowspan="3">Lamellibranchiata: in beds.</td><td>Number of species............</td><td>14</td><td>22</td><td>3</td><td>13</td><td>43</td><td>4</td><td>13</td><td>36</td><td>4</td><td></td><td></td></tr>
<tr><td>Received from below and passing up......................</td><td>? | 7</td><td>4 | 7</td><td>3 | 1</td><td>2 | 13</td><td>18 | 2</td><td>0 | 0</td><td>2 | 4</td><td>4 | 3</td><td>3 | 0</td><td></td><td></td></tr>
<tr><td>Number of species restricted to beds.....................</td><td>7</td><td>11</td><td>0</td><td>0</td><td>23</td><td>4</td><td>7</td><td>29</td><td>1</td><td></td><td></td></tr>
<tr><td rowspan="3">Lamellibranchiata: in groups.</td><td>Number of species ..........</td><td></td><td>32</td><td></td><td></td><td>47</td><td></td><td></td><td>46</td><td></td><td>6</td><td>15</td></tr>
<tr><td>Received from below and passing up......................</td><td></td><td>? | 7</td><td></td><td></td><td>7 | 2</td><td></td><td></td><td>2 | 0</td><td></td><td>0 | 1</td><td>1 | 0</td></tr>
<tr><td>Number of species restricted to groups... ..............</td><td></td><td>25</td><td></td><td></td><td>38</td><td></td><td></td><td>44</td><td></td><td>5</td><td>14</td></tr>
<tr><td rowspan="3">Gastropoda: in beds.</td><td>Number of species............</td><td>2</td><td>67</td><td>6</td><td>17</td><td>42</td><td>8</td><td>29</td><td>59</td><td>13</td><td></td><td></td></tr>
<tr><td>Received from below and passing up......................</td><td>? | 2</td><td>2 | 22</td><td>6 | 1</td><td>4 | 13</td><td>23 | 10</td><td>1 | 2</td><td>9 | 17</td><td>24 | 8</td><td>7 | 0</td><td></td><td></td></tr>
<tr><td>Number of species restricted to beds.....................</td><td>0</td><td>44</td><td>0</td><td>1</td><td>13</td><td>6</td><td>9</td><td>29</td><td>6</td><td></td><td></td></tr>
<tr><td rowspan="3">Gastropoda: in groups.</td><td>Number of species............</td><td></td><td>67</td><td></td><td></td><td>50</td><td></td><td></td><td>78</td><td></td><td>7</td><td>13</td></tr>
<tr><td>Received from below and passing up......................</td><td></td><td>? | 18</td><td></td><td></td><td>12 | 12</td><td></td><td></td><td>16 | 2</td><td></td><td>1 | 3</td><td>5 | 0</td></tr>
<tr><td>Number of species restricted to groups..................</td><td></td><td>49</td><td></td><td></td><td>29</td><td></td><td></td><td>61</td><td></td><td>4</td><td>8</td></tr>
</table>

*Table showing number of species found in each of the beds, groups and periods of the Lower Silurian in Minnesota, number of same received from below and passing up, and number restricted to each.—Continued.*

| | | Trenton period. | | | | | | | | | Hudson River or Cincinnati period. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stones River group. | | | Black River group. | | | Trenton group. | | | Utica group. | Richmond group. |
| | | Lower Buff. | Vanuxemia bed. | Sticto-porella bed. | Rhini-dictya bed. | Cteno-donta bed. | Phyllo porina bed. | Clitam bonit's bed. | Fusis-pira bed. | Mac-lurea bed. | | |
| Cephalopoda: in beds. | Number of species | 6 | 31 | 2 | 1 | 10 | 4 | 4 | 13 | 1 | | |
| | Received from below and passing up | ? \| 6 | 6 \| 10 | 2 \| 1 | 1 \| 1 | 5 \| 4 | 3 \| 2 | 2 \| 2 | 6 \| 1 | 0 \| 0 | | |
| | Number of species restricted to beds | 0 | 16 | 0 | 0 | 3 | 1 | 1 | 6 | 1 | | |
| Cephalopoda: in groups. | Number of species | | 31 | | | 12 | | | 16 | | 1 | 2 |
| | Received from below and passing up | | ? \| 9 | | | 6 \| 3 | | | 6 \| 1 | | 1 \| 1 | 1 \| 0 |
| | Number of species restricted to groups | | 22 | | | 6 | | | 9 | | 0 | 1 |
| Ostracoda: in beds. | Number of species | 6 | 11 | 16 | 26 | 4 | 15 | 8 | 9 | 0 | | |
| | Received from below and passing up | ? \| 6 | 4 \| 10 | 10 \| 4 | 4 \| 5 | 3 \| 3 | 3 \| 0 | 1 \| 2 | 2 \| 0 | 0 \| 0 | | |
| | Number of species restricted to beds | 0 | 0 | 3 | 18 | 1 | 12 | 5 | 7 | 0 | | |
| Ostracoda: in groups. | Number of species | | 19 | | | 39 | | | 15 | | 4 | 4 |
| | Received from below and passing up | | ? \| 4 | | | 4 \| 3 | | | 2 \| 0 | | 1 \| 0 | 0 \| 0 |
| | Number of species restricted to groups | | 15 | | | 32 | | | 13 | | 3 | 4 |
| Trilobita: in beds. | Number of species | 12 | 13 | 7 | 5 | 2 | 2 | 10 | 17 | 0 | | |
| | Received from below and passing up | 1 \| 10 | 9 \| 9 | 7 \| 3 | 5 \| 4 | 2 \| 2 | 2 \| 2 | 3 \| 6 | 7 \| 3 | 0 \| 0 | | |
| | Number of species restricted to beds | 2 | 1 | 0 | 0 | 0 | 0 | 4 | 8 | 0 | | |
| Trilobita: in groups. | Number of species | | 16 | | | 5 | | | 21 | | 3 | 5 |
| | Received from below and passing up | | ? \| 6 | | | 5 \| 4 | | | 5 \| 3 | | 3 \| 2 | 2 \| 0 |
| | Number of species restricted to groups | | 10 | | | 0 | | | 13 | | 0 | 3 |
| Echinodermata, etc.: in beds. | Number of species | 3 | 5 | 5 | 9 | 4 | 7 | 4 | 9 | 0 | | |
| | Received from below and passing up | ? \| 3 | 3 \| 4 | 4 \| 1 | 1 \| 5 | 4 \| 2 | 3 \| 2 | 2 \| 1 | 1 \| 0 | 0 \| 0 | | |
| | Number of species restricted to beds | 0 | 0 | 1 | 4 | 0 | 4 | 2 | 8 | 0 | | |
| Echinodermata, etc.: in groups. | Number of species | | 6 | | | 13 | | | 12 | | 0 | 6 |
| | Received from below and passing up | | ? \| 1 | | | 1 \| 2 | | | 2 \| 0 | | 0 \| 0 | 0 \| 0 |
| | Number of species restricted to groups | | 5 | | | 11 | | | 10 | | 0 | 6 |
| Totals for Trenton beds. | Number of species | 66 | 177 | 96 | 152 | 123 | 113 | 133 | 222 | 20 | | |
| | Rec'd from below and passing up | ? \| 51 | 43 \| 80 | 50 \| 42 | 48 \| 72 | 73 \| 36 | 39 \| 37 | 42 60 | 78 \| 26 | 12 \| 0 | | |
| | No. of species restricted to beds | 15 | 76 | 21 | 54 | 40 | 55 | 48 | 128 | 8 | | |
| Totals for groups. | Number of species | | 246 | | | 296 | | | 305 | | 39 | 87 |
| | Rec'd from below and passing up | | ? \| 82 | | | 72 \| 58 | | | 68 \| 14 | | 10 \| 13 | 20 \| 0 |
| | No. of species restricted to groups | | 164 | | | 189 | | | 227 | | 22 | 67 |
| Totals for periods. | Number of species | | | | | 696 | | | | | 113 | |
| | Rec'd from below and passing up | | | | | ? \| 18 | | | | | 18 \| 0 | |
| | No. of species restricted to periods | | | | | 678 | | | | | 95 | |

*Comparison of Lower Silurian faunas in Minnesota with those of equivalent formations in Canada, New York, Cincinnati region and central Tennessee, showing the number and position of the species that are common to Minnesota and one or more of the foreign regions named.*

| | | Total number of species. | Occurring elsewhere. | Cincinnati region. | | | | Central Tennessee. | | | | New York. | | | | Canada. | | | Percent of occurrences in foreign rocks regarded as equivalent. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | St. | Bl. | Tr. | U.R. | St. | Bl. | O.M. | U.N. | B. | Bl. | Tr. | U.H. | B.B. | Tr. | U.H. | |
| Cœlenterata. | I. Stones River group | 8 | 2 | 2 | 2 | | 1 | 2 | 2 | | | 1 | 2 | | | 2 | | | 100 |
| | II. Black River group | 11 | 6 | 1 | 4 | 2 | 2 | 2 | 2 | 2 | | 1 | 2 | | | 4 | | | 84 |
| | III. Trenton group | 9 | 5 | | 1 | 2 | 1 | | | 1 | | | | 2 | 1 | | 2 | | 100 |
| | IV. Hudson River period | 8 | 6 | | | | 6 | | | | | | | | 1 | | | 2 | 100 |
| Echinodermata. | I. Stones River group | 6 | 2 | | | 2 | 2 | | | | | | | | | | | | |
| | II. Black River group | 13 | 2 | | | 2 | 1 | | | | | | | | | | | | |
| | III. Trenton group | 12 | 6 | | | 4 | | | | | | | | | | | 4 | | 100 |
| | IV. Hudson River period | 6 | 1 | | | | 1 | | | | | | | | | | | | |
| Bryozoa. | I. Stones River group | 44 | 11 | 6 | 1 | 3 | 2 | 3 | | 1 | | | | 1 | | | 1 | | 73 |
| | II. Black River group | 91 | 16 | | | 12 | 2 | 3 | | 5 | | | | 5 | | | 5 | | |
| | III. Trenton group | 65 | 25 | | | 14 | | 1 | | 5 | | | | 9 | | | 14 | | 100 |
| | IV. Hudson River period | 12 | 4 | | | | 4 | | | | | | | | | | | | 100 |
| Brachiopoda. | I. Stones River group | 22 | 14 | 6 | 5 | 4 | 1 | 8 | 1 | 2 | 1 | | | 5 | 1 | 7 | 5 | 1 | 93 |
| | II. Black River group | 28 | 19 | 4 | 8 | 10 | 5 | 6 | 2 | 8 | 4 | 2 | 1 | 12 | 3 | 15 | 14 | 4 | 75 |
| | III. Trenton group | 43 | 24 | 3 | 5 | 13 | 6 | 2 | 1 | 7 | 6 | | 1 | 17 | 5 | 9 | 20 | 5 | 95 |
| | IV. Hudson River period | 34 | 18 | | 2 | 5 | 12 | | | 3 | 4 | | 1 | 5 | 5 | 3 | 8 | 11 | 83 |
| Lamellibranchiata. | I. Stones River group | 32 | 7 | 1 | 1 | 1 | | 4 | 1 | | | | | 1 | | 4 | 1 | | 100 |
| | II. Black River group | 47 | 7 | 1 | 6 | 1 | | 1 | 2 | | | | | 1 | | 2 | 1 | | 100 |
| | III Trenton group | 46 | 8 | | | 4 | | | | 1 | | | | 4 | | | 4 | | 100 |
| | IV. Hudson River period | 20 | 13 | | | | 13 | | | | | | | | | | | | 100 |
| Cephalopoda. | I. Stones River group | 31 | 16 | 10 | 8 | 2 | 1 | 5 | 1 | 2 | | 1 | 2 | 5 | 0 | 4 | 4 | 0 | 75 |
| | II. Black River group | 12 | 7 | 3 | 4 | 1 | | 1 | 1 | 2 | | 0 | 0 | 4 | 0 | 2 | 5 | 0 | 57 |
| | III. Trenton group | 16 | 10 | 6 | 4 | 2 | 2 | 2 | 1 | 2 | | 1 | | 4 | | 2 | 6 | 0 | 70 |
| | IV. Hudson River period | 2 | 2 | | | | 2 | | | | | | | | | | | | 100 |
| Gastropoda. | I. Stones River group | 67 | 32 | 16 | 6 | 6 | 4 | 16 | 6 | 2 | | 3 | 1 | 7 | 1 | 11 | 6 | 2 | 75 |
| | II. Black River group | 50 | 24 | 6 | 9 | 12 | 7 | 6 | 2 | 2 | | | | 4 | 2 | 6 | 6 | 3 | 58 |
| | III. Trenton group | 77 | 34 | 3 | 7 | 25 | 5 | 7 | 4 | 10 | | 1 | 1 | 10 | 1 | 7 | 8 | 2 | 82 |
| | IV. Hudson River period | 17 | 9 | 1 | 2 | 4 | 6 | | | 1 | | | | 2 | 3 | | 3 | 3 | 67 |
| Ostracoda. | I. Stones River group | 19 | 5 | 4 | | | | 3 | | | | 1 | | | | 1 | 1 | | 100 |
| | II. Black River group | 39 | 2 | 1 | | 1 | 2 | | | | | | | | | | | | |
| | III. Trenton group | 15 | 3 | | | | 2 | | | | | | | | | 1 | | 1 | |
| | IV. Hudson River period | 8 | 3 | | | | 3 | | | | | | | | | | | | 100 |
| Trilobita. | I. Stones River group | 16 | 9 | 5 | 1 | 1 | 1 | 6 | 1 | 1 | | 2 | 2 | 4 | | 5 | 3 | 1 | 100 |
| | II. Black River group | 5 | 4 | 3 | | 2 | 1 | 2 | 1 | 1 | | | 1 | 4 | | 2 | 2 | 1 | 75 |
| | III. Trenton group | 21 | 13 | 1 | | 5 | 3 | 4 | 1 | 4 | 3 | | | 7 | 3 | 2 | 10 | 5 | 85 |
| | IV. Hudson River period | 6 | 4 | | | 4 | 4 | 1 | | 3 | 3 | | | 4 | 4 | 2 | 4 | 4 | 100 |
| Total. | | | | Found elsewhere in | | | | | | | | | | | | | | | |
| | I. Stones River group | 246 | 96 | 80 | | | | | | | | | | | | | | | 83 |
| | II. Black River group | 296 | 86 | | 47 | | | | | | | | | | | | | | 55 |
| | III. Trenton group | 305 | 123 | | | 107 | | | | | | | | | | | | | 87 |
| | IV. Hudson River period | 113 | 59 | | | | 53 | | | | | | | | | | | | 88 |

*Table showing number of species restricted to each of the Lower Silurian groups in the upper Mississippi region, number of same occurring in one or more of the four other regions, and the formations in which they are found.*

| | | Restricted species. | Occurring elsewhere. | Found elsewhere in | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Stones River. | Black River. | Trenton. | Utica. | Richmond. |
| Cœlenterata. | Stones River group... | 4 | 0 | | | | | |
| | Black River group... | 6 | 3 | | 3 | | | |
| | Trenton group........ | 8 | 3 | | | 3 | | |
| | Utica group........... | 2 | 2 | | | | 2 | |
| | Richmond group...... | 6 | 4 | | | | | 4 |
| Echinodermata, etc. | Stones River group.... | 5 | 0 | | | | | |
| | Black River group.... | 11 | 0 | | | | | |
| | Trenton group........ | 10 | 4 | | | 4 | | |
| | Utica group........... | 0 | 0 | | | | | |
| | Richmond group...... | 6 | | | | | | |
| Bryozoa. | Stones River group. | 24 | 11 | 11 | | | | |
| | Black River group.... | 56 | 6 | 2 | 1 | 3 | | |
| | Trenton group........ | 45 | 15 | | | 15 | | |
| | Utica group........... | 1 | 0 | | | | | |
| | Richmond group...... | 10 | 6 | | | | | 6 |
| Brachiopoda. | Stones River group.... | 10 | 6 | 5 | | 1 | | |
| | Black River group.... | 11 | 5 | | 4 | 1 | 1 | |
| | Trenton group........ | 24 | 10 | | | 10 | | |
| | Utica group........... | 7 | 3 | | | 1 | 2 | |
| | Richmond group...... | 15 | 9 | | | 1 | | 8 |
| Lamellibranchiata. | Stones River group.... | 25 | 3 | 3 | | | | |
| | Black River group.... | 38 | 6 | | 6 | | | |
| | Trenton group........ | 44 | 11 | | | 11 | | |
| | Utica group........... | 5 | 3 | | | | 3 | |
| | Richmond group..... | 14 | 10 | | | | | 10 |
| Gastropoda. | Stones River group... | 49 | 18 | 15 | 2 | 1 | | |
| | Black River group.... | 29 | 9 | 1 | 6 | 2 | | |
| | Trenton group........ | 60 | 20 | | 1 | 19 | | |
| | Utica group........... | 4 | 2 | | | | 2 | |
| | Richmond group...... | 8 | 2 | | | | | 2 |
| Cephalopoda. | Stones River group.... | 22 | 9 | 6 | 2 | 1 | | |
| | Black River group.... | 6 | 1 | | 1 | | | |
| | Trenton group........ | 9 | 3 | | | 3 | | |
| | Utica group........... | 0 | 0 | | | | | |
| | Richmond group...... | 1 | 0 | | | | | |
| Ostracoda. | Stones River group.... | 15 | 7 | 7 | | | | |
| | Black River group.... | 32 | 1 | 1 | | | | 1 |
| | Trenton group........ | 13 | 3 | | 1 | 1 | | 1 |
| | Utica group........... | 3 | 1 | | | | 1 | |
| | Richmond group...... | 4 | 2 | | | | | 2 |
| Trilobita. | Stones River group... | 10 | 6 | 5 | 1 | | | |
| | Black River group.... | 0 | 0 | | | | | |
| | Trenton group........ | 13 | 7 | | | 6 | | 1 |
| | Utica group........... | 0 | 0 | | | | | |
| | Richmond group...... | 3 | 0 | | | | | |
| Total fauna. | Stones River group... | 164 | 60 | 52 | 5 | 3 | | |
| | Black River group.... | 189 | 31 | 4 | 21 | 6 | 1 | 1 |
| | Trenton group........ | 227 | 76 | | 2 | 72 | | 2 |
| | Utica group........... | 22 | 11 | | | 1 | 10 | |
| | Richmond group .... | 67 | 33 | | | 1 | | 32 |

*Dates of publication.*

Some of the chapters in Part II were published in advance, at the following dates, in a small edition of 100 copies, viz.:

The Lower Silurian Lamellibranchiata, June 16, 1894.

The Lower Silurian Ostracoda, July 24, 1894.

The Lower Silurian Trilobites, September 27, 1894.

The other chapters in Part II have the date of publication of the volume, though still circulated separately in the same manner, February 15, 1897.

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# ERRATA.

FOR PART II, PAGES 475 TO 1081.

P. 490. Fourteenth line from top, after which insert I.

P. 504. Fifteenth line from bottom, add *M. modioliformis* M. and W.

P. 536. Eighth line from bottom, for "SUBOVATA, *n. sp.*" read HURONENSIS *Billings.* (A recent comparison of our specimens with the original types of Billings' species has shown that they belong to the same species.)

P. 537. Omit the paragraph which occupies the eighteenth to the twenty-second lines from the top.

P. 581. Eighth line from bottom, add *recurva* Ulrich, *similis* Ulrich and *? hamburgensis* Walcott.

P. 632. Ninth line from top, before *Tetradella* insert *Ceratopsis* Ulrich.

P. 657. Ninth line from bottom, for "*Ceratella*" read *Ceratopsis.*

P. 659. Fifth line from top, for "*Ceratella chambersi*" read *Ceratopsis chambersi.*

Explanation of plate XXXIX, thirteenth line from the top, for "CTENODONTA GIBBERA" read CYRTODONTA GIBBERA

Explanation of plate XXXIX, thirtieth line from the bottom, for "CYRTODONTA SUBOVATA, *n. sp.*," read CYRTODONTA HURONENSIS *Billings.*

ADDITIONAL ERRATA are to be found as follows: for the chapter on Lamellibranchiata on page 928; or the chapter on Cephalopoda on page 812; for the chapter on Gastropoda on page 1081.

Sincerely
W. H. Scofield.

## WILBUR H. SCOFIELD.

There remains one further duty to discharge. It is a duty which is fraught with sadness, but which is performed with cheerfulness. Wilbur H. Scofield, one of our collaborators, has died during the preparation of this volume.

His residence at Cannon Falls made it a point of rendezvous for parties in the service of the survey going to and coming from the southern portion of the state. Added to this convenience his interest in geology and his collection of fossils from the Lower Silurian brought him into constant intercourse with the members of the survey corps, and they all formed for him a strong personal attachment. His cooperation, which was always generously granted, has added much to the scientific value of this volume. Some feeble testimony to that service is seen in the dedication of several species to his name.

He was a native of Livingstone county, New York, born October 15, 1840, and removed to Minnesota in 1855, settling at Cannon Falls, a frontier hamlet. As the village and the country developed, he came to be recognized as one of the best and one of the foremost citizens. He served as teacher, postmaster, and president of the village council, and at the time of his death he was president of the Board of Education. He was tendered a nomination to the State Legislature but declined in favor of his brother, Hon. James L. Scofield.

He began the collection of fossils and their classification under the sole instigation and guidance of an inquisitive and enterprising mind, and, without association with scientists, necessitated by physical disability, he acquired great proficiency and manifested unwonted skill in the determination of species. His life and his service to geology illustrate the opportunities which lie in the pathway of the citizen who thoughtfully observes nature and who enters upon a systematic inquiry into the phenomena that surround him.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

# PALEONTOLOGY.

# CHAPTER VI.

# THE LOWER SILURIAN LAMELLIBRANCHIATA OF MINNESOTA.

BY E. O. ULRICH.

A number of names for this class of mollusks, commonly known as mussels, have, from time to time, been proposed, but none of them, save Blainville's *Lamellibranchiata*, which, on the whole, is an appropriate designation, has enjoyed more than merely temporary popularity. Of the other names, that proposed by Goldfuss in 1820, *Pelecypoda*, alone presents fair claims to recognition, since its adoption would produce that most desirable element, uniformity, in the terminology of the various classes comprised in the subkingdom *Mollusca*. Blainville's name, however, has six years' priority, and is so well established in literature that it is doubtful if the confusion which would result from a change of names would be sufficiently compensated for by the superior advantages of Goldfuss' term.

The Lamellibranchiata agree with the Brachiopoda in having bivalved shells, but differ in having them, as a rule, equal and inequilateral instead of inequivalved and equilateral; they are, furthermore, placed on the sides of the animal (for which reason we distinguish them as *right* and *left*), instead of above (dorsal) and below (ventral). From the Gastropoda and Cephalopoda they are distinguished by wanting a distinct head, in having bivalved shells, a bilobed mantle and lamelliform gills developed in pairs.

Generally the animal is symmetrically developed, of oval, rounded or transversely elongate form, laterally compressed and enclosed in the two fleshy, often more or less united, lobes of the mantle. Within the latter, which are attached to and secrete the calcareous or perlaceous valves, we have first the lamelliform gills, and between these the various internal organs, such as the heart, intestines and organs of generation, and the mouth and anal opening, and usually also a protrusible muscular foot. Numerous modifications of the mantle lobes occur. Sometimes they are separate, at other times their margins are grown together so as to enclose the animal as in a sack. In the latter case an opening is left in front for the protrusion of the foot, and another in the back serving for both the inhalation of water and the expulsion of the excrements. The posterior opening may be further modified so as to form two more or less distinct tubes or siphons, and these may be retractible or of such size and consistency that they project permanently through the gaping posterior margin of the shell. In most instances the siphons are capable of being completely or partially retracted, and the line of attachment of the muscles of the mantle producing this retraction is bent inward more or less decidedly. When such an inbending of the *pallial* line (as the attachment of the mantle to the inner surface of the shell is called) is found in fossil shells the inference is regarded as conclusive that the animal possessed retractile siphons. When, on the other hand, the pallial line is simple (*i. e.*, without a sinus) we are obliged to conclude that the siphons were either very small or wanting entirely.

The *foot*—a perfectly retractile organ, presumably of locomotion—lies in the anterior part of the shell between the gills and mantle lobes. Its form is various, but commonly compressed, hatchet or club-shaped, and the muscles which produce and regulate its action are attached usually above or behind the anterior adductor. Not infrequently chitinous threads spring from the lower side of the foot. When these are developed in sufficient number to form a bundle or *byssus*, the shells may thereby attach themselves to foreign bodies, and in such cases the anterior margins of the valves do not close tightly, but leave what is known as the *byssal opening*. Among paleozoic representatives of this class the *Ambonychiidæ* afford the best instances of shells with a byssal opening.

Of all the organs of the animal none are of greater importance to the paleontologist than the strong muscles (*adductors*) which serve to close the valves. There may be only one, the posterior, as in the recent oyster, or of the two the anterior one may be disproportionately small. In the majority of cases, however, the two muscles are approximately of equal size. Other and much smaller muscular scars may be noticed, especially in the umbonal cavity. which were produced by muscles which partially supported the movements of the gills and palpi and, as already stated, of the foot.

The shell in which the interest of the paleontologist is chiefly centered consists largely of two layers, the outer, secreted by the thickened margin of the mantle, being composed of vertically arranged prismatic cells filled with calcite, the inner of structureless thin parallel leaves. Generally a delicate chitinous epidermis is spread over the cellulose layer. Growth of the valves begins at the apex or beak, a more or less prominent point situated almost invariably somewhere along the anterior half of the hinge margin. Further increase takes place principally at the periphery, producing, when the edges of the mantle are entire, a simple, more or less regularly concentric, striation (growth lines) of the surface. But when the mantle edges are undulating or dentate the concentric growth lines are crossed by radiating striæ or plications.

The various parts of the shell are conveniently brought out and illustrated in the following section on terminology.

### Terminology.

*Outline:* The designation of the various parts of the outline depends upon the position in which the shell is placed. I shall adopt, because it is certainly the most convenient if not always the most natural position, the one in which the beaks are placed uppermost and the hinge line nearly or quite horizontal. The part in front of the beaks, toward which they are usually inclined, is therefore considered as the anterior end, while that behind them, often much the largest and widest, is the posterior. The upper edge is known as the *cardinal* or *dorsal* margin, while the lower is called the *basal* or *ventral*.

*Dimensions:* The length as given in the following pages always expresses the distance between the most prominent points (extremities) on the anterior and posterior

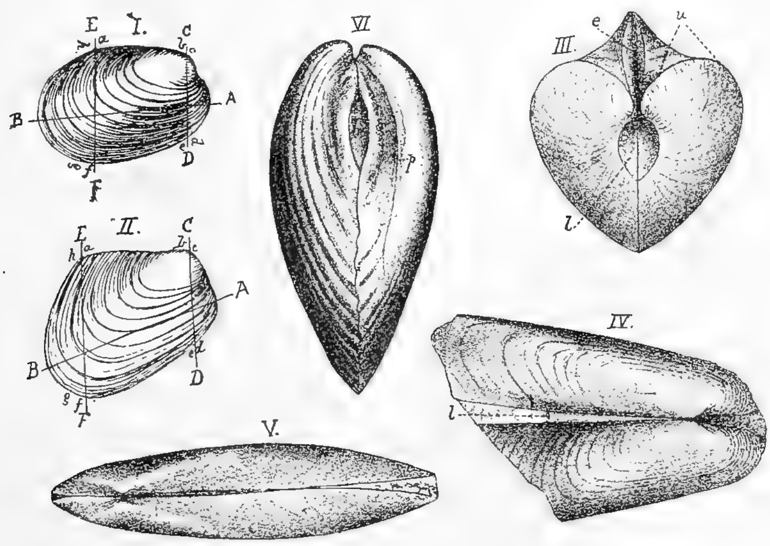


*Fig. 35. I and II, right valves of* Ischyrodonta (?) ovalis *Ulrich and* Matheria rugosa *Ulrich*, lettered and divided by lines to illustrate the section on outline and dimensions. A–B, length; C–D, anterior hight; E–F, posterior hight; *a b*, dorsal or cardinal margin; *c d*, anterior end and margin; *e f*, basal or ventral margin; *g h*, posterior end and margin.

III, antero-cardinal view of a small specimen of *Cuneamya curta* Whitfield, from the upper part of the Cincinnati group of Ohio; *u*, umbones and beginning of umbonal ridges; *e*, escutcheon; *l*, lunule.

IV, the two valves of an undescribed species of *Orthodesma* lying open in the shale and showing the ligament at *l;* middle beds of the Cincinnati group at Cincinnati.

V, dorsal view of an entire cast of the interior of *Chœnodomus typicalis*, a new genus and species from the upper beds of the Cincinnati group of Ohio, showing a shell gaping at both ends.

VI, anterior view of *Byssonychia radiata (Ambonychia radiata* Hall), illustrating a shell with a byssal opening. This specimen is from Cincinnati, Ohio, and is peculiar in having the right valve (left side of figure) preserved as a cast of the exterior and the left valve as a cast of the interior. In the latter is shown the pallial line (at *p*) running along the anterior side to a point under the beak.

margins. This line may be parallel with the hinge, but more commonly diverges more or less strongly posteriorly. The hight is given in one or two measurements; the former, when the shell is approximately equilateral (as in many species of *Tellinomya*) or elliptical in form (*Clidophorus*) with the greatest hight subcentral or beneath the beaks; the latter, when the shell is elongate or has one end much wider than the other (*Orthodesma* and *Modiolopsis*). In such cases two lines are drawn at right angles with the hinge line, one from the beaks to the ventral margin, the interval between the two points being the *anterior hight*, the other across the posterior end, from the posterior extremity of the hinge, giving the *posterior hight*. By *thickness* is understood the shortest distance between the points of greatest convexity of the valves.

*Area* or *Escutcheon:* A variously shaped, usually elongate, inflection of the dorsal edge, generally longitudinally lineate, and serving as a receptacle for the ligament. When the area is restricted to posterior to the beaks, as in *Cuneamya*, it is, strictly speaking, to be called an *escutcheon*.

*Lunule:* A similar, but shorter and commonly heart-shaped inflection or distinguishable area in front of or beneath the beaks. *Cuneamya* offers good examples.

*Gaping* and *closed* shells: The valves fit either closely all around or they may fail to do so and gape at one or both ends, and sometimes ventrally.

*Byssal opening:* A small, distinctly modified portion of the anterior margin, through which the byssus protruded. Among the paleozoic types the *Ambonychiidæ* furnish the best examples.

*Beak:* A more or less prominent point on each valve, usually bending forward and overhanging, in a variable degree, the dorsal edge. It marks the point at which growth began, and generally is situated anterior to the center of the valves. Many species of *Tellinomya*, *Nucula* and *Clinopistha* afford exceptions to the last rule.

*Umbones:* The use of this term, which is generally applied in a sense synonymous with *beaks*, is here restricted to the gibbous rostral portion of valves in which the beaks are incurved over the hinge line and invisible in a side view.

*Umbonal ridge:* A more or less strongly rounded or angular ridge-like prominence, extending from the beaks or umbones toward the posterior extremity of the shell. Example, *Whitella*.

*Cardinal* or *dorsal slope:* Generally applies to the flattened or concave declivity from the umbonal ridge to the dorsal edge posterior to the beaks. When the declivity on the anterior side is sufficient to be noted it is designated as the anterior cardinal slope.

*Anterior, posterior* and *ventral slopes* are self-explanatory terms.

*External ligament:* An elastic, horny band, of variable length, serving to hold the valves in position, and situated invariably over the dorsal edges close behind or under the beaks. But rarely preserved in fossil shells.

*Internal ligament* or *cartilage:* This is generally of cartilaginous consistency, and often but a modification or extension of the external ligament. In the latter case it lies along the posterior inner border of the hinge, where its presence may be indicated by linear thickened supports which, in casts of the interior, may sometimes be confounded with impressions of lateral teeth, (*Whitella*). A true internal cartilage, usually occupying a small pit beneath the beaks (Fig. 36, III and VII), is found in *Nucula, Pecten* and many other types of the secondary and more recent rocks, but is rather rare among paleozoic species.

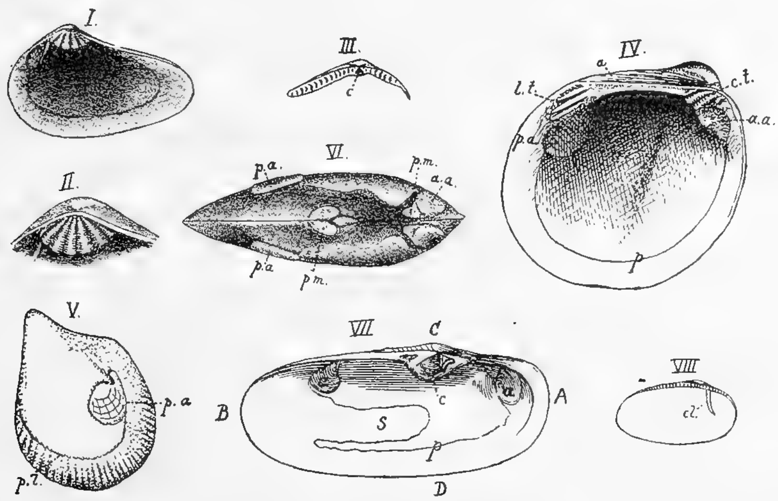


*Fig. 36. Illustrating Hinge Types, Muscles and Pallial Impressions.*

I and II, interior of a right valve of *Lyrodesma major* Ulrich, of the natural size, and the rostral portion of the valve × 2; upper beds of the Cincinnati group of Ohio.

III, hinge of a species of *Nuculana*, showing internal cartilage pit at *c*.

IV, interior of a left valve of *Vanuxemia hayniana* Safford, sp., from the upper Trenton limestone of central Kentucky; *a*, area; *c. t.*, cardinal teeth; *l. t.*, posterior lateral teeth; *a. a.*, anterior adductor, and *p. a.*, posterior adductor impression; *p.*, pallial line.

V, cast of the interior of a left valve of an unnamed variety of *Byssonychia radiata* Hall, sp. (*Ambonychia bellistriata* Miller and others, not Hall, 1847,) from the lower beds of the Cincinnati group of Ohio. In this specimen the posterior adductor impression *(p. a.)* and the pallial line are usually distinct.

VI, a sharply defined cast of the interior of *Lyrodesma major* Ulrich (see also I and II), showing the muscular impressions in a very satisfactory manner; *a. a.*, anterior adductors; *p. a.*, posterior adductors; *p. m.*, two pairs of pedal muscles.

VII, interior of a shell with a strongly sinuate pallial line *(s)*, and an internal ligament pit *(c)*; *Lutraria elliptica* Roissy, Pliocene, Rhodus (one-half nat. size). The outline of this shell is to be noted in connection with Fig. 34, I and II.

VIII, undetermined species of *Clidoporus*, showing clavicle *(cl.)*.

*Hinge teeth:* This term applies to the teeth in general, but more especially when these are numerous and subequal, as in *Tellinomya*.

*Cardinal teeth:* Refers to the teeth situated on the hinge in the region of the beaks.

*Lateral teeth:* One or more, generally elongate, subhorizontal teeth or interlocking ridges, often situated at the posterior extremity of the hinge.

*Muscular impressions:* That of the *anterior adductor*, when present, is situated near the margin in the antero-cardinal region. It may be as large or much smaller than the posterior adductor, which, when both are present, is placed at some point in the postero-cardinal region. When only one adductor scar is present (*Monomyaria*), or the anterior one is much the smaller of the two (*Heteromyaria*), the posterior scar is situated nearer the center of the valve. *Umbonal* scars are small impressions in the umbonal cavity, while the *pedal* muscles often leave small scars above and behind the anterior adductor impressions.

*Pallial line:* This is a more or less sharply defined line running nearly parallel with the free margins of the valves and connecting the two adductor scars. Among paleozoic representatives of the class the line is usually *simple*, but among more recent forms a *sinuate* pallial line (said of it when its posterior part is bent more or less strongly inward), is quite common.

*Clavicle:* A thin plate or ridge in each valve, of varying length, extending from the hinge margin, immediately in front of the beaks, vertically downward, or curving slightly forward. Example, *Clidophorus.*

## Preservation and Methods of Study.

In common with the Gastropoda, and probably for the same reasons, the paleozoic Lamellibranchiata are oftenest found in the condition of casts of the interior. This is true, especially of specimens preserved in dolomitic limestones like those of the lower Trenton and Galena in Minnesota, Wisconsin and Illinois, and the Niagara of northern Illinois and Wisconsin. These dolomitic specimens are to be regarded as in a favorable state of preservation so far as study is concerned. The shell, though dissolved away, has left good moulds of both the exterior and interior in the matrix, so that with the aid of plastic gutta percha the student is enabled to produce counterfeits of the shell that for purposes of classfication are scarcely to be excelled. To make good impressions it is often necessary to clean the moulds of the small crystals and other foreign matter that may in part occupy the space originally filled by the shell. Unfortunately, collectors too often are careless in preserving the outer mould, believing it, perhaps, of little consequence. In the interests of paleontology I would recommend greater caution and a lessening of the number of fragments by an early application of the contents of the glue pot.

Good casts of the interior are also to be met with in shaly rocks, indeed, most excellent ones when the shales are arenaceous. In soft shales, like those of the Cincinnati group of Ohio, they are generally preserved as partial moulds of the exterior. The approximately unaltered shell is to be counted as rare in lower paleozoic formations when compared with their frequent occurrence in Carboniferous deposits.

The most favorable method of preservation, so far as Lower Silurian material is concerned, is that in which the originally calcareous shell is more or less completely replaced by silica. Such specimens are rare in the Northwest, but common in the solid limestones of the Trenton in Tennessee and Kentucky, and in the Black River limestone of Canada. Beautiful specimens of this kind are to be found weathered out, or blocks of the limestone may be treated with dilute acid with the same result.

The first essential in the study of fossil Lamellibranchiata is to determine whether or not the material, as it lies before us, has retained its *original form.* Distortion through pressure in the rock matrix is a most fruitful source of error and one that even the greatest experience cannot entirely negative. It is evident that the softer and, consequently, the more yielding the character of the matrix, the greater the degree of the distortion. It is least in limestones and dolomites and greatest in shales and slates. The direction of the distortion depends upon the position occupied by the shell with respect to the bed planes of the enclosing rock.

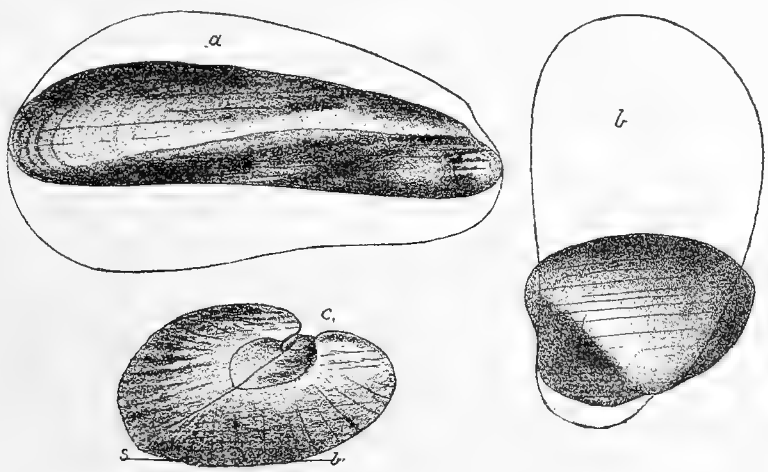


*Fig. 37. Illustrating distortion of shells through pressure.* *a*, right side of a specimen of *Modiolopsis modiolaris* Conrad, the hight of which has been reduced, as shown in outline, to less than half what it was originally. *b*, a shell of the same species greatly compressed lengthwise. *c*, the shell of an undescribed species of *Cuneamya*, from Ohio, illustrating the effect of pressure on shells occupying an oblique position in the shales. The line *s–b* indicates the plane of the strata and sea bottom. (See fig. 38.)

The exceedingly diverse results of the pressure, especially in specimens from shale, are most puzzling to the beginner. If a shell happened to stand upon end, its length will be greatly reduced; if upon its base, the hight; if upon its side, the thickness. When these positions were in no wise oblique, the beginner may fail entirely to notice the distortion, which, when their position in the strata is oblique to the plane of deposit, will be more or less clearly obvious to him because of the unsymmetrical forms of the two valves. A careful examination. however, will reveal, at any rate on specimens that have not been much weathered, certain fine parallel lines on the sides of the crushed shell. These lines are coincident with and probably produced by the deposit laminæ of the matrix, and an experienced student may, with their aid, at once determine the direction and perhaps the amount of the reduction of the particular dimension affected. It is to be remembered that the pressure under which the fossils suffer acts, except in comparatively rare instances, in a vertical direction only. Complete shells are generally compressed more or less obliquely, for the simple reason that after the death of the animal the natural position of the shell, with respect to the plane of the sea bottom, must be approximately as shown in fig. 37, c. For the same natural cause, the disunited valves are better calculated to preserve the original *outline*, because they are most likely to lie upon their inner edges, the latter being, therefore, at right angles to the direction of the pressure; in which case, under ordinary circumstances, the only dimension that can be altered is the thickness, this being reduced according to the amount of compression sustained by the surrounding rock.

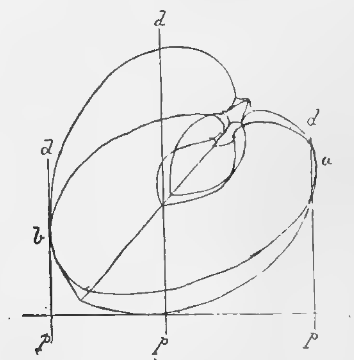


*Fig. 38. Illustrating how to obtain a restoration of an obliquely compressed shell.* The inner outline represents the specimen as it is now (see fig. 36-c), the outer one a restoration of its original form. S-B. plane of sea bottom; *d.-p.*, direction of compressing force.

In making the restoration shown in fig. 38, only the two regions or points *a* and *b* can be assumed as having retained their positions on the original boundary, because there alone the outline of the shell coincides with the direction of the compressing force. The only effect the latter could have had upon them was to increase their convexity and to press them down slightly beneath their original positions. On all other points, however, the effect was a reduction in the convexity of the outline and consequently of the size of the specimen. The rostral region of the right valve was greatly reduced and flattened, that of the left not so much reduced and made more strongly convex at *a*. In the lower half of the shell the result of distortion was reversed in the two valves. In the restoration, assuming the two valves to have been equal, we draw a curve through the point *a* that is intermediate in convexity between the flattened curve of the rostral half of the right valve and the sharpened one of the left. An equivalent curve is then drawn for the right valve and then continued to and beyond the point *b*. We now have the original outline of one of the valves as it would appear in an end view. The outline of the other valve being equally curved, only in an opposite direction, is then easily finished.

Having satisfied ourselves as to the original shape of the shell, it is first desirable to determine whether the valves are equal, as in *Modiolopsis* and *Whitella*, or unequal, as in *Pterinea* and *Aristerella*. Next we note the relation of the various parts of the outline to each other, the relative width of the two ends and other features bearing upon the determination of the *contour*. Now the position, altitude and degree of fulness of the beaks and umbones is taken into account. The former may be *terminal* (*i. e.*, situated at the anterior extremity of the hinge line and projecting as far forward as the margin beneath them), as in *Ambonychia;* or they may be nearly central in position, as in some species of *Ctenodonta*. Then the umbones may be strongly gibbous and the beaks curve over the hinge line (*Cuneamya*, *Whitella*), or they may be less full and comparatively erect (*Clionychia*), or depressed, or scarcely distinguishable (*Cycloconcha* and *Clidophorus*). Decided deviations in the position and altitude of the beaks are generally of generic value, but lesser modifications are likely to prove of merely specific importance. The character of the surface markings will probably have been taken into account at once.

In the next order, and here we usually credit them with generic and greater value, the student should observe the presence or absence of a byssal opening, of the lunule and escutcheon, and the character of the area. He should note also whether the edges of the valves fit tightly or gape at one or both ends or ventrally. His next step is to observe the position, distinctness and relative size of the various muscular impressions, the adductors particularly. Nor is he to forget to trace out the pallial line. Next he may find internal sockets, plates or ridges, that supported internal ligaments, or to which muscles were attached. Finally, he will observe the method of hingement. The hinge may be edentulous, in which case an external ligament (perhaps internal also) may usually be assumed if not found (see fig. 35, IV). In *Modiolopsis* there may be a slight thickening or rudimentary cardinal tooth in each valve beneath the beaks, in *Matheria* there are two in the left and one in the right, in *Cypricardites* three or more, and these are added to by the development of lateral teeth (fig. 36, IV); some types may have radiating teeth (fig. 36, I and II); in others the whole hinge margin will be divided transversely into numerous small teeth, while still others may present a combination of short transverse and long lateral teeth. On the whole, after giving due consideration to other pecularities, modifications in the structure of the hinge are to be ranked as of the highest importance.

## Classification.

The class Lamellibrachiata, or Pelecypoda, is variously divided by authorities. It is neither necessary nor desirable that the numerous systems should be considered here, since it is my impression, and here I merely follow the opinions of some of our latest and highest authorities, that they are all more or less misleading and inadequate. The fact is, we have not yet arrived at that stage in knowledge where a really natural classification is possible. Too little of the paleozoic representatives of the class is known well, and until more is learned of the evolution of the recent types from their fossil ancestors no attempt is likely to prove more than provisional. What we want now are facts and when sufficient of them have accumulated I doubt not the desired natural scheme of classification will evolve itself.

Still, since we have systems, they may as well be used till something better is furnished. Of course, only paleozoic types are here considered, and in viewing these alone, I cannot say that I am satisfied with the following arrangement. In drawing it up I have paid due attention to the arrangements proposed by Tryon, Stoliczka, Zittel, S. A. Miller and others, and sought to avoid what has seemed objectionable in each. At best the result is premature, and in submitting it in the hope that it may prove a little nearer the truth than their schemes, I beg that it may be considered with lenity.

# CLASSIFICATION OF PALEOZOIC LAMELLIBRANCHIATA.

## Subkingdom MOLLUSCA.

## Class LAMELLIBRANCHIATA, Blainville.

## Order ASIPHONIDA, Woodward.

Mantle lobes separate, siphons wanting. Pallial line without sinus.

### Suborder MONOMYARIA.

A single adductor muscle, the anterior one wanting.

#### Family PECTENIDÆ, Lamarck.

GENERA: *Aviculopecten*, McCoy; *Crenipecten*, Hall; *Euchondria*, Meek; *Lyriopecten*, Hall; *Pernopecten*, Winchell; *Pterinopecten*, Hall; *Streblopteria*, McCoy.

### Suborder HETEROMYARIA.

Anterior adductor muscle very small, the posterior one large.

#### Family AVICULIDÆ, d'Orbigny.

GENERA: *Actinopteria*, Hall; *Bakevellia*, King; *Ectenodesma*, Hall; *Glyptodesma*, Hall; *Liopteria*, Hall; *Leptodesma*, Hall; *Limoptera*, Hall; *Monoptera*, Meek and Worthen; *Monotis*, Bronn; ? *Palæopinna*, Hall; *Posidonomya*, Bronn; *Pseudomonotis*, Beyrich; *Pterinea*, Goldfuss (*Vertumia*, Hall); *Pteronitella*, Billings; *Pteronites*, McCoy; ? *Ptychopteria*, Hall.

#### Family PINNIDÆ, Gray.

GENERA: *Aviculopinna*, Meek; *Pinna*, Linne.

#### Family AMBONYCHIIDÆ, Miller.

GENERA: *Allonychia*, Ulrich; *Ambonychia*, Hall *(restricted)*; *Amphicœlia*, Hall; *Anomalodonta*, Miller; *Anoptera*, Ulrich; *Byssonychia*, Ulrich; *Byssopteria*, Hall; *Clionychia*, Ulrich; *Ectenoptera*, Ulrich; *Eridonychia*, Ulrich; *Mytilarca*, Hall; *Palæocardia*, Hall; *Plethomytilus*, Hall. *Psilonychia*, Ulrich.

#### Family CHÆNOCARDIIDÆ, Miller.

GENERA: *Chænocardia*, Meek and Worthen; *Megambonia*, Hall.

#### Family MYTILIDÆ, Lamarck.

GENERA: ? *Anthracomya*, Salter; ? *Anthracoptera*, Salter; *Gosselettia*, Barrois; *Lithodomus*, Cuvier (*Lithophaga*, Bolton); *Modiella*, Hall; *Modiola*, Lamarck; *Myalina*, Koninck; *Mytilops*, Hall; ? *Spathella*, Hall.

#### Family MODIOLOPSIDÆ, Ulrich.

GENERA: *Actinomya*, Ulrich; ? *Aristerella*, Ulrich; *Colpomya*, Ulrich; ? *Cymatonota*, Ulrich; ? *Cypricardella*, Hall; ? *Endodesma*, Ulrich; *Eurymya*, Ulrich; *Goniophora*, Phillips; *Modiolodon*, Ulrich; *Modiolopsis*, Hall; *Modiomorpha*, Hall; *Orthodesma*, Hall and Whitfield; ? *Prolobella*, Ulrich; ? *Psiloconcha*, Ulrich; ? *Pyanomya*, Miller.

Family CYPRICARDINIIDÆ, (Provisional.)

GENUS: *Cypricardinia*, Hall.

Family CYRTODONTIDÆ, Ulrich.

GENERA: ? *Cypricardites*, Conrad; *Cyrtodonta*, Billings; *Ischyrodonta*, Ulrich; *Matheria*, Billings; *Ortonella*, Ulrich. ? *Ptychodesma*, Hall; *Vanuxemia*, Billings; *Whitella*, Ulrich.

Suborder HOMOMYARIA.

Mantle lobes either separate or united posteriorly. The two adductor muscles of nearly equal strength.

Family ARCIDÆ, Lamarck.

GENERA: *Carbonarca*, Meek and Worthen; *Macrodon*, Lycett; *Nyassa*, Hall; ? *Spenotus*, Hall.

Family PARARCIDÆ, (Provisional).

GENERA: *Cardiola*, Broderip; *Cardiopsis*, Meek and Worthen; *Dexiobia*, Winchell; *Glyptocardia*, Hall; *Lunulicardium*, Münster; *Orœcardium*, Herrick; *Panenka*, Barrande; *Paracardium*, Hall; *Pararca*, Hall.

Family NUCULIDÆ, Gray.

GENERA: ? *Clidophorus*, Hall; *Ctenodonta*, Salter (*Tellinomya*, Hall); *Goniodon*, Herrick; *Nucula*, Lamarck; *Nuculana*, Link; *Nuculites*, Conrad; *Palæoneilo*, Hall; ? *Pyrenomœus*, Hall; *Yoldia*, Möller.

Family LYRODESMIDÆ, Ulrich.

GENERA: *Allodesma*, Ulrich; *Ischyrina*, Billings; *Lyrodesma*, Conrad; *Technophorus*, Miller.

Family TRIGONIDÆ, Lamarck.

GENERA: ? *Cytherodon*, Hall; ? *Schizodus*, King.

Family UNIONIDÆ

GENERA: ? *Amnigenia*, Hall; ? *Anthracosia*, King; *Prisconaia*, Conrad.

Family ELYMELLIDÆ, (Provisional).

GENERA: *Elymella*, Hall; *Glossites*, Hall.

Order SIPHONIDA, Woodward.

Mantle lobes more or less united; siphons of varying lengths, either separate or united, are developed; both adductor muscles well developed.

Family SOLENOMYIDÆ, Gray.

GENERA: *Solenomya*, Lamarck; *Clinopistha*, Meek and Worthen; *Phthonia*, Hall.

Family SANGUINOLITIDÆ, Miller.

GENERA: *Promacrus*, Meek; *Sanguinolites*, McCoy.

Family PHOLADELLIDÆ, Miller.

GENERA: *Allorisma*, King; *Chænomya*, Meek and Worthen; *Cimitaria*, Hall; *Pholadella*, Hall; *Physetomya*, Ulrich; *Rhytimya*, Ulrich.

Family GRAMMYSIIDÆ, Hall.

GENERA: *Cuneamya*, Hall and Whitfield; *Grammysia*, De Verneuil; ? *Leptodomus*, McCoy; ? *Sedgwickia*, McCoy; ? *Sphenolium*, Miller; *Saffordia*, Ulrich.

Family ASTARTIDÆ, Gray.

GENUS: *Astartella*, Hall.

Family MEGALODONTIDÆ, Zittel.

GENERA: *Megalodon*, Sowerby; *Megalomus*, Hall; ? *Plethocardia*, Ulrich.

Family LUCINIDÆ, Deshayes.

GENUS: *Paracyclas*, Hall.

Family CYCLOCONCHIDÆ, (Provisional).

GENERA: *Cycloconcha*, Miller; ? *Anodontopsis*, McCoy.

Family CONOCARDIIDÆ, Miller.

GENERA: *Conocardium*, Brown; ? *Eopteria*, Billings; *Euchasma*, Billings.

Family CARDIOMORPHIDÆ, Miller.

GENERA: *Cardiomorpha*, Koninck; *Edmondia*, Koninck; *Euthydesma*, Hall; *Protomya*, Hall.

Family SOLENIDÆ, Adams.

GENUS: *Solenopsis*, McCoy; *Palæosolen*, Hall; ? *Orthoncta*, Conrad.

Family PALÆANATINIDÆ, Miller.

GENERA: *Ilionia*, Billings; *Palæanatina*, Hall; *Prorhynchus*, Hall.

Family PROTHYRIDÆ, Hall.

GENUS: *Prothyris*, Meek.

The literature pertaining to Lower Silurian Lamellibranchiata is not only meager but, in great part, unreliable. The principal cause for the latter is to be found in the want of experience of the authors, who, failing to understand the effects of pressure to which a large proportion of the shells have been subjected, have thrown together as identical widely different forms, and oftener, perhaps, distinguished the distorted specimens from those which have more nearly retained the normal form. The illustrations also are too often, if not entirely worthless, misleading. Here, more than in any other part of the study, the greatest care and experience are required. Entire and undistorted specimens are not by any means the rule, so that slight restorations of the outline, if the figures are to be of real assistance in the identification of the species, are generally not only desirable but necessary. An *absolutely correct* reproduction of an imperfect specimen might be quite sufficient for the trained specialist, but not for the beginner. He requires all we can give him, and I know from experience that an approximation even to an "absolutely correct reproduction" is anything but common among illustrations of early Lamellibranchiata.

In the accompanying plates nearly all the specimens are represented as entire, but in each instance the fact of the restoration is mentioned or indicated by a fracture-like line. Respecting the drawings, I shall say only that they were in every case made by myself and with as great care and fidelity to nature as I could command.

The synonomy of the species is scarcely as complete as I could wish, but as the volume must be kept within certain limits, and because it is in many instances at least doubtful that current identifications of the old species are really the same as the originals, I have restricted the synonomy to the citation of the first work containing a description and such of subsequent memoirs as added materially to our knowledge of the objects under consideration. Desiring also to save as much space as possible for general remarks, I have generally avoided what seemed unnecessary repetition by giving full descriptions of the principal species only. In characterizing the others I have depended chiefly upon comparisons, which, if they are complete, I hold to be more useful than bare descriptions.

While the greater part of the northwestern material used was collected by myself, and is now part of my private cabinet, about one-fourth of the whole belongs to the survey museum, for which, as is shown by the museum register, the specimens were collected chiefly by Prof. N. H. Winchell, Prof. C. L. Herrick, and Messrs. W. H. Scofield and Charles Schuchert. For much of the remainder I am personally indebted to Mr. Scofield, who, with unusual generosity, allowed me to select anything I desired from his extensive private collection of Minnesota fossils. I am under obligations also to Dr. C. H. Robbins, of Wykoff, Minnesota, for several choice specimens from the Galena limestone of Fillmore county; likewise to Prof. C. W. Hall, Mr. A. D. Meeds and Mr. A. H. Elftman for good specimens collected by them in the vicinity of Minneapolis.

# Class LAMELLIBRANCHIATA.

(PELECYPODA.)

## Family AMBONYCHIIDÆ, Miller.

Valves equal, very inequilateral; beaks prominent, terminal or nearly so; posterior cardinal region more or less alate; anterior side abruptly convex, with or without a byssal opening. Small cardinal and elongate posterior lateral teeth may be present or wanting. Posterior adductor impression large, bilobed (the upper part probably formed by a pedal muscle), situated above and behind the center of the valves. Anterior adductor wanting or very small, situated in the umbonal region. Pallial line simple, strongly impressed in the anterior region, becoming obsolete near the anterior extremity of the hinge.

This family is unquestionably a valid one, and readily distinguished from the *Aviculidæ* with which its old genera are usually associated. In that family of shells the valves are always unequal and drawn out in front of the beaks into a distinct wing or lobe. The *Ambonychiidæ,* on the contrary, are always equivalved and without an anterior wing, the situation of the beaks being approximately terminal.

As may be seen from the scheme of classification on page 485, I have extended the limits of the family so as to include several genera that are very differently arranged by other authors. Thus *Amphicœlia,* Hall, is regarded as the type of a new family by Miller, while Whitfield has said that the genus is probably identical with *Leptodomus,* McCoy, and Meek and Worthen placed it near *Pterinea*. But, as I shall show in another work, *Amphicœlia* possesses every essential character of the present family. *Palæocardia,* likewise founded by Hall upon a Niagara species, also is closely related to *Ambonychia*. Hall's *Mytilarca* and *Plethomytilus* again, can be shown, I believe, to be direct descendants of Lower Silurian types of this family and should not be placed with the *Mytilidæ*.

### Genus AMBONYCHIA, Hall (emend. Ulrich).

*Ambonychia* (part.), HALL. 1847. Pal. N. Y., vol. i, p. 163. Not *Ambonychia*, Hall, 1859, Pal. N. Y., vol, iii, pp. 269 and 523; nor of American and European authors generally.

Equivalved and profoundly inequilateral shells; valves ventricose, very thin, closing tightly all around; beaks full, strongly incurved. Surface with fine radiating striæ, crossed by concentric growth lines and obscure undulations. Internally a thin plate passes vertically down from the anterior end of the hinge plate separating a small lobe, immediately beneath and sometimes a little in front of the beaks, from the umbonal cavity. Hinge plate narrow, with a few ligament striations and two small oblique cardinal teeth; no lateral teeth. Muscular impressions and pallial line very faint.

Type: *A. bellistriata* Hall.

It will be seen that the foregoing description of this genus is, in many respects, widely different from that adopted by all preceding authors. Hall's original diagnosis is, of course, too broad and on the whole indefinite, since it included species which subsequent study proved to be quite different from the typical species. Again, the commonly accepted characterization of *Ambonychia*, since the publication of Hall's notes on the genus in 1859, is based upon his *A. radiata* and not upon *A. bellistriata*, which, of all the species placed under *Ambonychia* by him in 1847, alone is entitled to the distinction of being the type. *Ambonychia*, therefore, as generally understood, is synonymous with the group of shells which now propose to name *Byssonychia*, and quite distinct from *Ambonychia* as based upon *A. bellistriata* and *A. orbicularis* (Emmons), the two species first following the original description of the genus.

This new interpretation of the genus may produce some confusion, but it is necessitated by the rule of priority, which demands that when no type is mentioned the first species to follow the original description must be regarded as the type of the genus. Having then no alternative but to accept *A. bellistriata* as the type, I have redefined the genus in accordance with the characters presented by that species and four others, *A. orbicularis* Emmons, *A. planistriata* Hall, *A. affinis*, n. sp., and *A. amygdalina* Hall, all of which, with the possible exception of the last, are unquestionably congeneric.

Compared with other members of the family, *Ambonychia*, as here understood, differs from *Clionychia*, Ulrich, in having a small lobe-like cavity beneath the beaks where, in that genus, there is a mere thickening of the margin of the valves. In casts of the interior the whole upper part of the anterior side of *Clionychia* is impressed to the edge of the valves, while in *Ambonychia* the same part presents a small protruding, vertically elongate lobe, separated from the anterior side of the rostral cavity by a sharply-impressed thin line. This lobe reminds one greatly of the anterior adductor impression of *Vanuxemia*, but I could not satisfy myself that it really lodged such a muscle. Other differences are that in *Ambonychia* the valves are more ventricose and the umbones and beaks more strongly incurved, while the surface is marked not only concentrically but also radially. In *Byssonychia* there is a byssal opening in the anterior side and the hinge is strengthened by two or three slender posterior lateral teeth. The Upper Silurian genus, *Amphicœlia*, Hall, may be more nearly related to *Ambonychia* than either of the genera mentioned. Certain it is that I find it more difficult to point out the distinguishing features than I did in those cases. The general appearance of the shells of the two genera (*Ambonychia* and *Amphicœlia*) is very similar, both in the matter of form and in their surface markings. The hinge also is very much the same in the two genera, the chief difference being that the area is wider in *Amphicœlia.* The greatest difference, however, seems to lie in the antero-cardinal region, where the margin of the latter is thickened, causing casts of the interior to appear as broadly impressed in this region.

### Ambonychia planistriata *Hall.*

PLATE XXXV. FIGS. 3 and 4.

*Ambonychia planistriata* Hall, 1861. Rep't. Sup't. Geol. Sur. Wis., p. 32.

Shell obliquely acuminate-ovate or subrhomboidal, ventricose, with the point of greatest convexity near the center of the antero-cardinal half. Upper half of anterior side somewhat flattened, nearly straight, sloping backward slightly, and more rapidly below, into the basal margin, which, with the greater part of the posterior edge, forms a semicircle; postero-cardinal margin subangular, hinge line straight, one-third or a little less shorter than the greatest length of the shell beneath. Beaks prominent, strongly incurved; umbones full and rounded; posterior cardinal slope concave. Surface marked by distinct, broad and shallow concentric undulations and fine radiating striæ, of which about twelve occur in 5 mm. at the margin of an average example. These striæ, which are flattened and separated by very narrow interspaces, are cancellated by another set of even finer concentric lines. Test very thin, hinge plate narrow, apparently with two cardinal teeth in each valve and no lateral teeth. In good casts of the interior the antero-cardinal lobe is sharply defined.

This rare and beautiful species is readily distinguished from *A. bellistriata* Hall, and *A. orbicularis* Emmons, sp., by its concentrically undulated surface. In this feature it is like *Clionychia undata* Emmons, sp., but that form, aside from the fact that it has the characters of *Clionychia*, is less ventricose, of somewhat different shape and without radiating lines. For comparisons with *A. affinis* Ulrich, see that species.

*Formation and locality.*—From the "Lower Blue limestone" at Mineral Point and Beloit, Wisconsin, and the equivalent limestones at Cannon Falls, Minnesota, and Lee county, Illinois.

*Mus Reg.* No. 8327.

## Ambonychia bellistriata *Hall.*

PLATE XXXV. FIGS. 1 and 2.

*Ambonychia bellistriata* Hall, 1847. Pal. N. Y., vol. i, p. 163. Not *Ambonychia bellistriata* S. A. Miller, 1874, Cin. Quart. Jour. Sci., vol. i, p. 14.

The Minnesota specimen illustrated on the accompanying plates differs slightly in its outline from the original figures of the species given by Hall in the work cited.* The hinge line is a trifle longer and the anterior side less uniformly curved. Still, I cannot for a moment doubt its specific identity with the types of the species, since it possesses all the more essential characters. The beaks and umbones are very prominent and strongly incurved, and the radiating striæ fine (about twelve or thirteen in 5 mm.) and apparently of the same character as in *A. planistriata*, excepting that they show no traces of the fine concentric lines noticed in that species.

Compared with *A. planistriata* the present species is found to differ in the relative narrowness and greater prominence of its umbones, and in wanting the shallow concentric undulations, which are always a striking feature of that species. *A. orbicularis* is a more erect and rounded form, and not so ventricose.

The name *Ambonychia bellistriata* occurs in all the published catalogues of the fossils of the Cincinnati group, but the species referred to in the lists is really a very different one. Indeed, it is a true member of the proposed genus *Byssonychia*, and closely related to the type of that genus, *B. radiata* Hall, sp.

*Formation and locality.*—In the central part of the Trenton limestone at Middleville and Trenton Falls, New York; and in the middle Galena near Wykoff, Minnesota.

## Ambonychia affinis, *n. sp.*

PLATE XXXV. FIGS. 5–7.

This species or variety is most probably a later phase of *A. planistriata* Hall, and as it resembles that species very greatly it will be sufficiently characterized by pointing out the differences. Thus, the beaks and umbones are a little less tumid and the convexity of the shell correspondingly less. The shell is also a trifle more erect and rounder, the hinge line slightly shorter and the postero-cardinal margin more rounded. Finally, the concentric undulations are much more obscure, while the radiating striæ are coarser, there being only eight in 5 mm. to twelve in the same space for that species. At first I thought the species might prove the same as *A. orbicularis* Emmons, sp., but a comparison with Hall's figures in vol. i of the Palæontology of New York, will show that the anterior side of the New York species is

* An examination of the types of the species, which are now preserved in the American Museum of New York City, proves that figs. 4*a* and 4*b* (on plate 36) are faulty in showing the radiating lines stronger than natural. Indeed, they are quite as strong in these figures as in the magnified views of the surface represented in fig. 4*d*.

more prominent, giving it a more erect appearance than any of the other species referred to the genus. Nor can I find that *A. orbicularis* ever has concentric undulations.

*Formation and locality.*—Middle Galena, Weisbach's dam, near Spring Valley, Minnesota; also in Carroll county, Illinois.

*Mus. Reg.* No. 8343.

### AMBONYCHIA AMYGDALINA *Hall.*

PLATE XXXV. FIGS. 8 and 9.

*Ambonychia amygdalina* HALL, 1847. Pal. N. Y., vol. i, p. 165.

None of the specimens seen by me preserve the surface characters well enough to prove that this species was provided with radiating lines. Obscure traces of such striæ are to be made out on one of the casts of the interior, but the evidence is not sufficient for me to assert that they are what they seem. Still, it is highly probable that radiating striæ will be found on perfect specimens, in which case the species would stand very near *A. bellistriata,* differing from it, so far as we can now see, chiefly in its greater size, less incurved beaks, flatter anterior side and less angular postero-cardinal margin.

The anterior lobe is longer, more sunken and less sharply defined in this species than in the others here referred to *Ambonychia.*

*Formation and locality.*—Middle Galena of Goodhue county, Minnesota. The New York type of the species is credited to the Trenton limestone at Adams, Jefferson county. Billings also catalogues the species from the same horizon in Canada.

## Genus CLIONYCHIA, Ulrich.

*Ambonychia* (part.) HALL, 1847. Pal. N. Y., vol. i, p. 163.
*Clionychia*, ULRICH, 1892. American Geologist, vol. x, p. 97; *Clionychia*, MILLER, 1892. First Appendix, N. A. Geol. and Pal., p. 699.

Shells equivalve, moderately convex, subalate posteriorly; beaks terminal, comparatively small, not very prominent and but little incurved. Cardinal line straight, rather long, forming an angle of less than 90° with the anterior side. Surface marked concentrically only. No byssal opening, the margins closing tightly all around. Muscular impressions situated in the postero-cardinal third, large, bilobed, the lower lobe much larger than the upper. Pallial line simple, extending from the posterior adductor to the rostral cavity. Hinge plate of moderate strength, without cardinal or lateral teeth, excavated longitudinally for a linear ligament. Upper part of anterior edge thickened, producing a more or less well-marked impression in this part of casts of the interior. Anterior pedal muscle attached a short distance behind the beaks.

Type: *Ambonychia lamellosa* Hall.

This well marked genus embraces probably the simplest and earliest types of the family, from which all the other genera descended. Yet, while a direct line to *Mytilarca* and *Plethomytilus* seems obvious enough, I must confess my inability to bridge over the gap between the radially ribbed genera on the one hand—and these form a very natural and closely interrelated group—and those in which the surface is marked with concentric lines only, on the other. At present, therefore, the evidence favors the conclusion that in times preceding the Chazy there existed a more primitive type still that combined the characters of the two groups.

Compared with *Ambonychia*, as here restricted, the present genus differs in its smaller umbones and less incurved beaks, in wanting radiating striæ and in the structure of the anterior side, there being, instead of a clavicle-like plate or ridge beneath the beaks, a mere thickening of the margin, leaving a cavity or impression in the cast where that genus presents a small lobe. *Mytilarca*, Hall, which probably was not evolved till after the close of the Lower Silurian, is distinguished by its cardinal and posterior lateral teeth, and more oblique form.

In the remarks following the original description of the genus I mentioned *Ambonychia amygdalina* Hall, as belonging here. This I now believe to have been an error. Respecting *A. nitida* and *superba*, described by Billings from Anticosti, and other concentrically marked species that have been referred to *Ambonychia*, it may suffice to say that they are not congeneric with the types of that genus. Their true relations cannot be established until we know something definite about their hinges. Some of the species in question are much like *A. acutirostra* and *aphæa*, two species described by Hall from the Niagara rocks of Wisconsin and Illinois that should go with *Mytilarca* and not with *Clionychia*.

### CLIONYCHIA LAMELLOSA *Hall.*

PLATE XXXV, FIGS. 10–14.

*Ambonychia lamellosa* HALL, 1861. Rept. Sup't. Geol. Sur. Wis., p. 31; WHITFIELD, 1882, Geol. Rep. Wis., vol. iv, p. 205.

*Ambonychia attenuata* HALL, 1861. Rep. Sup't. Geol. Sur. Wis., p. 33; WHITFIELD, 1882, Geol. Rep. Wis., vol. iv, p. 206.

Shell obliquely subquadrangular or subovate in outline; hinge line straight, generally but little shorter than the length of the shell beneath; anterior margin nearly straight, sloping backward five to fifteen degrees from a vertical line, below curving rather rapidly into the strongly convex basal line; posterior margin more gently curved, joining the hinge line sometimes sharply at other times gradually. Valves rather strongly convex, most ventricose in the umbonal region and near the anterior side where the slope to the edge is abrupt; cardinal slope gentle, in some cases nearly flat, in others distinctly concave. Beaks terminal, small, acutely attenuate in casts, generally curving slightly forward, projecting but little above the hinge and scarcely incurved. Beneath them the anterior side of casts presents a broad and often sharply-defined depression which, in extending downward, gradually dies out at or a little beneath a point midway between the base and the hinge. Surface, especially near the free margins, marked with numerous, unequally distributed concentric lines of growth, having the appearance, even on the casts, of being the edges of overlapping lamellæ. Hinge plate rather strong, without teeth, the ligamental area wide and faintly striated. Muscular scar bilobed, situated almost entirely within the postero-cardinal third of the valve. Pallial line simple, extending up the anterior side apparently to the cavity of the beak.

The form of this species seems to be quite variable, but after a careful study of numerous specimens I have concluded that much of this supposed instability is due to distortion through pressure. On the other hand, for the same reason, I found it utterly inpossible to detect really normal specific differences between the specimens which Hall in his original work and Whitfield in the later volume cited above have separated as two species under the names *Ambonychia lamellosa* and *A. attenuata.* According to my view the latter is founded upon specimens of the former whose original form was changed by pressure acting so as to decrease the diagonal or the vertical diameter of the valves, causing them to appear abnormally elongate. Whitfield's figure of *A. attenuata*, (*op. cit.* plate V, fig. 6) represents, instead of the left, most surely the right side of an obviously distorted specimen. It is a little surprising that a paleontologist of such wide experience as Prof. Whitfield should have failed to observe the evidences of distortion, and more so still, that he should mistake one valve for the other, especially of a specimen that preserves the posterior adductor scars. These we know are situated in the postero-cardinal third of the valves, but his error leads him so far astray that he asserts without qualification "they are situated near the anterior border of the valve."

This species cannot be confounded with the associated *Ambonychia planistriata* Hall, but care is required in separating it from the two species of *Clionychia* next described.

*Formation and locality.*—Lower Blue and Upper Buff limestones, Beloit, Mineral Point and Janesville, Wisconsin; Dixon, Illinois, and the upper part of the Trenton limestone at Minneapolis and St. Paul, Minnesota.

*Mus. Reg.* Nos. 5676, 8314.

### Clionychia nitida, *n. sp.*

PLATE XXXV, FIGS. 15 and 16.

This form is so much like the preceding (*C. lamellosa*) that it scarcely deserves specific recognition. Critically compared it is found to differ in the following respects: The umbonal slope is less defined, the whole surface being more uniformly convex, the beaks not so attenuate and more incurved, and the concentric growth lines not nearly so sharp, much more numerous and more equal. Casts of the interior are almost smooth, and the shell substance must have been very thin. The anterior side also is less concave, the shell smaller and the valves proportionally a little more convex.

*Formation and locality.*—Central part of the Trenton limestone at Minneapolis, Minnesota. *Mus. Reg.* No. 5099.

### CLIONYCHIA ERECTA *Hall.*

PLATE XXXV. FIGS. 17 and 18.

*Ambonychia erecta* HALL, 1861. Rep. Sup't. Geol. Sur. Wis., p. 32.

This species also is exceedingly like *C. lamellosa*, and for a time I was inclined to question the propriety of maintaining it. A more careful comparison, however, has revealed slight peculiarities that cause me now to view the separation with some favor. The valves of *C. erecta* are not so convex and more nearly square, the outer side being almost vertical and more produced below, the posterior side is straighter above and the postero-cardinal angle sharper. In all other respects the two forms are, so far as we can learn, identical. *C. nitida* is more oblique, its valves more convex and their surface markings finer.

*Formation and locality.*—Trenton limestone Beloit, Wisconsin, and Minneapolis, Minnesota.

### CLIONYCHIA RHOMBOIDEA *Ulrich.*

PLATE XXXV. FIGS. 19 and 20.

*Clionychia rhomboidea* ULRICH, 1892. Amer. Geol., vol. x, p. 97.

Shell, as seen in casts of the interior, of medium size, very oblique, rhomboidal in outline, the anterior and posterior and the dorsal and ventral margins subparallel. Dorsal edge nearly straight, likewise the posterior, the two lines meeting at an angle of about 120°. Postero-ventral margin sharply curved, the ventral side gently convex and rounding almost uniformly up to the base of the anterior side, from which point the outline continues to the beaks in very nearly a straight line. Beaks terminal, small, pointed, projecting slightly above the hinge line, scarcely incurved. Umbonal ridge strongly convex, extending toward the postero-ventral extremity in a slightly curved direction, so that the slopes on the anterior and ventral sides are more abrupt than on the opposite sides. Point of greatest convexity a little in front of and above the middle.

Interior with hinge plate rather wide and strong, and the anterior edges of the valves, for a short distance beneath the beaks, much thickened inwardly, the decay of the shell leaving a distinct depression in the casts. Muscular scars large, situated about midway in the postero-cardinal half of the valve, the two lobes united by a narrow neck, the upper one oval in shape and about one-third as large as the more nearly circular lower one.

The posterior extremity is more produced and more narrowly curved than in the other species referred to this genus.

*Formation and locality.*—Lower limestone of the Trenton formation at Minneapolis, Minnesota.

*Mus. Reg.* No. 5526.

### CLIONYCHIA UNDATA *Emmons.*

PLATE XXXV. FIGS. 21 and 22.

*Pterinea undata* EMMONS, 1842. Geol. Report. New York, p. 395.
*Ambonychia undata* HALL, 1847. Pal. New York, vol. i, p. 165.

Shell subquadrate, cardinal margin long, straight, anterior side straight, nearly vertical, curving sharply backward below into the gently convex base, which in its turn curves rapidly upward into the broadly rounded posterior margin; antero-cardinal angle about 85°, postero-cardinal angle about 115°. Beaks prominent, attenuate, slightly incurved, with the umbones strongly convex, the anterior slope very abrupt, the rapidity of the descent becoming gradually less in following the margin around to the posterior extremity of the hinge, where it is very gentle; cardinal slope concave, becoming strongly so and very abrupt in nearing the beaks. Surface marked with broad concentric folds, which are strongest on the cardinal and umbonal slopes and fade away gradually in curving around to the anterior side. Immediately beneath the beaks the anterior side of a good cast of the interior presents a sharply defined lunule-like impression, which, having been occupied by an internal thickening of the margin of the valves, was scarcely indicated on the exterior of the shell. Hinge plate narrow, muscular impressions undetermined.

The above description is based upon the specimen illustrated on plate xxxv. It presents no evidence of distortion and seems to be in every respect in a good state of preservation. Comparing this example with Hall's description and figures of the New York types of the species we observe that it differs in several particulars that might be regarded as important. The outline is more nearly quadrate, and the convexity of the valves less, giving a form that deviates from the figures of the New York specimen precisely as *C. erecta* does from *C. lamellosa.* Hall also mentions the absence of a "definite lunette," while such an impression is distinctly present in the casts of the Minnesota specimens. Despite these differences I am almost confident of the specific identity of the latter and the types of the species, because I am inclined to doubt the actual existence of the discrepancies noticed.

The broad undulations of the surface distinguish the species from the other shells referred to *Clionychia*.

*Formation and locality.*—Middle Galena, Fillmore and Goodhue counties, Minnesota; associated with *Zygospira uphami* W. and S., *Vanuxemia abrupta* Ulrich and *Lichas (Hoplolichas) robbinsi* Ulrich. The original specimen is from the Trenton limestone at Watertown, New York.

## Genus BYSSONYCHIA, n. gen.

*Ambonychia* (part.), HALL, 1847. Pal. New York, vol. i, p. 163.
*Ambonychia*, HALL, 1859. Pal. New York, vol. iii, pp. 269 and 523; also of all American and European authors who have described that genus subsequent to this date.

General aspect as in *Ambonychia*, Hall, excepting that the beaks and umbones are not so full. A well-defined byssal opening in the upper half of the anterior side. Hinge with a striated ligamental area, several small cardinal teeth and generally two or three slender lateral teeth near the posterior extremity. Posterior adductor impressions large, situated a little behind the center of the valves. Pallial line simple, terminating in the rostral cavity.

Type: *Ambonychia radiata* Hall. (See fig. 35, VI, p. 477.)

The erection of this genus became a necessity when a critical study of *Ambonychia bellistriata* Hall, and several other species undoubtedly congeneric with that peculiar type of the genus *Ambonychia*, proved them to be without not only lateral teeth but a byssal opening as well. On the other hand *Byssonychia* has nothing like the anterior subrostral clavicle, while the external radiating costæ are nearly always stronger than in *Ambonychia*. We have, therefore, at least three ordinarily valid generic differences to separate the two genera. Indeed, there is room for one or more intermediate genera. Two very nearly such groups actually exist in the Cincinnati rocks and I hope to publish descriptions of them in the next (7th) report of the state geologist of Ohio. One (*Allonychia*) will contain, besides the type, *Ambonychia (Megambonia) jamesi* Meek, two new species. They are all more erect shells, possessing a protruding byssal opening, a short hinge with wide ligamental area, but neither cardinal nor lateral teeth. The other group (*Eridonychia*) is based upon several elongate new species, having but little incurved beaks, scarcely ventricose umbones, a long and narrow byssal opening, thin hinge plate and no teeth.

*Byssonychia* is closely related to *Anomalodonta*, Miller, but is distinguished by its hinge, that genus having neither true lateral nor cardinal teeth. It is to be admitted, however, that in certain species, otherwise precisely like *Byssonychia*, the posterior lateral teeth are nearly or quite obsolete. Descriptions of these and other new species of this genus have been written for the Ohio work above mentioned.

The *Ambonychia intermedia* Meek and Worthen, of the Galena, seems to be the earliest species of *Byssonychia* now known. Perhaps contemporaneous with this is a form, occurring in the Trenton of Kentucky and Tennessee, that is scarcely distinguishable from the Hudson River *B. radiata.* Nine or ten additional species, of which two only are described (*A. retrorsa* and *robusta*, of Miller) occur in the Hudson River and Cincinnati rocks. So far as known the genus became extinct with the close of the Lower Silurian.

### BYSSONYCHIA INTERMEDIA *Meek and Worthen.*

PLATE XXXV, FIGS. 23–26.

*Ambonychia intermedia* MEEK and WORTHEN, 1868. Geol. Sur. Ill., vol. iii, p. 306.

Shell small, rhombic-subovate, the length and hight about as eleven is to fourteen; gibbous in the umbonal, anterior and central regions, compressed and subalate postero-dorsally. Hinge line a little shorter than the greatest antero-posterior diameter of the valves, ranging at an angle of about 90° with the anterior margin. Anterior side truncated nearly vertically above, below rounding backward into the base, the outline around the lower two-fifths of the shell forming nearly a regular semicircle. Posterior margin straightened above or rounding regularly into the hinge line. Beaks prominent, full, obtusely pointed, strongly incurved with a slight forward direction. Internal casts are somwhat excavated in the upper part of the front in the space surrounding the small byssal opening, and between the latter and the points of the beaks there is a small protuberance representing the filling of a little cavity at the extremity of the hinge plate. Surface marked by rather fine radiating plications, the total number, as near as can be determined from casts, being between forty-five and fifty. They are coarser on the ventral slope than on the posterior wing, always simple and increase in strength with the growth of the shell. On large casts the costæ are not defined except at the free margins, the rest of the surface being smooth.

Muscular scar and pallial line unusually obscure, their positions and form not certainly determined.

This little shell is a true *Byssonychia* and quite different from *Ambonychia bellistriata* Hall, with which Meek and Worthen compare it. It is related to the following species, but a nearer ally is found in the *B. vera* Ulrich, of the lower part of the Cincinnati exposures. That species, of which an excellent internal cast is figured on page 479 (fig, 36, pl. V), is less gibbous, more oblique and has smaller beaks, while the muscular scars and pallial line are usually more distinctly impressed.

*Formation and locality.*—Galena limestone, Mount Carroll, Illinois; Oshkosh, Wisconsin, and near Wykoff, Minnesota.

*Mus. Reg.* No. 8359.

BYSSONYCHIA TENUISTRIATA, *n. sp.*

Fig. 39. *Byssonychia tenuistriata*, n. sp. Hudson River group, Granger, Minnesota. The right side and a front view of an imperfect cast of the the interior. *Mus. Reg.* No. 8371.

Shell rather small, subovate, moderately ventricose in the umbonal region and anterior half, compressed in the postero-cardinal region where the surface is distinctly concave; anterior slope strongly convex, but scarcely abrupt; beaks small, projecting but little, moderately incurved. Hinge line comparatively short, the outline passing rather gently into the broadly-rounded posterior margin; basal line strongly convex, curving uniformly into the ends; anterior side slightly concave above, neatly convex below. Byssal opening small, its position high, it and the surface around it appearing in casts as a distinct impression immediately beneath the beaks. Surface marked with very fine radiating striæ and obscure concentric varices of growth, both showing through the marginal parts of the shell, so as to be visible on good casts of the interior. The total number of the radiating striæ is probably more than seventy. Near the base of the specimen figured eleven were counted in the space of 5 mm.

This species is closely related to *B. vera* Ulrich, (see *ante* p. 479, fig. 36, V) from the Utica horizon of the Cincinnati group of Ohio, differing from it chiefly in its finer radiating striæ and more impressed byssal opening. *B. intermedia* M. and W., of the Galena, has coarser striæ and is a more ventricose shell.

*Formation and locality.*—Rare in the upper part of the Hudson River rocks at Granger and Spring Valley, Minnesota, and in an equivalent position at Richmond, Indiana.

*Mus. Reg.* Nos. 8370, 8371.

## Family MODIOLOPSIDÆ, n. fam.

Shell equivalved, usually elongate ovate, but varying to oblong subquadrate, generally thin; valves fitting closely or gaping slightly at one or both ends. Beaks near the anterior end, but never terminal. Hinge long, of variable strength, edentulous or with one or two cardinal teeth in one or both valves. Ligament long, linear, external and internal. Anterior adductor impressions rather large and distinct, situated between the beaks and the anterior extremity; above them a very small pedal muscle scar. Posterior adductors large, very faintly impressed, situated less than their diameter from the posterior extremity of the hinge. Pallial line simple. Inner side of valves usually with one or two obtuse ridge-like thickenings extending from the beaks obliquely backward toward the center of the ventral margin.

Of the various genera included in this family in the scheme of classification on page 485, I am satisfied that some of those preceded by a question mark will be sooner or later placed elsewhere. No more satisfactory arrangement having suggested itself, they were referred here, because their known characters agree with one or another of the more typical genera. Thus, *Aristerella,* aside from its unequal valves, compares favorably with *Eurymya*, *Cypricardella* seems to be related to *Modiomorpha*, and *Endodesma* to *Modiolopsis* and *Cymatonota*, while *Psiloconcha,* in a general way, resembles *Actinomya.* But of *Pyanomya* too little is known to venture an opinion as to its ultimate placement, the only excuse for recognizing the genus in this connection being that it would be even more out of place in any of the other families. The position of *Prolobella* also is quite uncertain.

Some of the species of *Modiolopsis* remind us so strongly of *Modiola* and *Myoconcha* that we can scarcely escape the conviction that the latter genera, which are placed respectively in the families *Mytilidæ* and *Prasinidæ* by Stoliczka and Zittel, have really descended from *Modiolopsis.* Still, I am of the opinion that the paleozoic types constitute a more natural grouping by themselves than can be attained by any of the courses adopted heretofore. The position usually assigned to *Modiolopsis* is near *Modiola* in the family *Mytilidæ,* but Stoliczka and Zittel see greater resemblances with *Myoconcha* and therefore regard the genus as an early type of the *Prasinidæ.* But both of these families, the first in partiular, seem to me to include heterogeneous material, and if they were revised according to the genesis of the Lamellibranchiata, I have no doubt their limits would be greatly modified.

The first reason to influence me for the separation of *Modiolopsis* from the *Mytilidæ* occurred during a comparison with *Myalina*, Koninck, a genus that, while it seems to be very justly associated with *Mytilus,* has no relation to *Modiolopsis.* Indeed, according to my view, the progenitors of *Myalina* are to be sought for among the *Ambonychiidæ.*

Next, a comparison with recent species of *Modiola* proved that while a general resemblance obtained there were still certain features in which the genera here classed as the *Modiolopsidæ* agreed thoroughly among themselves and differed from *Modiola.* Thus, in the latter, and the same is true of all the *Mytilidæ,* the anterior adductor impression is always smaller and the posterior one situated farther from the cardinal margin as well as of a shape, including the prolongation formed by the pedal muscles, never seen in the paleozoic shells under consideration. On the whole the configuration of these parts in the latter is much more like what we see in the *Crytodontidæ*. Another feature in which the *Modiolopsidæ* resemble the *Cyrtodontidæ*, and one that, so far as I am aware, has never been noticed in *Modiola* nor *Mytilus*, is the presence on the inner surface, at any rate of all the thick shells, of one or two obtuse ridges extending from the beaks obliquely backward and toward the ventral margin, producing corresponding more or less well-marked furrows on casts of the interior.

Finally, there is to be urged that it is only a few shells, like *Modiolopsis modiolaris* and *M. concentrica*, in which the anterior end is narrow and unusually short, and a byssal sinus present, that exhibit any striking resemblances to either *Modiola* or *Myoconcha*. No one would, I believe, say this of elongate shells like *M. arguta* and *M. angustata*, and when it comes to *Orthodesma*, which can be shown to have originated in the same stock that produced *Modiolopsis*, all agree in removing that genus far from the *Mytilidæ*.

The many points of agreement that may be noticed between the *Modiolopsidæ* and the *Cyrtodontidæ* probably indicate a close union of the two groups in times preceding the Chazy; but, as far back as our knowledge now extends, there prevailed at least one important distinguishing feature. Namely, there existed a difference in the shell structure which, though its exact nature is unknown, is nevertheless clearly evidenced by the appearance of the two groups of fossils when they are preserved in soft shales, the shells of the former always being covered by a black or dark film never seen on the latter.

## Genus MODIOLOPSIS, Hall.

*Modiolopsis* (part.), HALL, 1847. Pal. New York, vol. i, p. 157.

Shell more or less elongate, usually subovate, widest posteriorly; valves moderately ventricose, closing tightly all around. Beaks small, near the anterior extremity; umbones depressed by a flattening or depression which crosses the valves obliquely and widening causes a straightening or sinuation of the basal outline. Hinge of moderate strength, rarely straight, generally somewhat arcuate, without well-marked teeth; an obscure oblique thickening beneath the beak of one valve and a corresponding depression in the other occasionally distinguishable. Ligaments linear, external and internal, chiefly the former. Anterior adductor impression subovate, large, deep, sharply defined on the inner side, occupying the greater part of the small anterior end. Posterior scar very faintly impressed, large, subcircular, situated near the center of the posterior third of the cardinal slope. Pallial line simple. Anterior pedal muscle forming a minute pit in the under side of the hinge plate beneath the beak. Posterior pedal muscles large, attached just above and in front of the adductor.

Type: *M. modiolaris* Conrad, sp.

As here restricted and defined, this genus constitutes a well-marked group of lower paleozoic shells. The oldest species, so far as known, occur in the Birdseye and Black River divisions of the Trenton formation. Some of these are of an oval type that, by gradual modifications of the base, evolved species of the *M. modiolaris* type. At the same time there existed elongate forms like *M. arguta*, having so much in common with *Orthodesma* that we cannot doubt that they indicate the primitive stock from which *Modiolopsis* and *Orthodesma* were evolved. The *M. arguta* line continued and formed a reasonably complete chain through *M. nana*, *M. mytiloides* Hall, *M. angustata*, and one or two undescribed species of the middle beds of the Cincinnati group, into *M. concentrica* H. and W., a common species of the upper part of that series of rocks in Ohio and Indiana, and into *M. excellens* from equivalent strata in Minnesota. In this case the form was shortened, the anterior end particularly. In the *M. modiolaris* line, however, the changes were different. Here we may begin with *M. similis*, an oval form with the posterior end broadly rounded and widest. This seems to have gone over into an upper Trenton species (*M. subrecta* Ulrich, Ms.) having a much narrower posterior end—indeed, the back and base are nearly parallel. We next follow the type by easy stages through varieties occurring in the Utica horizon to the normal form of *M. modiolaris*. Much indeed might be said upon these not only interesting but important questions of evolution, and nothing would please me more than to be allowed to demonstrate the positions here outlined. But time and space are lacking, and the few points made are offered chiefly in the hope that the suggestions may stimulate students to researches in similar lines. The field is inviting and the results to be obtained all important.

The relations of the genus to the other genera of the family treated of in this chapter will be discussed in the remarks following their descriptions.

No comparison of *Modiolopsis* and *Modiomorpha*, Hall, has, so far as I can learn, ever been published. This is strange, since the species of the two genera are strikingly similar. As a rule it seems they are regarded as differing widely, but in what respects we are not informed. Mr. S. A. Miller, for instance, places them into two distinct families, but fails to state his grounds for the separation.* A mistaken idea seems to prevail—where it originated I cannot say—that the hinge of *Modiolopsis* has lateral teeth, and this is given as the principal difference between the two genera by Nettleroth.†

Now, let us see what differences really exist between them. Taking *Modiomorpha concentrica* as representative of the Devonian genus, we find that, so far as external characters are concerned, it would pass very well for a species of *Modiolopsis*. Even

*North American Geology and Palæontology, p. 458; 1889.
†Kentucky Fossil Shells, p. 216; 1889.

its interior, in a casual glance, would pass, there being the same large and deeply-impressed anterior adductor scar, and nearly every feature with which those conversant with species of *Modiolopsis* are familiar. The exception is in the hinge, which is found to have a slightly oblique fold or tooth over the muscular scar in the left valve and a corresponding groove in the right. In true *Modiolopsis* this tooth is wanting, or rather, it is but little developed, since an obscure thickening of the hinge plate between the muscular impression and the beak is noticeable in many species of *Modiolopsis*. Another feature is observed in *Modiomorpha concentrica* that may be of importance. Namely, the hinge plates posterior to the beaks are wider than in any *Modiolopsis* known. They extend inwardly and at the same time diverge, probably for the reception of a strong internal ligament, the removal of the thin plate leaving a sharp slit a little within the cardinal edge of casts of the interior. The value of the character is to be tested only by its persistence in other species referred to *Modiomorpha*. It is a matter worthy of being looked into, for it must be admitted that another difference between *Modiolopsis* and *Modiomorpha*, besides the only one now recognizable, is, to say the least, desirable.

Of the numerous species which have been placed in this genus many proved distinct when subjected to critical study. Others look doubtful, but must remain here for want of material to determine their relations. Of those to be removed some fall under the new genera about to be proposed. Thus, *M. plana* Hall, *M. alata* Ulrich and perhaps *M. truncata* Hall, belong to *Eurymya; M. oviformis* Ulrich, to *Modiolodon; M. subelliptica* Ulrich, to *Allodesma; M. cincinnatiensis* Hall and Whitfield, *M. pulchella* Ulrich, *M. cancellata* Walcott, *M. oblonga* Ulrich, *M. pholadiformis* Hall, and *M. superba* Hall to *Actinomya; M. gesneri* Billings and *M. trentonensis* Hall, to *Endodesma*. *M. nasuta* Conrad, sp., and *M. subnasuta* Meek and Worthen, belong to *Orthodesma*, Hall and Whitfield, and *M. carinata* Hall, possesses all the essential characters of *Goniophora*, Phillips. Of Upper Silurian species *M. recta* Hall, from the Niagara of Wisconsin, is a *Matheria*, while the *M. dicteus* of the same author and locality, and *M. primigenia* Conrad, sp., of the Medina, have slender cardinal and posterior lateral teeth of the *Cyrtodonta* type.

### Modiolopsis similis *Ulrich.*

PLATE XXXVI, FIGS. 1 and 2; PLATE XLII, FIG. 19.

1892. *Modiolopsis similis* Ulrich. Nineteenth Ann. Report, Geol. Nat. Hist. Sur. Minn., p. 225.

Shell of medium size, obliquely elongate ovate, highest in the posterior half, contracted at the beaks to between one-half and three-fifths of the greatest hight. Hinge line nearly straight, about half as long as the shell posterior to the beaks. Anterior end small, neatly rounded; ventral margin gently convex, nearly straight in the middle; posterior end broadly rounded, slightly produced and more strongly convex in the lower half, the upper more gently curved and sometimes forming an obtusely angular junction with the hinge line. Beaks about one-seventh of the entire length of shell behind the anterior extremity, rather small, incurved, projecting moderately above the hinge; umbones compressed in the cast, a little less so in the shell. Surface moderately convex, most prominent along the umbonal ridge, the latter a little stronger than usual for species of this genus. Cardinal slope concave. A broad and comparatively well-defined mesial depression extends obliquely across the shell from the beak and, expanding, causes the straightening of the ventral margin. Excepting in this part the shell is very thin, and the anterior muscular scar, which is comparatively of small size, is scarcely distinguishable in casts. Surface rather obscurely marked with numerous fine concentric lines and a few stronger varices of growth.

As might be expected, this early species exhibits features intermediate between those marking the group of forms which I now propose to distinguish as *Actinomya* and true *Modiolopsis*. This is seen in the thin shell and consequent indistinctness of the anterior adductor impression, in the full and prominent umbones and in the convex rather than straight or concave basal line. At first I was inclined to put the species into the new genus, but later comparisons have shown that *Actinomya* was at that time already well established and that *M. similis* belongs to the line which finally produced *M. modiolaris*. Then the comparatively strong mesial depression indicates *Modiolopsis* and not *Actinomya*.

Compared with Minnesota Trenton species, all the others referred to *Modiolopsis* are narrower posteriorly. The *Actinomya superba* Hall, sp., has a larger anterior end, the postero-basal margin more produced, and the umbones larger. The undescribed Kentucky species referred to in the original description proves to be a *Cyrtodonta* closely related to *C. subovata* Ulrich.

*Formation and loality.*—Middle third of the Trenton shales at Minneapolis, Minnesota.

### Modiolopsis (?) consimilis, *n. sp.*

PLATE XLII, FIGS. 17 and 18.

This shell is so much like *M. similis* that at first I believed it might belong to the same species. Carefully compared, however, it proved to differ in several characters that are more important than striking. The umbones are larger and very little compressed, and the mesial sulcus, which is a well marked feature in that species, is scarcely distinguishable. The outline also is a little different, the posterior hight being relatively somewhat less than in the preceding species.

This species ought, perhaps, to go with *Actinomya* rather than *Modiolopsis*, but as I have so far seen only the exterior of the shell, and therefore know nothing of the internal characters, it seemed best to refer it to *Modiolopsis* provisionally, because of a general resemblance to *M. similis*. I wish to say further, that I would not be surprised if the shell proved to have the hinge of a *Cyrtodonta*, several species of which it resembles quite as much as it does *Modiolopsis*.

*Formation and locality.*—Near the base of the Trenton formation, Murfreesboro, Tennessee.

### Modiolopsis oweni, *n. sp.*

PLATE XLII, FIGS. 15 and 16.

This species is founded upon a single and not very well preserved cast of the interior. It seems to belong to *Modiolopsis* and very near *M. similis*, with which species it should be compared. As far as can be seen its valves were a little more convex, the mesial sulcus narrower, the anterior part of the shell somewhat inflated and the posterior part comparatively narrower.

*Formation and locality.*—Galena shales, about five miles south of Cannon Falls, Minnesota.

### Modiolopsis arguta, *n. sp.*

PLATE XXXVI, FIGS. 3–6.

Shell small, ventricose, elongate, highest posteriorly, the length twice the greatest hight, and three times the hight at the beaks. Cardinal margin straight; anterior end unusually long, sharply rounded at the extremity of the hinge beneath which it slopes backward gradually curving into the straight ventral margin; posterior end strongly convex and most prominent in the lower half, above curving more gently and very gradually into the dorsal edge. Beaks a little more than one-sixth of the length from the anterior extremity, moderately prominent and incurved, compressed; mesial impression scarcely more than a mere flattening of the sides of the shell; umbonal ridge rather sharply rounded. Point of greatest convexity of valves very near the center. Surface with concentric lines, sharp, subequal and thread-like on the cardinal slopes, here with about ten in 5 mm. at their strongest parts, becoming faint before they pass over the umbonal ridge in their course to the anterior end where they are again somewhat thread-like. In good casts of the interior the anterior adductor scars are large, prominent, and marked on their inner halves with transverse lines. The surface markings do not show through the shell so as to mark the casts. Hinge thin, apparently edentulous. An average specimen is 24 mm. long, the largest seen about 31 mm.

This is one of a number of closely related species ranging from the lower Trenton to the middle beds of the Cincinnati group. They are all elongate, especially so for

*Modiolopsis*, anterior to the beaks. Their general expression, therefore, is decidedly like *Orthodesma*, of which some member of this line is believed to have been the ancestor. In *Orthodesma* the valves gape slightly at the ends, which is not the case in these shells. In that genus again the point of greatest thickness is more or less behind the center, while in all the species referred by me to *Modiolopsis* this point is central or anterior to the center. Furthermore, as stated under the generic description, the *M. arguta* line traces by very gradual degrees into *M. concentrica* H. and W., which is a *Modiolopsis* in every respect.

*M. nana*, of the Galena shales, has stronger concentric striæ, and these extend further forward and are visible on the internal cast, is scarcely so convex, with a deeper mesial depression and more obtuse umbonal ridge, and more rounded and shorter anterior end; *M. mytiloides* Hall, is without the even thread-like lines on the cardinal slope; and *M. angustata* Ulrich, of the Cincinnati rocks, has a more truncate posterior margin, more uniformly rounded anterior end, and more nearly parallel dorsal and ventral margins.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis, St. Paul, Chatfield and Fountain, Minnesota.

*Mus. Reg.* No. 8350.

## Modiolopsis nana, *n. sp.*

PLATE XXXVI, FIG. 7.

This small species is closely related to *M. arguta*. The differences are as follows: The valves are not quite as convex, the umbonal ridge is less sharply rounded, the mesial depression a trifle deeper, and the anterior end a little shorter and more uniformly rounded. The most striking peculiarity, however, is found in the concentric lines which show very distinctly on casts of the interior, are coarser (eight in 5 mm.), more regular and continue of the same strength over the cardinal slope, umbonal ridge and forward into the mesial depression, near the center of which they are lost.

In *M. mytiloides* Hall, as identified in Minnesota, the surface of the casts is very obscurely marked with concentric lines, and the posterior extremity of the hinge line subangular.

Only two specimens have been seen. Of one the length is 19 mm., the posterior hight 9.3 mm., the anterior hight 7.2 mm., the thickness 6 mm. Of the other these dimensions are respectively 16, 8, 6 and 5 mm.

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

## Modiolopsis mytiloides *Hall.*

PLATE XXXVI, FIG. 8.

*Modiolopsis mytiloides* Hall, 1847. Pal. New York, vol. i, p. 157.

Three incomplete casts of the interior are referred to this species. They agree very well with Hall's description and figures, except in being proportionately higher. But the general appearance of his figure 4*a*, particularly in the abruptness of the postero-basal curve, causes me to believe that the original of the figure has been compressed vertically and is therefore narrower than normal.

Compared with *M. arguta* and *M. nana*, which are closely simulated, it is found to differ in its surface markings, which are fine, with stronger wrinkles of growth, the latter showing only on casts; the concentric lines are, therefore, not equal nor thread-like. The outline differs in the subangular junction of the posterior and cardinal margins. The mesial depression also is more pronounced and the end of the casts in front of the depression more swollen, causing a slight concavity in the ventral margin.

*Formation and locality.*—Trenton limestone, Middleville, New York; middle Galena, Goodhue and Fillmore counties, Minnesota, and Oshkosh, Wisconsin. According to Billings, in the Trenton and Black River groups of Canada.

*Mus. Reg.* No. 8361.

## Modiolopsis chatfieldensis, *n. sp.*

PLATE XXXVI, FIGS. 9 and 10.

Shell small, subelongate, the length a little less than twice the hight. Dorsal and ventral margins nearly straight, subparallel, diverging slightly posteriorly; anterior end rather long, rounded; posterior margin broadly rounded, scarcely oblique, curving gradually into the hinge line. Beaks compressed, projecting little, situated about one-fourth of the entire length from the anterior extremity. Valves moderately convex, thickest at the middle, the umbonal ridge sharply rounded in the upper half; mesial flattening distinct, very gently concave. Surface of cast exhibiting rather broad and unequal concentric furrows which, on the shell itself, seem to have separated sharply-elevated lines. The latter were probably restricted to the cardinal and posterior slopes. Anterior adductor scar large, its inner edge sharply defined and curving forward. Hinge apparently thin and edentulous.

Length 10 mm., posterior hight 5.2 mm., anterior hight 4.5 mm., thickness 3.3 mm.

This species is not elongate, like the *M. angustata* Ulrich, of the Cincinnati rocks, its anterior end is shorter and the sides of the valves flatter; with a better defined umbonal ridge than in *M. subparallela* Ulrich, also occurring in that higher series of strata at Covington, Kentucky. Compared with Minnesota species, it is perhaps nearest *M. arguta*, with which it is also associated. It is, however, readily distinguished by its surface markings, which are not visible on the casts of that species, and by its less oblique anterior and posterior ends and more nearly parallel ventral and dorsal margins. In *M. faba* Hall, which is probably not a true *Modiolopsis*, the mesial depression is much more distinct. *M. nana* is wider and more oblique posteriorly, and has more regular surface markings.

*Formation and locality.*—Middle third of the Trenton shales, Chatfield, Minnesota.

### MODIOLOPSIS OBSOLETA, *n. sp.*

PLATE XXXVI, FIGS. 11 and 12.

Shell small, elongate ovate, the length twice the greatest or posterior hight. Valves thickest a little above the center, rather uniformly convex, the umbonal ridge and mesial depression being both nearly obsolete. Beaks small, between one-fourth and one-fifth of the entire length from the anterior extremity. Dorsal margin gently arcuate, anterior end narrowly but almost uniformly rounded, ventral edge straight, posterior end slightly oblique, rather broadly rounded, most prominent a little beneath the center, above which it curves forward gradually into the hinge line. Surface with very fine concentric lines; these are equal and strongest near the posterior cardinal border. Hinge very thin, edentulous. Muscular scars not observed.

Length 13.3 mm., posterior hight 6.6 mm., anterior hight 5 mm., thickness (left valve only) about 2.5 mm.

Considerably like, and probably a near relative of *M. arguta*, but differs in the more uniform convexity of its surface, obsolete umbonal ridge and less oblique anterior margin. The posterior end also is comparatively narrower and the shell smaller. *Aristerella nitidula* is associated but cannot be confounded, since it is a smooth shell, with unequal valves, and much wider posteriorly.

*Formation and locality.*—Associated with *Plethocardia umbonata*, *Matheria rugosa* and other species marking the upper part of the middle third of the Trenton shales near Cannon Falls, Minnesota.

### MODIOLOPSIS CONCAVA *Ulrich.*

PLATE XXXVI, FIGS. 15, 16, 16a.

*Modiolopsis concava* ULRICH, 1892. Nineteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 227.

Shell very small, elongate, the greatest hight a little less than the length, arcuate, the posterior end much the widest and broadly rounded, the anterior end exceedingly short, narrow and contracted beneath the beaks; the latter are small, compressed, and project but little above the hinge. Hight of posterior third about two and one-half times as great as at the beaks. Dorsum gently arcuate; anterior two-thirds of ventral margin strongly concave, a fact due in a great measure to the width of the mesial sulcus and the rapid descent of the surface included in it. Umbonal ridge slight, cardinal slope, convex. In a dorsal view the anterior half of the shell appears compressed, yet the point of greatest thickness is very near the middle of the length. Surface marked with simple concentric lines of growth. Hinge plate very thin, without teeth or appreciable thickening under the beak. Muscular scars not observed.

This peculiar species, which is decidedly mytiloid in appearance and probably not a true *Modiolopsis*, is distinguished at once from all known Lower Silurian Lamellibranchiata, except *M. arcuata* Hall, by its strongly arcuate form. Hall's species is represented as larger and with a straight instead of convex back.

*Formation and locality.*—Same as the preceding.

### Modiolopsis concentrica *Hall and Whitfield.*

PLATE XXXVII, FIGS. 15 and 16.

*Modiolopsis concentrica* Hall and Whitfield, 1875. Pal. Ohio, vol. ii, p. 86.

Shell rather exceeding medium size, elongate ovate, highest in the posterior half. Hinge line arcuate, gently declining toward the extremity and rounding gradually into the oblique posterior margin, the same curve continuing to the lower third when it is sharpened in turning forward into the basal margin. The latter is gently convex in the posterior half and anterior third, the part between being very slightly concave. Anterior end very short, narrowly rounded. Beaks small, compressed, projecting very little above the hinge. Surface of valves moderately convex, most prominent a little in front of and above the middle; this point is on the umbonal ridge, which is low, broadly rounded, and not a conspicuous feature. Mesial sulcus shallow, forming an undefined depression across the valves from the beak to the middle third of the basal margin. Surface marked on the cardinal slope and posterior end by regular, even, concentric furrows, four to six of them in 5 mm. in their strongest parts. These furrows are most distinct along a line following the middle of the cardinal slope; in crossing the umbonal ridge they become suddenly obsolete, existing on the sides, basal portion, and anterior end only as fine irregular striæ of growth.

In casts of the interior the concentric furrows are distinctly visible on the posterior half of the cardinal slope. The mesial sulcus is much deeper and rather sharply defined on the posterior side by a strongly convex ridge extending obliquely across the cast from a point a short distance behind the beaks toward the basal margin, which, if the ridge did not become obsolete before reaching it, would be intersected at a point about three-fifths of the length of the shell behind the anterior extremity. In front of this ridge the surface is impressed and flattened to the strongly elevated filling of the anterior adductor scar. The latter is large, of oval shape, horizontally marked in its upper half, sharply defined all around and, because of the brevity of the anterior end, is situated partly beneath the point of the beak. Posterior scar large, but so faintly impressed that its exact shape cannot be determined with the material at hand. Pallial line distinct only in the anterior half, where it consists of an obscurely pustulose raised line.

To this species I refer provisionally a badly distorted mould of the exterior of a right valve, collected by me at Spring Valley in 1887. Its surface is marked precisely as described above, but the reference is still rendered doubtful by the fact that its anterior end is a little longer than is normal for the species. There is, however, no reason to doubt that *M. concentrica* occurs in Fillmore county, and it is to draw attention to its probable occurrence in Minnesota that the species has been included in the report.

*Formation and locality.*—A common species in the upper beds of the Cincinnati group at numerous localities in Ohio, Indiana and Kentucky. Probably also in the Hudson River shales near Spring Valley, Minnesota.

## MODIOLOPSIS EXCELLENS, *n. sp.*

PLATE XXXVI, FIGS. 13–14.

This species, of which we have five specimens, is closely related to *M. concentrica* Hall and Whitfield, and was at first confounded with it. A careful comparison however proved its distinctness in the following respects: It attains a larger size, the casts are more uniformly convex, with the mesial sulcus, on both the shell and the cast, much shallower, for which reason the ventral margin is very slightly convex where it is sinuate in that species. The outline differs also in the postero-cardinal region being less uniformly curved and more prominent at the extremity of the hinge. The anterior end is longer so that a line drawn from the point of the beak across the shell at right angles to the hinge line passes within the inner border of the anterior adductor scar, whereas it cuts a third of the scar away in *M. concentrica.* Finally, the concentric surface markings are finer and the difference between them as developed on the cardinal slopes and on the sides of the shell is a much less striking feature. The number of the concentric lines at a point about midway between the beaks and the posterior extremity varies in different specimens from six to nine in 5 mm.

What I regard as a nearer ally occurs at the top of the Cincinnati hills. The outline of this species is intermediate between figures 6 and 13 of plate XXXVI. In its characters also it approaches one almost as nearly as the other.

*Formation and locality.*—Upper part of the Hudson River group, Spring Valley and Granger, Minnesota.

*Mus. Reg.* No. 8374.

## Genus EURYMYA, n. gen.

*Modiolopsis (part.)* HALL and ULRICH.

Shell thin, short, compressed, high and subalate posteriorly, greatly narrowed anteriorly, transversely truncate-ovate or subtriangular in outline. Cardinal margin straight, base oblique, gently convex. Beaks small, near the anterior extremity. Umbonal ridge moderate, rounded or subangular. No mesial sulcus, the surface of the valves forward and downward from the umbonal ridge being slightly convex or flat rather than concave. Hinge strong, with a broad longitudinally striated ligamental area posterior to the beaks, and beneath them an obscure cardinal fold or tooth in the left valve and a corresponding depression in the right. Muscular impressions and pallial line apparently as in *Modiolopsis*.

Type: *Modiolopsis plana* Hall.

The alate appearance of the postero-cardinal region, rounded base, absence of a mesial depression, and the presence of a striated ligamental area are the principal distinguishing features when compared with *Modiolopsis*. The anterior part of the hinge is precisely as in *Modiomorpha*, Hall, but the Devonian shells, upon which that genus is founded, have no posterior striated ligamental area, while in nearly every other respect they agree with *Modiolopsis*. The new genus *Modiolodon* has one or more strong cardinal teeth in both valves, no ligamental area, and a mesial thickening of the inner sides of the valves that produces mesial sulci on the casts.

Besides the type only one other species has been described that I would place in this genus without question. This is the *Modiolopsis alata* Ulrich, from the hill quarries at Cincinnati, Ohio. A third form, if it is really distinct from *E. plana*, occurs in the middle beds of the Trenton in Kentucky and Tennessee. A possible fourth species is the *Modiolopsis truncata* Hall, a rare shell of the Cincinnati rocks. This species is known only from indifferently preserved casts of the interior. So far as these admit of judgment, the species might well be classed with *Eurymya*. Of the hinge nothing is known beyond this, that it was stronger than usual for *Modiolopsis*.

### EURYMYA PLANA *Hall*.

PLATE XXXVI. FIGS. 27 and 28.

*Modiolopsis plana* HALL, 1861. Rep't. Sup't. Geol. Sur. Wis., p. 30; Geol. Wis., vol. i, pp. 38 and 438, fig. 6; ULRICH, 1892, Nineteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 224.

Shell rather small, compressed, subtriangular in outline, alate and highest posteriorly, the greatest hight and length (the latter measured parallel with the hinge line) respectively as six is to seven. Cardinal margin straight, nearly as long as the shell; anterior end very small, sharply rounded above, curving backward into the slightly convex, medially almost straight, basal margin; posterior edge gently curved, truncate, nearly vertical, strongly convex below; above turning abruptly into the hinge line. Beaks small, but little incurved, not prominent, about one-sixth of the length of the shell behind the anterior extremity. Umbonal ridge moderate, cardinal slope flat or slightly concave, ventral and anterior slopes depressed convex. Surface marked with distant strong concentric lines of growth, and between these with a finer set. In casts of the interior the anterior muscular impression is well marked, not very large, vertical, situated in front of the beaks and close to the cardinal margin. A little more than one-third of the scar is divided off above by a distinctly impressed transverse line. Posterior scar indistinct, much larger than the anterior, situated behind the center of the posterior cardinal slope. Pallial line simple, rather distinct, not following the outline of the shell, being farther removed from the margin in the postero-basal region than elsewhere. Hinge as shown in figure 28 on plate xxxvi. Free casts of the interior of both valves, being without the hinge plate, are longer in proportion to the hight than are the impressions of single valves.

The shape of the shell will distinguish this species at once from all Minnesota Lamellibranchiata except *Matheria rugosa* and *Cyrtodonta affinis*, both of which occupy a higher horizon and have a different shell structure.

I have before me ten more or less complete silicified shells from the middle Trenton or "Orthis beds" of Tennessee and Kentucky. These belong to a species that is closely allied to *E. plana* and which may be called *Eurymya subplana*, n. sp. The new species does not attain the size of the Minnesota form, and is not so high and more oblique posteriorly, while the margin is less narrowly rounded in the postero-basal region. The Cincinnati species, *E. alata* (*Modiolopsis alata* Ulrich) is a slightly shorter and more compressed shell, with a more convex basal margin and different anterior muscular scar.

*Formation and locality.*—Lower limestone of the Trenton formation in Minnesota at Minneapolis, St. Paul and Cannon Falls. In Wisconsin the species seems to be restricted to the "Lower Blue" limestone at Janesville, Beloit and Mineral Point.

*Mus. Reg.* Nos. 749, 757, 5011, 5012, 5013, 5062, 5358, 5669, 5834, 8312.

## Genus ACTINOMYA, n. gen.

*Modiolopsis (part.),* of various authors.

Shell ovate, more or less elongate, narrowing anteriorly. Valves moderately ventricose, fitting each other tightly. Anterior end short, but not excessively so. Base gently convex, occasionally straight, never sinuate. Mesial sulcus wanting.

Beaks comparatively large, full and rather prominent. Umbonal ridge generally strongly rounded, sometimes subangular. Surface with concentric lines of growth and often with radii or divaricating folds; the radii sometimes restricted to the inner side of the shell, showing on casts of the interior and not on the exterior of the shell itself. Muscular scars and pallial line as in *Modiolopsis*, excepting that in the majority of the species they are very faintly impressed. Hinge plate edentulous, very narrow, especially so under the beaks, a little wider and grooved on each side for the reception of a linear internal ligament. A similar external ligament probably also present.

Type: *Modiolopsis cincinnatiensis* Hall and Whitfield.

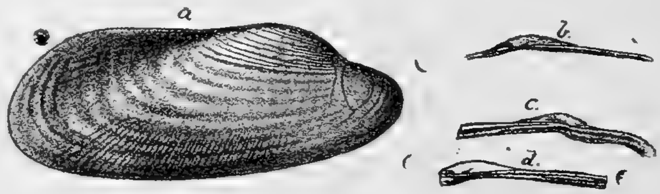


Fig. 39. *a*, a large right valve of *Actinomya cincinnatiensis*, mostly devoid of shell, showing the muscular scars and delicate internal radii on the cast; *b*, the hinge of another right valve of the same species; *c* and *d*, hinges of a left and a right valve of *Actinomya pholadiformis* Hall, sp. The student will do well to compare these hinges with those of *Modiolopsis* and related genera, figured on a succeeding page.

This genus brings into very natural association a number of Lower Silurian species, the described forms of which have heretofore been placed chiefly with *Modiolopsis*. These are *Modiolopsis cincinnatiensis* H. and W., *M. cancellata* Walcott, *M. pulchella* Ulrich, and two undescribed species from the lower or Utica horizon of the Cincinnati group, *A. subcarinata*, n. sp., from the Galena, and *Modiolopsis superba* Hall, *M. modioliformis* Meek and Worthen, and *Orthodesma saffordi* Ulrich, from the lower limestone of the Trenton formation.

Besides these, I propose to place here another group of species, so far known only from rocks above the Trenton, that approaches *Modiolopsis* in the strength and definition of the anterior adductor impression, while differing from that genus, and therein giving us a clue to their origin, in the convexity of the basal outline and absence of a mesial depression or so-called "byssal sulcus," and in the character of the hinge, which is thinner, and thus more like that of an *Orthodesma* than of species of *Modiolopsis* of the same size. Four species of this kind, all from the Cincinnati rocks, are known to me, only two of them, however, being described, *i. e.*, *Modiolopsis pholadiformis* Hall, and *M. oblonga* Ulrich.*

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*Mr. S. A. Miller has described three forms having surface markings like *Actinomya pholadiformis*. These *may* be distinct from Hall's species, but I cannot now admit that they are. The one called *M. sulcata* is almost certainly founded upon vertically compressed specimens of the *pholadiformis*, while the *M. corrugata* is, so far as I can make it out, in no wise different from the same species.

The systematic position of *Actinomya* seems to be nearly intermediate between *Orthodesma* and *Modiolopsis*, differing from the former in the somewhat shorter form and tightly closing instead of gaping valves, from the latter in the thinner hinge plate and shell, and from both in the convex basal outline and absence of a mesial sulcus.

ACTINOMYA MODIOLIFORMIS *Meek and Worthen.*

PLATE XXXVI, FIGS. 19 and 20.

*Modiolopsis modioliformis* MEEK and WORTHEN, 1868. Geol. Sur. Ill.; vol. iii, p. 294.
Compare *Modiolopsis superba* HALL, 1861. Rep't., Sup't. Geol. Sur. Wis., p. 31.

Shell of medium size, elongate, obliquely ovate, much the widest in the posterior half; strongly convex. Hinge nearly straight, rather short, extending anterior to the beaks almost half as far as posterior to them, and posteriorly less than half the distance from the beaks to the posterior extremity of the shell. From the hinge the outline passes almost imperceptibly into the oblique posterior margin, and this slopes backward with a gentle convexity to the abruptly rounded posterior basal extremity. Basal margin extending obliquely upward and forward, very slightly convex throughout its length. Anterior end narrow, rounding sharply into the extremity of the hinge. Beaks rather prominent, incurved, situated about one-sixth of the entire length of the shell from the anterior extremity; a strongly rounded or subangular umbonal ridge extends from the beaks to the posterior extremity of the shell, the convexity becoming gradually less as it recedes from the beaks. Surface with fine concentric striæ and rather strong (especially on the flattened regions anterior to the umbonal ridge) wrinkles of growth. Muscular impressions so faint that they cannot be traced with certainty on the casts of the interior at hand.

I believed this species to be identical with Hall's previously described *Modiolopsis superba*, but Prof. R. B. Whitfield, to whom a specimen was sent for comparison with the original types of Hall's species, writes me that it is "less angular on the umbonal ridge, more rounded on the base, and fuller on the lower disc." These differences are probably of specific importance. Figure 20 is taken from the type used by Meek and Worthen. The specimen, though a good one, is slightly distorted by vertical pressure, and imperfect in front and along the base. To facilitate comparison with fig. 19, the missing parts have been restored in the figure.

This fine species I regard as in every sense an *Actinomya*. It is, perhaps, nearer *A. saffordi* Ulrich, than any other known, but there is little likelihood of confusion between them, that species being a higher shell, with a larger anterior end and somewhat smaller umbones. It has also several radiating folds on the posterior cardinal slope not seen in this species.

*Formation and locality.*—Lower part of the Trenton formation at Beloit and Mineral Point, Wisconsin. Not yet known to have been found in Minnesota, but there is no reason why it should not occur in the limestone at Minneapolis, St. Paul and elsewhere in the state.

*Mus. Reg.* No. 8341.

### ACTINOMYA SUBCARINATA, *n. sp.*

PLATE XXXVI, FIGS. 17 and 18.

Shell of the same general form as *A. modioliformis* M. and W. sp., only smaller, not so oblique, subalate and higher posteriorly and consequently not so elongate. The hinge also is longer, the posterior margin more erect and the junction between them subangular. The postero-basal margin, furthermore, is not so sharply rounded, while the beaks are less incurved and farther apart. Surface of cast entirely smooth except between the umbonal ridge and the postero-cardinal border, where a number of very fine radiating striæ are obscurely visible.

This species reminds somewhat of the New York Trenton *Modiolopsis aviculoides* of Hall (Pal. N. Y., vol. i, p. 161; 1847), but I cannot believe they are identical. Indeed, it is more likely that they will prove widely distinct. I know of no Minnesota species with which it might be confounded.

*Formation and locality.*—Rare in the shaly part of the middle Galena of Goodhue county, Minnesota.

## Genus ORTHODESMA, Hall and Whitfield.

*Orthodesma*, HALL and WHITFIELD, 1875. Pal. Ohio, vol. ii, p. 93.

Shell elongate, usually increasing slightly in hight posteriorly. Anterior end comparatively long, contracted in front of the beaks. Valves moderately convex, usually with a strong umbonal ridge and a broad mesial depression in front of it, their edges fitting tightly along the straight or sinuate ventral margin, but leaving a narrow gape at each end. Umbones prominent, wide, compressed, often extending posteriorly as low cardinal ridges between which the hinge is sunken. Hinge plate edentulous, very thin, long, extending in almost a straight line from the posterior cardinal angle, past the beaks, nearly to the anterior extremity of the shell. Ligament linear, internal and external, the latter chiefly. Posterior muscular scar large, very faint, elongate ovate; anterior scar large, though scarcely half the size of the posterior, well defined, ovate or approaching semicircular in shape, the vertical diameter the longest. Pallial line simple. Shells thin, marked externally with more or less distinct concentric striæ and wrinkles.

Type: *Orthodesma rectum* Hall and Whitfield.

The above diagnosis does not agree exactly with Hall and Whitfield's original description of the genus, but as it corresponds with the fossils no apology is necessary. They make, for instance, the erroneous statement that the hinge plate is bent down in front of the beaks; and the fictitious feature has become so well established in literature that it stands as the most important peculiarity of the genus, indeed, as the only one separating it from *Orthonota*, Conrad. Now, despite the fact that the hinge plate is nearly or quite as straight in *Orthodesma* as in *Orthonota*, I am fully satisfied that there is little affinity between the two genera. The Lower Silurian genus, doubtless, is closely related to *Modiolopsis* and *Actinomya*. Not so, however, with the Devonian genus, which seems to me to be totally different and nearer *Solen* than *Modiolopsis*.

Species have been placed under *Orthodesma* that are very different from the types, some of them belonging, I believe, to other families. Thus, *O. byrnesi* S. A. Miller, and *O. mickleboroughi* Whitfield, belong to *Rhytimya*, a new genus that obviously belongs to the same family as *Pholadella*, Hall, and *Allorisma*, King. *O. cuneiforme* Miller, has recently been made the type of his new genus *Sphenolium*. This genus seems to be related to *Cuneamya* and therefore cannot belong to the *Modiolopsidæ*. *O. subovale* Ulrich, together with a number of undescribed species, belongs to the new genus *Psiloconcha*, while *O. saffordi* Ulrich, should be referred to *Actinomya*.

### ORTHODESMA MINNESOTENSE *Ulrich.*

PLATE XXXVII, FIGS. 12 and 14.

*Orthodesma minnesotense* ULRICH, 1892. Nineteenth Ann. Rep. Geo. Nat. Hist. Sur. Minnesota, p. 228.

Shell small, elongate, subrhomboidal, with the dorsal and ventral margins nearly straight and parallel; the length two and one-half times the width. Beaks small, incurved, compressed, projecting moderately above the hinge and situated about one-fourth of the entire length from the anterior extremity; posterior umbonal ridge subangular, cardinal slope abrupt, in casts of the interior with a linear impression close to and on each side of the hinge line. Anterior end small, contracted a little in front of the beaks, almost uniformly rounded; posterior end oblique, sloping upward and forward from the produced and narrowly rounded lower part.

Interior with the anterior pair of muscular scars rather distinctly marked and large; above and between them and the beaks, two other very small pairs of scars are to be seen on the specimen figured above, but the posterior muscles left no appreciable impressions. Surface of casts with few obscure folds of growth.

This shell is related to *O. curvatum* Hall and Whitfield, though more nearly approaching *O. contractum* Hall, in its outline. It differs from both in having the posterior end narrower and in wanting the strong concentric furrows which occur on the posterior cardinal slopes of those shells.

*Formation and locality.*—Middle third of the Trenton shales, St. Anthony Park, St. Paul, Minnesota.

## Orthodesma schucherti, *n. sp.*

PLATE XXXVI, FIGS. 25 and 26.

Shell only moderately elongate, subovate, between two and two and one-half times as long as wide; cardinal and basal margins nearly straight, gradually diverging posteriorly to near the posterior end, where the hight is equal to once and a half times the hight at the beaks; posterior margin obliquely truncate above and rather strongly rounded in the lower half; the anterior end, though narrowly rounded, is still a little wider and shorter than usual for the genus. Umbones not prominent, less so than usual, compressed; beaks incurved, a little less than one-sixth of the length of the shell from the anterior extremity; umbonal ridge subangular and a well marked feature above, becoming obtuse and at last indistinguishable as it is traced to the postero-basal margin. Mesial sulcus undefined, obsolete, the surface anterior to the umbonal ridge being scarcely flattened. Surface with a very fine and a stronger set of concentric lines. Anterior muscular impression large, well defined, the inner side somewhat straightened, giving it a semicircular shape.

This species, which, in the absence of a mesial sulcus, recalls *Actinomya*, is still so much like *Orthodesma* in all other respects that its generic position cannot be in doubt. Indeed, excepting the feature mentioned, the species is very similar to *O. recta*, the type of the genus. That species is more elongate and narrower posteriorly, and has oblique folds on the cardinal slope not seen on the Minnesota form.

The specific name is given in honor of Mr. Charles Schuchert, who found the only specimen seen.

*Formation and locality.*—Middle Galena, Weisbach's dam, near Spring Valley, Minnesota. *Mus. Reg.* No. 8343.

## Orthodesma subnasutum *Meek and Worthen.*

PLATE XXXVI, FIGS. 23 and 24.

*Modiolopsis subnasuta* Meek and Worthen, 1870. Proc. Phila. Acad. Nat. Sci., p. 41; 1875, Geol. Sur. Ill., vol. vi, p. 494. (Not *Modiolopsis subnasuta* Hall, 1860.)
*Modiolopsis carrollensis* Worthen, 1882, Bull. No. 1, Ill. St. Mus. Nat. Hist.

Shells rather small, elongate, narrow and slightly arcuate, the length a little more than two and one-half times the greatest posterior hight and more than three and a half times the hight at the beaks. Valves rather strongly convex, the most prominent part being on the well defined umbonal ridge a little behind and above the middle of the valves. Dorsal and ventral margins slightly diverging posteriorly, the former very gently arcuate, the latter with an equally slight and broad sinuosity chiefly anterior to the middle. Anterior end narrow, produced, rather sharply rounded posterior edge obliquely truncate, very gently convex above the narrowly rounded basal part and passing rather abruptly into the hinge line. Beaks not prominent, compressed, situated between one-fifth and one-sixth of the length of the shell behind the anterior extremity. Surface of cast showing moderately distinct irregular concentric undulations, which are most strongly defined on the umbonal ridges and on the flattened or concave flanks. These are crossed on the cardinal slopes by two obscure sulci. Anterior muscular scar moderate in size and definition, ovate; small pedal muscular scars distinct above them.

The valves of this shell gape very slightly posteriorly and probably also in front, but upon this point the material at hand presents no conclusive evidence. They have also the point of greatest convexity a little behind the center. Both of these features are characteristic of *Orthodesma*. On the other hand the species presents considerable resemblance to the early elongate forms of *Modiolopsis* like *M. arguta*, but this indicates, I believe, merely, what I have already stated, a common origin for the two genera and not that *O. subnasutum* was evolved from the *Modiolopsis*. I come to this conclusion because the present species is even nearer the *O. minnesotense* which occurs in the same beds holding *M. arguta*. Further, as regards the developmental history of *Orthodesma*, I view *O. minnesotense* and *O. subnasutum* as the earliest known stages in the line of development that produced *O. curvatum* H. and W., and one or two undescribed species occurring at Cincinnati, Ohio, while *O. rectum* H. and W., appears to have been derived through intermediate species from *O. schucherti*.

Specifically *O. subnasutum* is distinguished from *O. minnesotense* by its more elongate and posteriorly diverging form, better defined mesial depression, the longitudinal sulci on the cardinal slope, and more distinct concentric folds.

As regards the name of the species, it will be seen from the synonomy that Meek and Worthen first called it *Modiolopsis subnasuta*, being evidently unaware that the same name had been used previously by Prof. James Hall (Can. Nat. and Geol., vol. v, p. 148; 1860) for an Upper Silurian species from Canada. This fact being brought to the notice of Prof. Worthen he, in 1882, proposed to change the name to *Modiolopsis carrollensis*, and this specific designation will have to be used should the Canadian species also prove to be an *Orthodesma*. But until that has been established, the original name will have a clear field.

*Formation and locality.*—The types of the species are from the Galena of Carroll county, Illinois. The specimen here figured and described is from the same horizon near Dixon, Illinois. In Minnesota the species is to be looked for in the "Maclurea beds" of the Galena.

## ORTHODESMA CANALICULATUM.

PLATE XXXVII, FIGS. 7–11.

Shell elongate, the length three times the hight; cardinal and basal margins straight, nearly parallel; posterior margin oblique, rounding into the hinge line, below which it slopes backward with a gentle curve to the postero-basal extremity where it turns abruptly into the basal line; anterior end contracted in front of the beaks, of moderate length, rounded, most prominent a little above the middle. In a side view the beaks project very little, are compressed by a broad shallow sulcus which crosses the valves and occupies a large part of the anterior three-fifths of the shell; umbonal ridge rather distinct, extending from the beaks to the postero-basal extremity. In a cardinal view of casts of the interior, the only condition in which the species has been noticed, the hinge line is strongly depressed, lying at the bottom of a wide and deep channel, deepest between the rather widely separated beaks and gradually shallowing posteriorly. Casts usually almost smooth, exhibiting only a small number of obscure concentric furrows. One specimen preserves a small part of the shell and this shows that near the dorsal edge the outer surface is marked with somewhat regular raised lines, about six of them in 5 mm. The best preserved casts exhibit in the posterior half of the mesial sulcus a number of obscure radii. Anterior muscular scar sharply defined at the inner side, rather small, broad-oval or circular, occupying the middle two-fourths of the upper half of the anterior end. Posterior impression somewhat larger than the anterior, subcircular, with a narrow prolongation extending forward nearly parallel with the posterior cardinal margin. Pallial line distinct in the anterior half, consisting (on the casts) of a straight row of obscure pustules extending in a slightly oblique direction from the base of the anterior adductor impression toward a point much nearer the ventral border.

There are several peculiar features about this species. (1) I have never seen its valves separate, a fact indicating, if it is not fully accounted for by the next circumstance, a strong ligament. (2) Its natural position seems to have been with the anterior end down, and so it is commonly found in the shales, and in consequence it is often greatly shortened by pressure. (3) The channel-like depression of the hinge; and (4) the unusual course of the anterior half of the pallial line. These peculiarities distinguish the species readily from all others of the genus known.

*Formation and locality.*—Hudson River group, Spring Valley, Minnesota. Fragments have been found at many localities in Ohio and Indiana where the upper beds of the Cincinnati formation are exposed. Good specimens, however, are very rare.

## Genus MODIOLODON, n. gen.

*Cyrtodonta* (part.) SAFFORD, 1869, Geol. of Tenn.; *Modiolopsis* (part.), ULRICH, 1890, Amer. Geol., vol, v.

Ovate shells of the same general type as *Modiolopsis* and *Modiomorpha*, but having from one to three oblique cardinal teeth in each valve.

Type: *Modiolopsis oviformis* Ulrich.

The hinge in this genus is much like that of *Ischyrodonta*, Ulrich, and I might have placed the species under that genus were it not for the fact that their shells are of the same composition as those of *Modiolopsis*, while the shells of that genus are generally heavier and of the more calcareous nature characterizing the *Cyrtodontidæ*.

The development of distinct cardinal teeth is an important deviation from *Modiolopsis*, and I cannot see how any one could object to the generic separation of species possessing them. Surely, if *Modiomorpha* can stand, then *Modiolodon* must, for its claims for recognition are certainly better. This may be seen from the accompanying sketches of the hinges of the three genera.

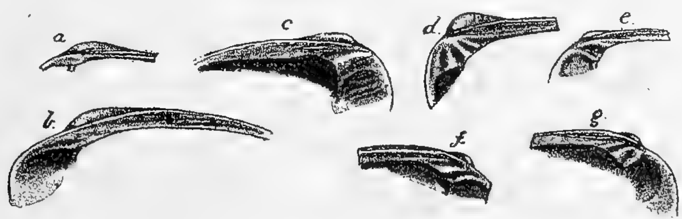


Fig. 40. Hinges of *Modiolopsis*, *Modiomorpha* and *Modiolodon*. *a*, anterior half of hinge of a right valve of *Modiolopsis versaillensis* Miller, from the upper part of the Cincinnati group at Versailles, Indiana. *b*, hinge of a right valve of *Modiolopsis valida*, a new species from the top of the Lower Silurian at Waynesville, Ohio. This species, though closely related to *M. modiolaris*, has a wider hinge plate than in any other species of the genus known. *c*, hinge of a left valve of *Modiomorpha concentrica* Conrad, sp., from the Hamilton of New York. *d*, anterior part of hinge of right valve of *Modiolodon ganti* (*Cyrtodonta ganti* Safford), *e* and *f*, of right and left valves of *Modiolodon winchelli* (*Cyrtodonta winchelli* Safford), and *g*, of a left valve of *Modiolodon oviformis* Ulrich; all from the middle Trenton ("Orthis beds") of Wilson county, Tennessee, and from specimens kindly given to the author by Prof. J. M. Safford.

*Modiolodon ganti* and *M. winchelli*, two of the most typical species of this genus, were placed into the genus *Cyrtodonta*, Billings, by Prof. Safford. Aside from their different shell structure, they have no right in that genus, being without posterior lateral teeth.

### MODIOLODON PATULUS, *n. sp.*

PLATE XXXVII, FIGS. 20–24.

Shell of medium size, suberect, compressed convex, broad ovate, very inequilateral; anterior end very short, in the casts occupied almost entirely by the strongly elevated, lobe-like, anterior muscular scar. Hinge line short, the posterior part of the cardinal region compressed and rounding, except in the youngest stages, gradually into the posterior margen. Beaks small, rather prominent, scarcely incurved in the shell and not at all in the casts. Surface of casts almost uniformly convex. Pallial line distinct along the anterior and ventral margins, not traced posteriorly; nor has the posterior muscular scar been observed. Hinge with two interlocking cardinal teeth in the left valve, and corresponding sockets and teeth in the right.

This shell is wider, more erect and more uniformly convex than *M. oviformis*, the type of the genus. The erectness of the beaks is a very unusual feature among the *Modiolopsidæ* and should render good service in the identification of the species.

*Formation and locality.*—Middle Galena, Kenyon, Goodhue county, Minnesota, and Decorah, Iowa; also in the Trenton near Danville, Kentucky. Rare.

*Mus. Reg.* No. 8363.

### Modiolodon (?) gibbus, *n. sp.*

PLATE XXXV. FIGS. 28 and 29.

Shell small, obliquely ovate, the anterior end very small, separated as a bicarinated lobe from the body of the shell by a distinct sulcus extending vertically across the valves from the anterior side of the beaks. Behind this sulcus the valves are gibbous, especially in the umbonal region and anterior to the center; posterior cardinal region somewhat compressed; beaks full, prominent, incurved. Surface with simple concentric lines of growth, rather stronger in the sulcus than elsewhere. Hinge very thin immediately under and behind the beaks. It widens some in front of them, and here the left valve exhibits a small protuberance. Being a small shell, and the specimen not very well preserved, the nature of this protuberance has not been determined with certainty. Examined under a good lens it looks like the remains of a double tooth. Muscular scars and pallial line not observed.

This species cannot be confounded with any Lower Silurian bivalve known to me. The small size and peculiar character of the anterior end, and the unusual gibbosity of the shell, render its systematic position doubtful. I place it with *Modiolodon* chiefly because the outline is much like that of *M. patulus*, but I suspect strongly that it belongs to an undescribed genus.

*Formation and locality.*—Upper third of the Trenton shales near Cannon Falls, Minnesota.

## Genus COLPOMYA, n. gen.

Shell subelongate, oblique, inequilateral, subrhomboidal or ovate in outline, widest posteriorly or with the ventral and dorsal margins nearly parallel. Mesial sulcus distinct, causing a flattening of the umbones and a sinus in the ventral margin. Umbonal ridge prominent, strongly convex. Hinge plate straight, long, very thin posterior to the beaks, much heavier in front of them; beneath the beak of the right valve a tooth-like prominence which fits into a corresponding depression beneath the beak of the left valve; in front and beneath this depression in the left valve, a strong process projects obliquely downward, backward and toward the opposite valve, and is partly received in a socket that defines the anterior side of the tooth in the right valve, while its lower end curves under that tooth. Muscular scars and pallial line apparently as in *Modiolopsis*, excepting that there is a small accessory scar in the hinge plate just behind the anterior adductor,as in *Ischyrodonta*.

Type: *Colpomya constricta* n. sp.

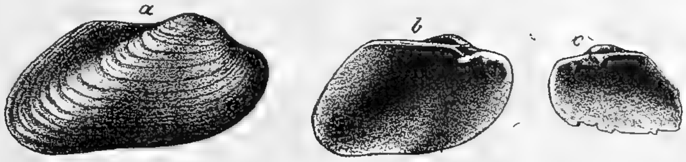


Fig. 41. *Colpomya constricta* Ulrich, top of Trenton group, Frankfort, Kentucky. *a*, right valve, showing the usual characters of the species; *b*, interior of a left valve; *c*, interior of an imperfect right valve.

*Colpomya* evidently belongs to the *Modiolopsidæ* with relations to *Modiolopsis, Modiolodon* and *Orthodesma*. In none of those genera, however, are the umbonal ridges and the mesial sulci quite such marked features, at any rate it would be rare, so that we may fairly regard their distinct development in shells of this family as indicative of *Colpomya*. When we come to internal characters all comparisons with the first and last of these genera may as well cease, since in both the hinge is practically toothless. In *Modiolodon*, however, we find cardinal teeth, but every one will admit that they are very different from those of the genus under consideration. There is nothing to represent the oblique process which projects under the tooth and hinge plate of the right valve, the teeth being approximately equal in the two valves of *Modiolodon*.

The species to be placed ino this genus are not numerous and with two possible exceptions are all new. The exceptions are *Modiolopsis milleri* Ulrich, from the Cincinnati rocks, and *M. faba* Hall, said to be a Trenton and Hudson River species. The general expression of these shells is very much as in undoubted species of *Colpomya*, but as their hinges are not yet known, their removal from *Modiolopsis* now would be of very doubtful advantage. Of four new species, *C. demissa* is a lower Trenton form, while the type of the genus and two other species occur in the upper Trenton of Kentucky.

### Colpomya demissa, *n. sp*,

PLATE XXXVI, FIGS. 21 and 22.

Shell small, gibbous, arcuate, subtriangular, very high posteriorly; hinge line very slightly arcuate, nearly as long as the shell, forming an angle where it joins the nearly erect and broadly rounded posterior margin; ventral margin abruptly rounded and much produced in the posterior third, then ascending rapidly with a broad yet distinctly concave curve into the narrow anterior end, which is most prominent above where it turns sharply into the hinge line. Beaks of moderate size, compressed, incurved, about one-sixth of the length of the shell from the anterior extremity; umbonal ridge prominent, strongly rounded, curved. Mesial sulcus broad and deep, occupying the greater portion of the ventral slope. Cardinal slopes slightly concave, somewhat compressed and alate posteriorly. Surface with distinct subequal concentric striæ. Hinge and interior unknown.

The prominent umbonal ridge and deep mesial sulcus are the characters that have induced me to place this peculiar little shell with *Colpomya*. Compared with the other species of this genus, it will be found to differ in the much greater hight of its posterior end. Of Minnesota species only *Modiolopsis concava* is at all similar, but even here there is scarcely a possibility of confusion, that species being more elongate, its anterior end much narrower and the posterior outline quite different.

*Formation and locality.*—Middle third of the Trenton shales, Chatfield, Minnesota.

## Genus ARISTERELLA, n. gen.

Shell small, almost smooth, subovate, moderately convex, inequivalved, the left valve smaller than the right. No mesial sulcus. Muscular and pallial impressions as in *Actinomya*. Hinge plate apparently very thin and edentulous.

This genus is founded upon a single species, which might have been placed into either *Actinomya* or *Eurymya* were it not for its unequal valves.

### Aristerella nitidula, *n. sp.*

PLATE XXXV, FIGS. 30—39.

Shell small, 5 to 8 mm. long, subovate, narrowest anteriorly; hinge line nearly straight, long; posterior margin slightly oblique, broadly rounded, subangular at the extremity of the hinge; basal margin gently convex, ascending into the narrowly rounded anterior end. Beaks situated about one-fifth of the length of the shell from the anterior extremity, small, projecting slightly above the hinge, and that of the right valve beyond that of the left. Umbonal ridge inconspicuous. Surface of shell smooth, nothing but an occasional growth line having been detected on any of the specimens seen. A good cast of the interior shows that the pallial line and muscular scars are very faintly impressed; the anterior scar is small, ovate, and situated in front of the beaks close to the hinge line; the posterior scar at least twice as large and situated just behind the center of the cardinal slope. As shown in figs. 33 and 35, the relative convexity of the two valves varies, the thickness of the left in some specimens being only half as great as that of the right, while in others it is quite two-thirds. A slight gap is left between the posterior edges of the valves.

I am not acquainted with any Silurian shell with which this species might be confounded. Several small species of *Modiolopsis* and *Colpomya demissa* are associated with it, but they can all be distinguished without the slightest trouble.

*Formation and locality.*—Middle third of the Trenton shales, Chatfield, Minnesota.

*Mus. Reg.* No. 8450.

## Genus ENDODESMA, n. gen.

Shell elongate, the dorsal and ventral margins subparallel, equivalved, generally ventricose. Mesial depression deep, often producing a decided oblique contraction of the shell and a sinus in the basal outline. Umbones compressed, elevated considerably above the hinge line on the anterior side, but not on the posterior side. Hinge thin, apparently edentulous. A strong linear internal ligament was attached on each side to a rib or ridge. Back of shell flattened or with the edges of the valves bent inward without, however, forming a true escutcheon. More or less well defined lunule in front of the beaks. An obscure sulcus in the middle of the cardinal slope. Shell very thin; surface marked with concentric growth lines. Muscular scars and pallial line so faintly impressed that they have not been determined satisfactorily.

Type: *Endodesma cuneatum*, n. sp.

This well marked genus is placed in the family *Modiolopsidæ* chiefly in deference to the views of Hall, Billings, and Meek and Worthen, who have each described a species as belonging to *Modiolopsis*. According to my own conviction there is little indeed to suggest that genus, the shape of the shell being often quite different (in this respect some of the species remind of *Orthodesma*) and the mesial depression deeper, while the faintness—so far as can be seen the total absence—of muscular scars on casts of the interior is not only a striking but an important difference. In the faintness of the muscular impressions the new genus agrees with the most typical forms of *Actinomya*, but they are distinguished at once by their want of a mesial contraction, in consequence of which their basal outlines are gently convex instead of sinuate. *Endodesma* finally is separated from all true *Modiolopsidæ* by the lunule in front of the beaks and the sulcus and ridge on each side of the hinge line.

A more natural placement of the genus seems to me to be near *Rhytimya*, Ulrich, which is regarded as an early type of the *Pholadellidæ*. But as *Endodesma* evidently is a complex primitive type with characters suggesting widely different Lamellibranchiata it is probably good policy to defer coming to a final conclusion as to its position until we know more of the origin of the group of species and its development in times succeeding the Trenton to which all the species now known are restricted.

Six species of *Endodesma* are illustrated in this work. Besides these, *Modiolopsis? trentonensis* (Conrad) Hall, is almost certainly also referable to the genus.

### Endodesma cuneatum, *n. sp.*

PLATE XXXVI, FIGS. 33, 34.

Shell elongate, the length and greatest hight, which is subcentral, respectively as nine is to four. Valves strongly convex, the point of greatest thickness on the umbonal ridge above and in front of the center; cuneate posteriorly. Dorsal margin gently arcuate, passing rather gradually into the posterior outline; the latter is prominent and sharply rounded near the middle, nearly straight in the upper half and slightly convex below; ventral margin gently convex in the posterior half, straight or barely sinuate near the center of the anterior half, and rather strongly convex in front; anterior end short, most prominent and narrowly rounded in the middle, very slightly concave in the upper half. Beaks of moderate size, strongly incurved, with a rather distinct lunette beneath them; mesial sulcus clearly defined; umbonal ridge unusually prominent, subangular near the beaks. Cardinal slope abrupt, concave, in casts of the interior showing a well marked curving depression and ridge on each side of the hinge line. Surface of cast with a few obscure concentric folds. Anterior muscular scar very faint, situated just within the anterior extremity of the shell, of semielliptical shape, the inner side straight.

This species must be closely related to *E. trentonense* Hall sp., from the Trenton of New York, but in the figure of that species the anterior end is quite different, being shorter and obliquely truncate. The anterior end of the Minnesota form is more like that of the Canadian *E. gesneri* Billings, sp., but in other respects these two species are quite distinct.

*Formation and locality.*—The specimen figured, which is the only one seen, was discovered by Dr. C. H. Robbins in the middle Galena near his home at Wykoff, Minnesota, and kindly given to the author for description.

### Endodesma postlatum, *n. sp.*

PLATE XXXVII, FIGS. 5 and 6.

Of this species I have seen only a single imperfect specimen—which under ordinary circumstances would scarcely merit description. Being however the most recent existence of the genus now known it is of interest as it may give us a clue to the later development of the genus. As may be seen from the figures the species is closely related to *E. cuneatum* but, as the name implies, the posterior width (hight) is greater in *E. postlatum.* In a cardinal view both ends also are more obtuse, giving greater convexity to the sides; the umbonal ridge, though prominent, is not so sharply rounded, the umbones fuller, the anterior end shorter, and the posterior margin more broadly rounded and most prominent in the basal half instead of near the middle. Finally, the mesial sulcus crosses the valves more obliquely and the sinuation of the ventral margin is wider and nearer the center of the length of the shell.

The side view of this shell is considerably like that of several species of *Modiolopsis*, but the absence of a strong anterior muscular scar on casts and the presence of the concave areas bordering the hinge line proves that it is not a *Modiolopsis* but an *Endodesma.*

*Formation and locality.*—Uppermost beds of the Galena, Dubuque. Iowa, where it was collected by Mr. Charles Schuchert.

*Mus. Reg.* No. 8345.

### Endodesma orthonotum *Meek and Worthen.*

PLATE XXXVII, FIGS. 1 and 2.

*Modiolopsis orthonota* Meek and Worthen, 1868, Geol. Sur. Ill., vol. iii, p. 295.
*Modiolopsis rectiformis* Worthen, 1882, Bull. No. 1, Ill. St. Mus. Nat. Hist., p. 38.

Shell elongate, the length being nearly three times the hight; valves quite convex, the greatest convexity being a short distance above the middle, in front of which they have an undefined concavity commencing in the umbonal region and widening and deepening to the base in front of the middle. Cardinal margin long, very nearly straight or but slightly arched; posterior margin obliquely substruncated, sometimes very faintly sinuous above, and rather narrowly rounded below the middle; basal margin subparallel to the dorsal, gently convex behind the middle, and broadly sinuous between the middle and the front; anterior side short, contracted beneath the beaks, narrowly rounded. Beaks depressed, appearing on a line with the dorsal margin, strongly incurved, placed about one-sixth of the entire length of the valves behind the anterior extremity; lunule rather large but not sharply defined. In the cast the dorsal edge from the beaks to near the posterior extremity of the hinge appears bent inward and downward. Surface marked with moderately distinct concentric striæ of growth, crossed on the dorsal slope by an obscure sulcus, extending obliquely from the posterior side of the beaks to the middle of the obliquely subtruncated upper part of the posterior margin.

Length about 64 mm., greatest posterior hight 22 mm., anterior hight 21 mm., convexity 20 mm.

The above description is founded upon the original type of the species which is preserved in the Illinois State Museum. The obscuring matrix of which the authors of the species complain was removed without much trouble and a good cast prepared. The figures on plate 37 were drawn from this counterfeit of the type and and give a reliable idea of the species, which most certainly cannot be said of Meek and Worthen's illustration.

Comparing the species as it is now known with other forms of the genus *Endodesma* we find that it is one, and the earliest, of three closely related forms which at first seemed scarcely distinguishable. As usual, however, with such hasty conclusions their error soon became manifest when careful comparisons were undertaken, so that now I may say that they are not only separable but with ease even when the specimens are complete. Thus the second of these species—the next described, *E. undosum*—is distinguished from Meek and Worthen's species by its irregularly undulating surface, more distinct growth lines, and uniformly rounded posterior margin. The third species, *E. gesneri* Billings' sp., is nearer than *E. undosum*, but as a comparison of figures 1, 2, 3 and 4 on plate 37 will show, there is in this case even little trouble in drawing the specific lines. Meek and Worthen in distinguishing *E. orthonotum* from the Canadian species seem to have relied chiefly upon the more central position of the point of greatest convexity in their species, but this difference is much less in the specimen of *E. gesneri* here illustrated.* We must therefore depend upon other differences among which I find one that seems to be well marked, namely, the anterior extremity of *E. gesneri* is subangular while in *E. orthonotum* it is almost regularly rounded. Carrying our comparison to other points we find that in the latter the upper posterior edge is more truncated, the dorsal outline somewhat straighter, and the valves on the whole more convex and a little longer.

I have rejected Worthen's name *rectiformis* because under *Endodesma* the specific name *orthonotum* is not preoccupied as was the case under *Modiolopsis.*

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*In Billings' figure 45 *b* (Palæozoic Fossils, vol. i, p. 43) this point is so far behind the center that I am constrained to believe the figure overdrawn or the specimen abnormal in this respect.

*Formation and locality.*—Lower Trenton limestone, Dunleith, Illinois. There is reason to believe the species occurs in Minnesota and it will be well to search for it in the limestone at Minneapolis and St. Paul. If *E. gesneri* occurs in the rocks of the state it will most probably be in the middle division of the Galena.

### ENDODESMA UNDOSUM, *n. sp.*

PLATE XXXVI, FIG. 38.

Shell of the same general form as *E. orthonotum* M. and W., sp., being elongate, with the length a little more than twice and a half the hight; dorsal and ventral margins subparallel; posterior edge almost uniformly rounded; anterior end short, narrowly convex. Beaks depressed, wide, strongly incurved; umbonal ridge inconspicuous; mesial depression undefined, wide, rather shallow. Lunule narrow but shaply defined. Ridge and sulcus rather distinct in the anterior half of the posterior dorsal slope of casts. Surface of casts with numerous strong and somewhat irrregular concentric lines of growth; on the dorsal slope and umbonal ridge a number of large and very irregular undulations or depressions.

This species is distinguished from *E. gesneri* Billings, sp., and *E. orthonotum* M. & W. sp., by its stronger lines of growth, the irregular surface undulations, and more uniformly rounded posterior margin.

*Formation and locality.*—"Upper Buff Beds" of the Trenton formation, one and a half miles west of Beloit, Wisconsin, where it was collected by Mr. Charles Schuchert.

*Mus. Reg.* No. 8344.

### ENDODESMA COMPRESSUM, *n. sp.*

PLATE XXXVI, FIGS. 35 and 37.

Shell elongate, dorsal and ventral margins subparallel, the length two and one-half times the hight. Anterior margin concave above, most prominent and subangularly bent down at the middle, beneath which point the upper part of the gradual curve into the basal line is nearly vertical; ventral outline very broadly sinuate; posterior margin oblique, most prominent and strongly rounded in the lower half, above passing rather gradually into the hinge line. Beaks compressed, mesial depression or sulcus illy defined but very wide, causing the sinuosity of the ventral margin to extend farther posteriorly than usual. Umbonal ridge rather sharply defined on the upper side by the distinctly concave character of the dorsal slope. Dorsal edge inflected, the inflected part extending rather far inward under the beaks (see fig. 37). Lunule narrow, deep and well defined. Surface of cast with a few obscure concentric undulations.

This species seems to be more nearly related to *E. gesneri* Billings, sp., than to any of the others. It is however readily distinguished by the broader sinuosity

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of the ventral margin, more compressed dorsal regions, sharper umbonal ridge, and somewhat different posterior outline. The central and posterior parts of the shell also are less convex.

*Formation and locality.*—Middle Galena, near Wykoff, Minnesota.

## Genus PSILOCONCHA, n. gen.

Shell elongate subelliptical, compressed convex, gaping slightly at both ends; inequilateral, with very small beaks, inconspicuous umbonal ridges and smooth or concentrically lined surface. Mesial depression very shallow or wanting; basal outline convex. Shell very thin; hinge plate very narrow, edentulous. Ligament internal, linear. Muscular impressions exceedingly shallow, rarely distinguishable. Anterior adductor scar small, subcircular or ovate, situated in front of the beaks and just within the hinge line. Posterior adductor about three times the size of the anterior, occupying the greater part of the middle third of the space between the beaks and the posterior extremity of the shell. Pallial line simple, more distinctly impressed in the posterior half of the shell than in the anterior.

Type: *Psiloconcha grandis* Ulrich.

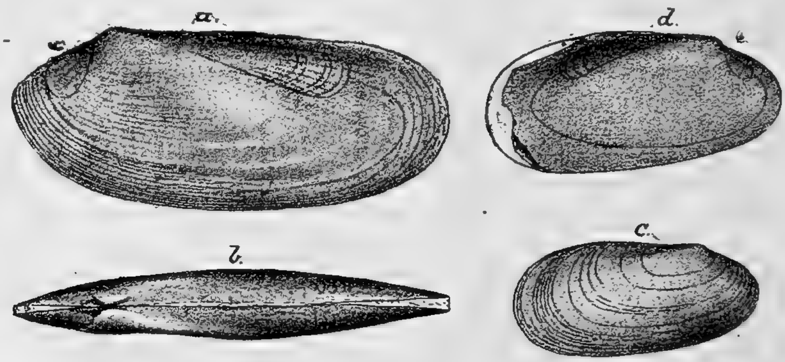


Fig. 42. *a.* and *b,* the left side and a dorsal view of an excellent cast of the interior of *Psiloconcha grandis,* n. sp , from the upper beds of the Cincinnati group, at Waynesville, Ohio. *c.* a right valve retaining the shell, and *d.* the right side of an internal cast of *Psiloconcha elliptica,* n. sp., from the same horizon at Clarksville, Ohio, and Richmond, Indiana.

The systematic position of this genus is doubtful. That it does not belong to the *Modiolopsidæ* I am satisfied, but where else to place it seemed a question whose solution it was deemed best to defer till we shall have learned a little more about certain Devonian and Carboniferous shells. Species of *Psiloconcha,* in their gaping ends and general expression, remind greatly of Carboniferous shells that are commonly referred to the recent genus *Solenomya,* but I cannot bring myself to believe that the short end of the Lower Silurian species is the posterior, as would be the case if they were related to *Solenomya.* Indeed, it appears to me far from established that this is true even of the Carboniferous forms referred to.

My conviction that *Psiloconcha* does not belong to the *Modiolopsidæ* rests partly upon the resemblance just noticed, but more especially upon a difference in the composition of the shells. That some difference, whatever its nature, really existed a comparison of the fossils will render obvious at once. Thus, I have collected from the same bed of shale species of *Modiolopsis*, *Actinomya*, *Orthodesma* and *Psiloconcha*. The shells of the first three genera were coated with either a black or dark brown film, while those of the last matched the color of the shales or were a few shades lighter.

A single and not very typical species occurs in the Galena of Minnesota. At least seven and probably eight species are found at various horizons in the Cincinnati group. Two of these are figured on the preceding page and one was described by me in 1879 as *Orthodesma subovale* (Jour. Cin. Soc. Nat. Hist., vol. 2, p. 82). The others I hope to describe in the next report of the Geological Survey of Ohio.

### Psiloconcha minnesotensis, *n. sp.*

PLATE XXXVI, FIGS. 31 and 32.

Shell rather small, moderately elongate, highest posteriorly, the length about twice the greatest hight. Hinge line straight, nearly as long as the entire shell; anterior end rounded, much narrower than the posterior; basal margin gently and uniformly convex; posterior end subtruncate above, slightly produced and strongly rounded in the lower half. Valves rather strongly convex for the genus, the greatest convexity in front of and above the middle. Beaks small, situated between one fifth and one sixth of the length of the shell behind the anterior extremity. Umbonal ridge subangular in the rostal region and unusually prominent for the genus. Anterior to the ridge the surface of the shell is gently convex. Cardinal slope slightly concave, abrupt near the beaks. Surface marked with fine concentric lines which are thrown into obscure folds in crossing the umbonal ridge. Internal characters unknown.

This species is doubtfully referred to *Psiloconcha*. It differs from all the other species of the genus in its greater convexity, proportionally narrow anterior end, and comparatively prominent umbonal ridge. I might have placed it with *Sphenolium*, Miller, but the shell is not sufficiently ventricose, the umbones are too small, and there is no lunule in front of the beaks, while a slight gap separates the edges of the valves at the ends.

*Formation and locality.*—Middle Galena, Pleasant Grove, Minnesota.

## Genus PROLOBELLA, n. gen.

Shell equivalved, moderately convex, very inequilateral, obliquely acuminate-ovate. Anterior end very small, auriculate or subnasute, sharply distinguished from the body of the shell. Basal and posterior margins rounded. Hinge thin, apparently edentulous, rather short and not produced at the posterior extremity; just in front of the beaks a short clavicle-like process produces a sharp linear depression in casts of the interior. Surface marked with concentric lines of growth and radial striæ or plications. Anterior adductor scar small, situated in the anterior lobe. Posterior impression and pallial line not observed.

Type: *Prolobella striatula*, n. sp.

It is almost certain that Conrad's *Avicula trentonensis* and *aviformis*, which Hall in 1847 united as one species, are congeneric with the Minnesota species which is made the type of this new genus. These shells are not true *Aviculidæ*, their valves being equal and without the prolonged posterior wing. Nor do they fit much better into any of the other families. They seem to be remnants of one of those complex primitive types that give the systematist so much trouble to classify. In this case there is almost as much reason for placing the genus with the *Ambonychiidæ* as with the *Aviculidæ* or the *Modiolopsidæ*. With such types it is good policy to defer conclusions until the collector has furnished us with the missing links. And they will be found sooner or later, for the lower paleozoic rocks are teeming with undiscovered fossils.

### PROLOBELLA STRIATULA, *n. sp.*

PLATE XXXV. FIG. 27.

Shell rather small, obliquely subovate, moderately convex. Anterior end very small, somewhat auriculate, narrowly rounded, and rather sharply distinguished from the rest of the shell. Cardinal margin straight, about half as long as the shell posterior to the beaks, passing with a gentle curve into the posterior margin, which is oblique and moderately convex to the lower third where the outline bends rapidly forward; basal margin almost uniformly convex; anterior outline strongly sinuate beneath the ear. Beaks full, slightly prominent, not much incurved, just in front of them the cast shows a vertical linear depression extending from the hinge half across the narrow sinuate part of the shell. Umbonal ridge inconspicuous. Surface with a small number of obscure concentric lines, and in the antero-basal third with numerous very fine thread-like radiating striæ.

This species cannot be confounded with any other Minnesota bivalve known. From *P. trentonensis* Conrad, sp. of the Trenton of New York, it is readily distinguished by its greater hight, different outline, and finer radiating striæ. The latter are also most distinct in that species centrally where they are wanting entirely in *P. striatula.*

*Formation and locality.*—Middle Galena, Pleasant Grove, Minnesota.

## Family CYRTODONTIDÆ, n. fam.

Shells commonly ovate or rounded, rarely elongate, valves generally ventricose or strongly convex. Shell substance calcareous, without epidermis, usually thick. Hinge plate often massive, strong, with from one to five cardinal teeth; elongate posterior lateral teeth usually present, but may be wanting. Ligament chiefly external. Anterior adductor scar strongly impressed, rather large though always smaller than the much more faintly impressed posterior adductor. Pallial line simple.

The genera included in this family seem to form a very natural group. With one exception, *Ptychodesma*, Hall, a Devonian genus, they are all restricted to the Lower and Upper Silurian rocks and many of the species rank among the most important fossils of the various beds in which they occur. The individuals also are often very abundant, while their preservation is on an average better than that of any other group of paleozoic bivalves.

The principal genera are variously placed by systematists, but the *Arcidæ* have been most favored. The conclusions of the authors seem to have been biased by a supposed resemblance between the hinges of *Cyrtodonta* and *Macrodon* and to Stoliczka the relation is so obvious that he is led to say "the former may be considered as the predecessor of the latter in geological history." Now, after careful examination, I am obliged to dissent in so for at least as to claim that the case is far from proved. So far as we can now tell the last species of *Cytodonta* (Upper Silurian) are as far removed from *Macrodon* as are the earliest, while the first species of *Macrodon* (Devonian) is no nearer *Cyrtodonta*, than are the Jurassic forms. Even should later discoveries prove a development of the latter from the Silurian genera under consideration, it would not settle the question for it is not by any means an established fact that *Macrodon* is genetically related to *Arca*.

There is something decidedly suggestive in the resemblances to be noted in a comparison of the interiors of true *Arcidæ* like those of the genus *Barbatia*, Gray, and certain species of *Ctenodonta*, Salter. Now if these should, as I am inclined to believe, indicate something more than a merely accidental agreement of structure, I should hold that *Macrodon* was not a member of the *Arcidæ*, since that genus most certainly did not arise in *Ctenodonta*.

The *Cyrtodontidæ* seem to me to be a family of shells that is essentially Lower Silurian, the Upper Silurian species being both few in number and of small size and thin-shelled. Indeed the evidence at hand goes to show that the family became practically extinct with the close of the Upper Silurian. If this is true then we cannot very well ally them with recent families of shells, and as they constitute an easily recognized group of genera it has been deemed necessary to establish a new family for their reception.

The *Cyrtodontidæ*, despite the well developed dentition prevailing among the typical members, seem to represent a very early type of structure, and one that probably antedated both the *Ambonychiidae* and *Modiolopsidæ*, to which also they appear to be more closely related than to any other of the contemporaneous families. Thus certain of the earliest species of *Vanuxemia* (e. g. *V. terminalis*) greatly resemble true *Ambonychia*, while the majority of the *Modiolopsidæ* present, aside from the hinge, an internal conformation of parts that is decidedly like the prevailing appearance in the present family. Perhaps the only constant difference between the shells of these three families is that while those of the *Ambonychiidæ* and *Modiolopidæ* were provided with a well developed epidermis those of the *Cyrtodontidæ* preserve no trace of such a covering.

## Genus CYRTODONTA, Billings.

*Cyrtodonta*, BILLINGS, 1858, Can. Nat. and Geol., vol. 3, p. 431.
*Palæarca*, HALL, 1859, Pal. N. Y. vol. iii, p. 27; also 12th Rep. Reg. N. Y. Mus. Nat. Hist., p. 10.
*Angellum*, S. A. MILLER, 1878, Jour. Cin. Soc. Nat. Hist., vol. i, p. 105.
*Cypricardites*, HALL, and most American authors, (not of CONRAD).

Shell varying from transversely or obliquely ovate to subcircular, moderately ventricose. Beaks prominent, rather tumid, incurved, situated in the anterior third, fourth or fifth of the shell. Surface marked with concentric lines of growth. No lunule nor escutcheon. Hinge plate strong, nearly straight, often with a narrow and not sharply defined ligamental area. Cardinal teeth well developed, subequal, generally obliquely curved, sometimes nearly horizontal, two to four in each valve, situated mostly in front of the beaks. Posterior lateral teeth usually two or three in each valve, strong, elongate, more or less curved and slightly oblique, situated near the extremity of the hinge. Adductor muscular scars placed immediately beneath the two sets of teeth, both subovate, the posterior very faint, the anterior only moderately impressed. Pallial line simple.

Types: *C. rugosus* and *C. canadensis* of Billings.

This is an excellently defined genus and one of the largest of the paleozoic genera of Lamellibranchiata. It is also pre-eminently a Lower Silurian genus, the

Upper Silurian forms now referred to it bring but impoverished remnants of the powerful stock that preceeded them.

Many species have been placed under *Cyrtodonta* or *Cypricardites,* which is usually considered as identical, that have no right there. Thus of forty-nine species classed as *Cypricardites* by S. A. Miller in the 1889 edition of his North Amer. Geol. and Pal., only eleven can with reasonable certainty be said to belong to *Cyrtodonta.* These are *C. breviuscula, canadensis, huronensis, rugosa, spinifera* and *subcarinata,* all described by Billings, *C obliqua* Meek and Worthen, and *C. obtusa, saffordi, subangulata* and *subspatulata* of Hall. The remainder belong to *Whitella, Ortonella, Vanuxemia* and *Modiolodon,* or are too little known for positive generic placement.*

To the eleven species mentioned we must add seven that have been described since the publication of Mr. Miller's list; also fifteen new species, of which ten are published in this work. This makes a total of twenty-six valid Lower Silurian species positively known to have the characters of the genus as above defined. Two Upper Silurian species, *Modiolopsis dicteus* Hall and *M. primigenia* Conrad, sp., also fall under *Cyrtodonta.* These have unusually thin shells but their hinges are essentially as demanded for the genus.

A few remarks are necessary to explain my adoption of *Cyrtodonta* instead of Conrad's *Cypricardites* as the name for this genus. Conrad's name has seventeen years priority over that proposed by Billings, but it was not until 1859 when Hall reproduced a sketch of the hinge that had been overlooked among the manuscripts left by Conrad that any adequate idea of his genus was possible. In the mean time (1858) Billings proposed and fully illustrated his genus *Cyrtodonta.* In the following year Hall published (in Pal. N. Y., vol. iii, p. 27, and 12th Rep. Reg. N. Y. State. Mus., p. 10) his genus *Palæarca* in which he proposed to include precisely the same group of shells. In the museum report mentioned (p. 13) Hall reproduces Conrad's sketch of the hinge of *Cypricardites* with the remark that both the description and figure of that genus as given by Conrad correspond in many respects with *Palæarca* and "should an examination of the typical species prove the two identical the later name will give place to that of *Cypricardites*". Finally in a supplementory note to vol. iii (p. 524) he again uses this cut and now adopts *Cypricardites* in place of his *Palæarca* and Billings' two genera *Cyrtodonta* and *Vanuxemia.* I have not noticed that the Canadian geologists have given up the use of *Cyrtodonta.* In the United States however, with a few exceptions all use *Cypricardites* instead, while of European authors Bigsby adopted *Palæarca* and the majority of the others *Cyrtodonta.*

*The following belong to *Whitella: hindi* and *plebeia* of Billings; *megambonus* and *quadrangularis* of Whitfield; *sterlingensis* Meek and Worthen; and *ventricosa* of Hall. The new geners *Ortonella* is founded upon *C. hainesi* S. A. Miller. *C. hayniana* Safford, and *niota, rectirostris* and *rotundata* Hall, belong to *Vanuxemia,* while *C. ganti* and *winchelli* of Safford belong to the new genus *Modiolodon.*

The above is a fair statement of the case as I found it when I began the present work. Had my studies shown what both Billings and Hall conceded to be the case, that Conrad's sketch of the hinge of *Cypricardites* was identical with that of *Cyrtodonta* and *Palæarca*, I would most surely have sided with Hall and adopted the oldest name. But here was the rub. Comparisons with the hinges of numerous species of this family of shells have demonstrated beyond question that Conrad's figure and description of the hinge of *Cypricardites* does not correspond exactly with that of any true *Cyrtodonta* or *Vanuxemia* known. He represents the cardinal teeth as diverging from the beak much as in a *Lyrodesma* and says that the anterior one is the "largest and most prominent". Neither of these conditions is ever present in *Crytodonta*. On the contrary the teeth are subparallel, and to be called horizontal rather than radial, while the anterior one, if any can be so called, is the smaller. Nor have I seen any *Cyrtodonta* with five cardinal teeth, the usual number being three; two is not uncommon, but four is very rare.

We are now confronted with the question, did Conrad *correctly* describe and illustrate the hinge of his genus? This question can be determined only by a study of the type of the genus. But here again we meet with trouble for of the sixteen species originally referred to the genus only one, his *C. curtus* remains, the others having proved generically distinct, being now referred to other genera. The genus must then, if it stands at all, be based upon *C. curtus*. I do not know whether the hinge drawn by Conrad represents that of this species or not. For the present we must assume that it does, and further, until we know the contrary, it must be accepted as correct. From this standpoint then it is evident that *Cyrtodonta* and *Cypricardites* are not synomymous, and that both may stand for the present. I would suggest that, however the question may be eventually terminated, *Cypricardites* may for a long time to come serve as a convenient temporary receptacle for those species which because they are insufficiently known cannot be definitely placed into other genera.

### CYRTODONTA SUBOVATA, *n. sp.*

PLATE XXXIX. FIGS. 28, 29, 31-33, ? 30 and ? 45.

Shell somewhat obliquely ovate, narrowest anteriorly. Dorsal margin short, less than half the length of the shell posterior to the beaks merging gradually into the uniformly rounded posterior margin, base gently convex, anterior end short and rather narrowly rounded; outline distinctly concave between the anterior extremity and the projecting umbones. Beaks incurved, umbones prominently rounded, inconspicuous. A slight flattening of the surface between the umbonal ridge and the anterior basal margin. Surface nearly smooth in the young and middle stages but with age one or more very strong marginal imbrications are developed. In aged examples the anterior end is proportionally narrower than in younger ones. Hinge plate of moderate length with a narrow ligamental area. Cardinal teeth three in each valve, sub-horizontal, their inner ends thickened and curved downward. Posterior teeth two in the left and three in the right valve. Both muscular impressions faint. Shell rather thin.

All the Kentucky types of this species retain the shell and in the absence of unquestionable casts of the interior for comparison with the Minnesota specimens provisionally referred here, there may well be some doubt regarding the actual existence of the species within the borders of the state. The cast represented by fig. 30 exhibits certain peculiarities that it seems scarcely likely would occur in casts of the Kentucky form. Thus the outline is less concave in front of the umbones and the length of the shell less than it ought to be in a specimen of this size. The original of figure 45, which is from the Trenton limestone at Cannon Falls, also differs a little, but in this case oblique pressure has produced distortion that may account for the differences.

This species is closely related to both *C. huronensis* and *canadensis* which Billings described from the lower Trenton or Black River limestone of Lake Huron. Compared with authentic specimens the first proves to be narrower posteriorly and the second wider in front. In the latter the umbones are also more inflated. The hinges of the two species as figured by Billings are also somewhat different.

*Formation and locality.*—The types of the species were found in the Birdseye and lower Trenton limestone near High Bridge, Kentutky. The original of Figure 30 is from the middle third of the Trenton shales at St. Anthony Park, St. Paul. That of Figure 45 from the Trenton limestone at Cannon Falls.

### Cyrtodonta janesvillensis, *n. sp.*

PLATE XXXIX, FIGS. 26 and 27.

Comp. *Cyrtodonta huronensis* Billings, 1858, Can. Nat. and Geol., vol. iii, p. 432.

Shell of medium size, strongly convex, somewhat obliquely ovate, widest posteriorly, the hight and length about as two is to three. Outline almost uniformly rounded for an oval, with a slight prominence at the beaks and occasionally at the posterior end of the hinge line. Anterior end very short. Beaks a little compressed, rather small, incurved, projecting but little above the hinge. In casts of the interior the umbonal ridge is strongly and the surface in front of it slightly depressed. Anterior adductor scar, well defined, ovate, small, not more than half the size of the posterior scar. The latter as usual is scarcely distinguishable. Pallial line well marked, particularly in the basal and anterior parts. Hinge plate of moderate strength; cardinal teeth three in each valve, sub-equal, curved and rather oblique; posterior teeth slender, two or three in each valve. Surface of shell with somewhat irregular concentric lines of growth. No trace of these are to be seen in casts of the interior.

It is possible that the casts above described really belong to *C. huronensis.* Although I have compared them with an authentic example of that species, labelled by Billings himself as from the original locality for the species, I could not satisfy myself. The Wisconsin casts are certainly distinct from this specimen, having smaller umbones and shorter anterior end, but the latter also does not agree with Billings' figures. Very likely the illustrations are not entirely trustworthy.

Compared with *C. subovata*, the species is distinguished by its shorter, narrower, and less distinct anterior end, comparatively greater length, less produced and more oblique cardinal teeth, and more distinct muscular and pallial impressions. That species also attains greater size.

*Formation and locality.*—"Lower Blue beds" of the Trenton at Janesville and Beloit, Wisconsin.

*Mus. Reg.* No. 8323.

## CYRTODONTA AMPLA, *n. sp.*

PLATE XXXIX, FIG. 34.

In the outline this species resembles *C. subovata* and *C. janesvillensis* very closely. It is known only from casts, but these are distinguished at once by the oblique ridge running from the beak toward the posterior third of the base. On the anterior side the surface descends sharply from the ridge into an unusually wide flattened space. *C. janesvillensis* is also narrower anteriorly and relatively more convex. Another species with which it is to be compared is the Galena form described by Meek and Worthen as *C. obliqua.* The outline of that species is different being narrower in front and more produced in the postero-basal region, giving the shell a more erect appearance. Its valves are also a little more convex. *C. glabella* is shorter. In the associated forms of *Vanuxemia* the anterior adductor scar is much more sharply defined.

*Formation and locality.*—Trenton limestone, Cannon Falls, Minnesota.

## CYRTODONTA BILLINGSI, *n. sp.*

PLATE XL, FIGS. 2—6.

*Cypricardites ventricosus* Whitfield, 1882 Geol. Wis., vol. iv, p. 209, pl. 5, fig. 9.

Shell of medium size or less, transverse, obliquely ovate, highest in the posterior half; valves strongly ventricose in the umbonal and central regions. Hinge line at least two-thirds the length of the shell, slightly arcuate, posteriorly declining and passing gradually into the broadly and uniformly curved posterior margin; basal line most prominent and strongly convex behind the center, in front of which point it ascends rather rapidly with a much more gentle curve into the short, small and sharply rounded anterior end. Umbones full, large and prominent, beaks small and strongly incurved; umbonal ridge subangular near the beaks only, inconspicuous in a lateral view. Surface marked with concentric lines of growth. These, with the exception of a few near the margin, are obscure in the material at hand. Ligamental area very narrow. Hinge plate of moderate strength, with three slightly curved and nearly horizontal cardinal teeth and two or three slender posterior lateral teeth in each valve. Pallial line and anterior adductor muscle distinct, the latter rather small and of obovate or subcircular shape; posterior adductor faintly impressed, situated immediately beneath the lateral teeth. Internal umbonal sulcus and ridge slightly developed but always distinguishable on good casts of the interior.

Although closely simulating several others this is still to be regarded as a well marked species. It may be compared with *C. huronensis* Billings but will be found to be higher, more erect and more ventricose. The umbones also are larger and the cardinal teeth longer and more nearly horizontal. *C. obliqua* Meek and Worthen has a straighter basal line and is more produced in the postero-ventral region. *C. glabellus* and *C. persimilis* have a more rounded outline and smaller umbones. *C. subovata* is longer, wider in front, not so ventricose, and has smaller umbones. A shell that is likely to prove more troublesome to separate than any of these is the *Vanuxemia decipiens.* They are associated in the same strata at Minneapolis but when good casts are available they may be distinguished at once by the higher position and much greater sharpness of definition of the anterior muscular scar in the *Vanuxemia.*

It is possible that the Wisconsin species referred by Whitfield to *Cypricardites ventricosus* Hall, sp., in 1882 (*loc. cit*) is not identical with *C. billingsi,* because his illustration, if correctly drawn, would indicate a distinct form. However that may be it is quite certain that he had this species before him when he drew up his description, since it is not uncommon at the localities mentioned by him. It is certain also that neither the specimen figured by him nor the form now named after Mr. E. Billings, the founder of the genus, are the same as the types of Hall's *Edmondia ventricosa* (Pal. N. Y., vol. i, p. 155; 1847). Indeed they are widely distinct species the last having proved to be a true *Whitella* and not *Cypricardites* nor *Cyrtodonta* at all. On page 271, Pal. N. Y., vol. iii, Hall figures another species of *Cyrtodonta* which he refers to his *ventricosa* as a *Palæarca.* This species is not the same as *C. billingsi* being longer and having a well developed legamental area and different cardinal teeth. In all these respects the shell agrees much better with an authentic example of *C. carinata* Billings, now before me, and as both the *Palæarca ventricosa* of Hall and the *Cyrtodonta subcarinata* of Billings are from the Trenton limestone in the northern part of Lake Huron, they are probably indentical.

*Formation and locality.*—Lower Trenton limestone Dunleith, Illinois; Beloit, Janesville and Mineral Point, Wisconsin; Cannon Falls and Minneapolis, Minnesota.

### CYRTODONTA OBLIQUA *Meek and Worthen.*

PLATE XXXIX, FIGS. 35 and 36.

*Cypricardites obliquus* MEEK and WORTHEN, 1868, Geol. Sur. Ill., vol. iii, p. 311.

Of this species I have seen only the original type figured and described by the authors. Their figures being unsatisfactory, it seemed worth the while to prepare others, especially as the species may at any time be found within the limits of the State. It is to be looked for in the middle and lower beds of the Galena in Fillmore county. The type specimen is from the Galena at Scales Mound, Illinois, and is now preserved in the Illinois State Museum.

### CYRTODONTA AFFINIS, *n. sp.*

PLATE XXXIX, FIGS. 20-23.

Shell small, rather compressed convex, obliquely subovate, alated and much the highest posteriorly. Dorsal margin straight or very gently arcuate, rather long, not passing gradually into the broadly and uniformly rounded posterior margin, the junction being obtusely angular; ventral margin but little convex, ascending rapidly to the small and narrowly rounded anterior end. Beaks small, projecting very little; umbones compressed, due to a flattening of the antero-ventral slope; umbonal ridge moderately distinct in the upper half; cardinal slope gently concave; greatest thickness on the umbonal ridge above and a trifle in front of the center of the valves. Surface with fine indistinct concentric striæ and distinct sublamellose lines of growth. Hinge of moderate thickness; cardinal teeth small, short, four in each valve; posterior lateral teeth very slender, four in the right valve. Muscular impressions rather faint, not well determined. Length 20 mm.; posterior (greatest) hight 15 mm.; anterior highest 10 mm.; entire thickness 6.5 mm.

A variety reappears in the middle Galena. This is relatively more convex and not quite as high posteriorly. Length 15 mm.; hight 10 mm.; thickness 7 mm. It may be distinguished as var. *fillmorensis.*

The typical form of this species is associated and was at first confounded with *Matheria rugosa.* Aside from the hinge, which is of course very different in the two forms, the *Matheria* is distinguished by its much shorter, subtruncate anterior end.

*Cyrtodonta halli* Nettleroth, sp., from the upper beds of the Hudson river group of Kentucky, is shorter and thicker, and has more prominent beaks and umbonal ridge.

*Formation and locality.*—The typical form occurs in the upper part of the middle third of the Trenton shales, six miles south of Cannon Falls, Minnesota. The Galena variety was collected near Wykoff, in Fillmore county.

### Cyrtodonta, parva, *n. sp.*

PLATE XXXIX, FIGS. 24 and 25.

This small species seems to be closely related to *C. affinis* Ulrich and *C. halli* Nettleroth, sp. In some respects it is intermediate between those species, differing from the first in its greater convexity, stronger umbonal ridge and larger anterior end, these being points in which the shell agrees rather closely with the latter. From both it differs in the more abruptly rounded postero-basal margin and straighter ventral outline.

Adductor scars very faint, undetermined. The specimen being a cast of the interior, the detail of the hingement could not be made out with certainty.

Greatest length, 9.5 mm.; greatest hight, 6.5 mm.; thickness, 4.5 mm.

*Formation and locality.*—Middle Galena, near Fountain, Minnesota.

### Cyrtodonta rotulata, *n. sp.*

PLATE XXXIX, FIGS. 16–19.

Shell small, moderately ventricose, nearly erect, the outline uniformly rounded (subcircular) except at the dorsal margin, which is straight behind the beaks and somewhat insinuated in front of them; hight and length about as five is to six; posterior extremity of hinge angular. Beaks small, incurved, scarcely prominent, situated about one-fourth of the length of the shell behind the most prominent point on the anterior margin. Umbonal region full, but not excessively so; point of greatest convexity a little above and in front of the center of the valves; postero cardinal slope gently concave, causing this part of the shell to appear as slightly alate. Surface marked with fine concentric lines, with a few (those shown in the illustrations) stronger than the rest. Shell and hinge plate thin; dentition undetermined beyond this that it is essentially as called for by the genus. Muscular scars unknown.

I am not acquainted with any species of *Cyrtodonta*, described heretofore, with which this one might be confounded. *C. persimilis* Ulrich, a much larger species, is in outline somewhat like it, but on comparison proves to have the beaks situated farther forward and to be proportionally less ventricose. Several species belonging to the genus *Vanuxemia* agree even more closely in their outlines, but in all of them the shell is much thicker and the hinge generically different. Of all known species the two next described are to be considered as the nearest.

*Formation and locality.*—The real types of the species were obtained from Mercer county, Kentucky, where they were found in a cherty bed equivalent to the Black River limestone of New York. Two specimens, both a little larger than the Kentucky types, were collected in Minnesota. Both are from the middle third of the Trenton shales, one at Minneapolis, the other near Fountain.

*Mus. Reg.* No. 8336.

### CYRTODONTA OBESA, *n. sp.*

PLATE XXXIX, FIGS. 10, 11 and 12.

This species is, so far as our knowledge extends, very closely allied to *C. rotulata*. It is also associated with it in both Kentucky and Minnesota, but I cannot say that I experienced much trouble in separating them. *C. obesa* is more gibbous and oblique, the anterior end is shorter and much more obtuse in a cardinal view, the posterior cardinal slope narrower and scarcely to be described as alate, while the outline at this extremity of the hinge is more rounded; the entire outline is to be called broadly ovate rather than subcircular. The umbones also are more prominent and inflated.

Length, 14 mm.; from beak to posterior extremity, 14 mm.; hight at center of shell, 11.; thickness, 10.5 mm. In another specimen these dimensions are respectively 14.2, 14, 11 and 10 mm.

The above measurements are furnished by two silicified examples from Kentucky, which are to be regarded as the types of the species. Besides these two evidently young shells from Minnesota localities are referred here provisionally. They are too oblique for *C. rotulata* and have not the proper shape for *C. cingulata*. The outline is very nearly as in *C. obesa*, but they differ from the Kentucky specimens in being less gibbous, especially in the umbonal region.

*Formation and locality.*—In cherty beds equivalent to the Black River limestone of New York, in Mercer county, Kentucky. Specimens doubtfully referred to the species were found in the middle third of the Trenton shales at St. Paul and Preston, Minnesota.

### CYRTODONTA GIBBERA, *n. sp.*

PLATE XXXIX, FIGS. 13–15.

In this specimen the umbones are more inflated even than in *C. obesa*. They are also situated farther forward, the anterior end being very short and exceedingly obtuse. Although the posterior extremity is subangular, the form on the whole is more rotund, the hight of the shell being greater. *C. rotulata* is much less gibbous in the umbonal and central regions, less oblique and a little longer, particularly in the part that is in front of the beaks. Several species of *Vanuxemia* present a similar external appearance, but they have all a thicker shell and are quite different internally, so that casts of the interior could not possibly be confounded.

Length, 14.2 mm.; from umbone to postero-basal margin, 14.8 mm.; hight at middle of shell, 13 mm.; thickness, 11 mm.

*Formation and locality.*—Base of the middle Galena, about thirteen miles south of Cannon Falls, Minnesota.

### CYRTODONTA GLABELLA *Ulrich.*

PLATE XXXIX, FIGS. 37 and 40.

*Cypricardites glabella* ULRICH, March, 1892, Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 234.
*Cypricardites minnesotensis* SARDESON, April, 1892. Bull. Minn. Acad. Nat. Sci., vol. iii, p. 338.

Shell of medium size, moderately convex; broad ovate or subquadrangular in outline, with the back straight and rather long, the posterior margin broadly rounded, sometimes nearly vertical and slightly straightened in the middle, above making an obtusely angular or more or less rounded junction with the hinge line; ventral and anterior margins rounded, the latter turning rather sharply backward at the hinge. Beaks situated well forward, small, very slightly prominent, the umbonal region full, with the line of greatest convexity—not sufficiently defined to be called a ridge—extending obliquely across the valve from the beaks. Cardinal slope flat, rather abrupt; between this and the undefined umbonal ridge, the surface is again flattened; anterior and basal slopes gently convex. Surface marked with somewhat irregular concentric lines of growth.

Good moulds of the interior show that the hinge plate was strong, the ligamental area very narrow, the cardinal teeth at least two and strong, and the posterior teeth two or three in each valve. The beaks are prominent, incurved, and compressed because of a sulcus that crosses the valves a little obliquely, but is lost before reaching one-half the distance to the ventral border. On each side of the sulcus is a very faint ridge. Anterior adductor distinct, rather small, ovate, acuminate below. Pallialline distinct, especially the anterior part where it appears as a sharply defined pustulose ridge in the cast. Posterior adductor ovate, the long diameter vertical, nearly three times the size of the anterior, situated about one-third of its length beneath the posterior end of the hinge plate.

This fine shell is an early form of the group of species of which *C. germana*, *C. grandis* and *C. billingsi* are more typical representatives. It is distinguished from them all by the more anterior position of the beaks, and greater prominence of the antero-basal margin. The next species, though very similar in most respects, belongs to another group of species, in which the internal ridge and sulcus is indistinguishable.

*Formation and locality.*—The original type is from the middle third of the Trenton shales at Minneapolis. A small cast of the interior, belonging to the survey collection, was found in the building limestone at the same place. Casts occur also in the lower Trenton limestone at Beloit, Wisconsin and Dunleith, Illinois.

*Mus. Reg.* No. 5100.

CYRTODONTA PERSIMILIS, *n. sp.*

PLATE XXXIX, FIGS. 41 and 44.

This form, which is known only from casts of the interior, was confused with *C. glabella* until a critical comparison proved it to be not only distinct but to belong to another group of species. The outline is very much alike in the two species, but here even some constant differences are to be observed, especially in the shape of the margin at the posterior extremity of the hinge, where the present species is more angular. But the main difference lies in the fullness of the umbones, there being no appreciable sign of the sulcus and ridge which cross this portion of casts of that species. This difference is very obvious after it has once been pointed out. The beaks are also more strongly incurved and the hinge bent downward anteriorly in a greater degree, while the plate is probably also of less width. Finally, the posterior muscular scar is closer to the hinge and the longer diameter of the impressions more oblique.

The systematic position of the species is near *C. rotulata*, *C. cingulata*, and *C. tenella*. The first is more rotund in outline, less oblique and has fuller umbones, the others are higher and have the beaks situated farther behind the anterior extremity.

At Minneapolis *C. persimilis* is associated with a small *Vanuxemia* that is not easily distinguished unless the casts are clean and in good condition. The latter (*V. decipiens*,)differs somewhat in its outline being proportionally narrower anteriorly, but the principal difference lies in the character of the anterior adductor scar, which is much more distinct from the umbonal cavity. In short, the species is not a *Crytodonta* but a *Vanuxemia* as now defined.

*Formation and Locality.*—Trenton limestones, Minneapolis, Minnesota, "Lower Blue Beds" of the Trenton formation at Beloit, Wisconsin.

CYRTODONTA OVIFORMIS, *Ulrich.*

PLATE XXXIX, FIG. 16; PLATE XL, FIG. 1.

*Cypricardites oviformis* ULRICH, 1892. Amer. Geol., vol. x, p. 99.

Shell rather above the medium in size, moderately convex, but little oblique, the outline almost regularly oval, with the posterior end a little the widest and a slight straightening along the cardinal margin. Beaks small, situated between one-fourth and one-fifth of the length behind the anterior extremity; erect, compressed and not incurved in casts of the interior; in the shell projecting very little above the hinge line. Umbonal ridge very indistinct, with the point of greatest convexity a little above and in front of the middle. In the casts there is a more or less sharply defined and unusually wide depressed or flattened strip running from the beaks downward. Hinge plate wide and strong, with two strong posterior lateral teeth in each valve, and sometimes a third small one above them in the left valve. Anterior teeth consisting of one long tooth placed parallel with the margin of the shell in front of the beaks and five or six small unequal teeth running downward from the horizontal tooth. Ligamental area well developed. Anterior muscular scar distinct, elongate, vertically disposed, situated immediately beneath the cardinal teeth. Posterior scar illy defined. Shell substance thin, except in the anterior and dorsal region.

The small vertically arranged anterior teeth, and the erect and strongly compressed beaks of casts of the interior are the two principal peculiarities of the species. These and other equally obvious characters distinguish it from *C. glabella* Ulrich. *C. saffordi* Hall, sp., often has the cardinal teeth broken up in a similar manner, but differs too obviously in other respects to render confusion between them at all likely.

*Formation and locality.*—Two opposite valves were collected by Mr. Chas. Schuchert at Janesville, Wisconsin, in the "Lower Blue limestone." These are now in the museum of the Geological and Natural History Survey of Minnesota.

*Mus. Reg.* No. 8324.

## CYRTODONTA CINGULATA *Ulrich.*

PLATE XL, FIGS. 7 and 8.

*Cypricardites cingulata* ULRICH, 1892. Nineteenth Ann. Rep., Geol. and Nat. Hist. Sur. Minn., p. 235.

Shell scarcely reaching the medium size, ventricose in the central and umbonal region, oblique, narrow anteriorly and broadly rounded posteriorly; the outline on the whole, excepting a slight prominence at the postero-cardinal edge, almost regularly ovate; hinge line rather short posterior to the beaks, slightly convex. Beaks of good size, strongly incurved, projecting well above the hinge, situated a little more than one-fourth of the entire length behind the anterior extremity; umbones prominent, full, with an obtuse ridge or line of greatest altitude running from the beaks towards the postero-basal side; anterior and cardinal slopes both slightly concave, the latter descending more rapidly. Point of greatest convexity near the middle of a line drawn parallel with and one third of the hight of the shell beneath the hinge. Surface marked with very fine concentric lines, easily abraded, and distant irregular lines or wrinkles of growth. Shell substance thin. Internal characters unknown.

This species seems to be rather closely related to *Cyrtodonta canadensis* Billings, but is more erect, comparatively higher posteriorly and has its outline more produced and more sharply rounded in the postero-cardinal region. *C. tenella* has a longer hinge line and is more uniformly convex. *C. grandis* Ulrich, is a larger and almost circular shell.

Although the hinge and internal characters are unknown, I cannot doubt that the species is a true *Cyrtodonta.* I judge further that it belongs to the group of species of which *C. persimilis* and *C. rotulata* are typical members.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis, Minnesota.

### Cyrtodonta tenella *Ulrich.*

PLATE XL. FIGS. 15-19.

*Cypricardites tenellus* Ulrich, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 237.

Shell of medium size or less, moderately ventricose, not very oblique, subovate, widest posteriorly, slightly alate and subangular or sharply rounded in the postero-cardinal region. Hinge line long, slightly arcuate, posterior margin straightened in the upper half, broadly rounded and produced a little in the lower half; ventral margin rather strongly convex, most prominent a little behind the middle; anterior end more or less narrowly rounded. Beaks small, incurved, projecting moderately beyond the hinge line; situated about one-fourth of the entire length behind the anterior extremity; umbones full, prominently rounded. Cardinal slope slightly concave. Surface marked with rather fine concentric striæ, and sometimes with strong distant lines of growth as well.

Shell substance very thin. Hinge plate narrow, a good part of it forming a finely striated ligamental area; two very slender posterior lateral teeth in the right valve, and the same number probably in the left; anterior teeth obscure in the specimen, consisting apparently of two slight horizontal folds in the margin of the shell, muscular impressions very faint.

The hinge plate and teeth are thinner in this species than in any other known from Lower Silurian deposits. In two Upper Silurian species, however, *C. primigenia* Conrad, sp. (Medina), and *C. dictæa* Hall, sp. (Niagara), the hinge is quite as slender if not more so.

*C. cingulata* is a more ventricose shell, especially in the central and umbonal regions; the outline is a little different, being longer from the beaks to the postero-ventral margin, and the hinge line shorter. *C. grandis* and its varieties *germana* and *luculenta*, the first and second from the Galena, the last from the Hudson River group, are very similar shells, differing chiefly in the greater strength of their hinges.

Casts of what may be a small variety of *C. tenella* occur in the Trenton limestone at Minneapolis. The largest seen (Mus. Reg. No. 700), is only 12 mm. long. Aside from the matter of size, they agree very well indeed with the types of the species.

*Formation and locality.*—Upper part of middle third of the Trenton shales, about six miles south of Cannon Falls, Minnesota.

*Mus. Reg.* No. 8336.

## CYRTODONTA GRANDIS *Ulrich; and varieties.*

PLATE XL, FIGS. 9-14.

*Cypricardites grandis* ULRICH, 1890. Amer. Geol., vol. vi, p. 387.
*Cypricardites germanus* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 236.
*Cypricardites luculentus* SARDESON, 1892. Bull. Minn. Acad. Nat. Sci., vol. iii, p. 338.

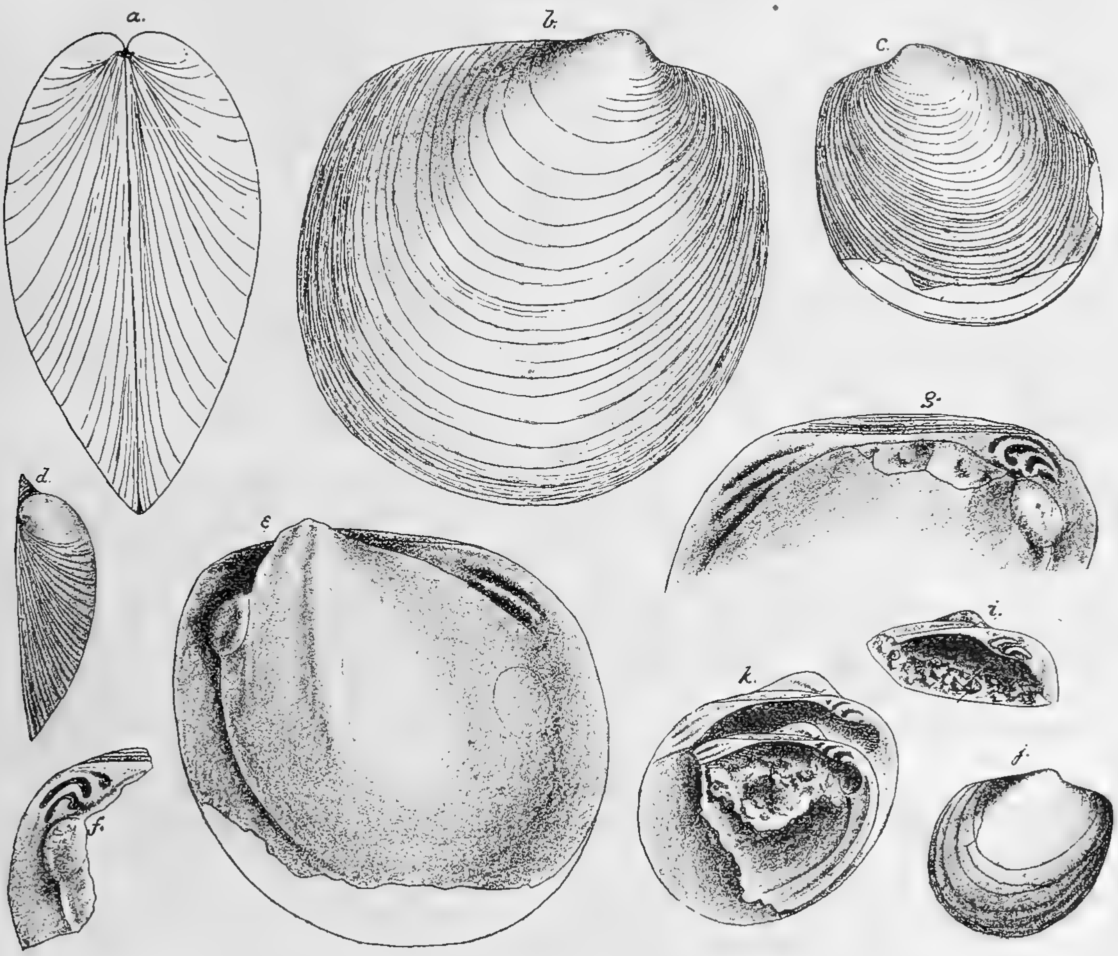


Fig. 43. *Cyrtodonta grandis*, and varieties. *a* and *b*, anterior and lateral views of a perfect specimen, upper Trenton, two miles south of Burgin, Kentucky. *c* and *d*, lateral and antero-cardinal views of a small left valve of same, with stronger surface markings than usual; from same formation and locality. *e*, nearly entire cast of the interior of a left valve, from same locality. *f*, small fragment of a cast of the interior of a left valve, preserving sharp impressions of the anterior adductor scar and cardinal teeth. *g*, the cardinal part of a cast of the interior of a right valve, drawn without the beak so as to show the entire hinge. *i*, hinge of specimen shown in figure *c* and *d*. *j*, original type of *C. germana*, restored; hinge of same figured on plate XL. *k*, interior of two left valves of *C. grandis* var. *intermedia*, n. var.; Trenton, Haynie's Mill, Tennessee.

Shell large, moderately ventricose, slightly oblique, the outline subcircular. Beaks small, projecting slightly above the hinge line, obliquely incurved, almost in contact; situated about in the middle of the anterior half of the cardinal margin. Umbonal ridge inconspicuous, the slope of the surface to the postero-cardinal margin gradual and slightly concave, the slope to the basal and anterior margins very gently convex; point of greatest convexity a little above the center of the shell. Anterior end longer in front of the beaks than usual in this genus, the margin narrowly rounded above, then with a very gentle and almost uniform downward and backward curve, merging imperceptibly into the basal, and later into the posterior margin. Antero-cardinal edge slightly produced; likewise the postero-ventral, but in most cases so gently as to be scarcely appreciable. Surface smooth, with fine concentric lines of growth.

Ligamental area deep but appearing narrow in a cardinal view. As usual, it is finely striated longitudinally. Hinge plate strong, with three anterior teeth in the left, and four in the right valve. These teeth are short and abruptly curved down at their posterior ends, terminating with a knob-like projection. In the right valve the first and fourth are much smaller than the second and third; the middle tooth of the three in the left valve is also much the largest. Posterior teeth longer, parallel, and slightly curved, three in the right valve and two in the left. Anterior and posterior muscular scars large, situated just beneath the two sets of hinge teeth, the posterior one rather faintly impressed, the anterior deep. Pallial line simple, only the anterior half sharply defined, and often emphasized by a series of small pits. Inner side of shell with two low, subparallel ridges extending from the beaks two-thirds the distance to the postero-basal margin. The furrow between these appears as a low ridge on casts of the interior. These often present another but much smaller ridge running downward from the inner margin of the anterior muscular scar. In casts the beaks are flattened, very prominent, not strongly incurved nor far apart.

The above description does very well for the large Kentucky types upon which the species was founded. It is also wide enough to include a few of the numerous casts that occur in the lower and middle beds of the Galena of Minnesota. The majority of them, however, seem to fall more nearly under the variety or species *germana* which was established (*loc. cit*) for the reception of usually smaller specimens in which the form is a little more oblique and the hinge plate proportionately thinner and longer, with the cardinal teeth less curved and the posterior teeth placed more nearly horizontal. The internal furrow and the anterior muscular scar, are both less deep in this variety, than in the true *grandis*. The same is true of the pallial line.

Fig. 9 of plate XL, represents what appears to be a large right valve of *germana.* The specimen is preserved as a partial mould of the exterior. Another specimen from the Galena near Wykoff may be said to be identical in its characters with the original types of *germana.* The specimen represented by fig. 10 is one of a number in which the balance of agreements is with the variety rather than with typical *grandis,* while the original of fig. 11 was made by a small right valve of which the opposite seems to be true.

Another variety was found in the Trenton of Tennessee by Prof. Jas. M. Safford, and sent to me for examination. The illustrations show that in its outline and general appearance this new variety closely simulates variety *germana* and *C. tenella.* It differs, however, in the teeth which are stronger and more curved than in those forms, being on the whole more like those of *C. grandis* and *C. saffordi.* As it marks another stage in the development of this type of shells it should receive a name. I propose therefore that it be called *Cyrtodonta grandis,* var. *intermedia.*

Mr. Sardeson has given the name *luculenta* (*loc. cit.*) to a Hudson River form of which the hinge and exterior of two fair examples are represented on Plate XL, by figs. 13 and 14. This form I cannot now regard as specifically distinct from *C. grandis,* since it is almost identical with var. *germana,* the only difference being small ones in the hinge and that the umbones are somewhat larger in the *luculenta.*

Two other stages in the development of this series of shells, in these cases perhaps of specific importance, occur in the upper beds of the Cincinnati group at Richmond, Indiana. These I hope to describe in another publication.

*Formation and locality.*—The types of *C. grandis* and the var. *germana,* are from the upper Trenton between Burgin and Danville, Kentucky. Casts of the species and variety have been found in the middle and lower Galena near Cannon Falls, Kenyon, Pleasant Grove, Wykoff, Lime City, and other localities in Minnesota; at Decorah, Iowa, and Oshkosh, Wisconsin. The variety *intermedia* is so far known only from the Trenton at Haynie's mill, in Tennessee, where it occurs in association with *Vanuxemia hayniana* Safford, sp. The var. *luculenta* occurs in the shaly limestones of the Hudson River group at Granger and other localities in Fillmore county, Minnesota.

*Mus. Reg.* Nos. 8337, 8347, 4102, 8360, 8333. Var. *luculenta* 8332.

## Genus VANUXEMIA, Billings.

*Vanuxemia,* BILLINGS, 1858. Rep. of Progr. Geol. Sur. Can., p. 186.

Shells ventricose, oblique, acuminate ovate to subcircular; anterior end very short and small, the posterior broadly rounded. Umbones full, prominent, beaks strongly incurved. Surface with concentric growth lines only. Hinge strong, with teeth as in *Cyrtodonta,* two to four, rarely more, cardinal, and two to four posterior lateral teeth in each valve. Teeth frequently striated transversely, an elongated ligamental area generally present. Two adductors, the anterior depression very sharply defined and deep, and situated in a prolongation from the anterior end of the hinge plate;

in casts of the interior forming a distinct lobe-like prominence, often of reniform shape, immediately in front and sometimes partly between the filling of the beaks. Posterior scar indistinct, larger than the anterior. Pallial line simple. Internal umbonal ridge well developed.

Type: *Vanuxemia inconstans* Billings.

As a rule this genus can be distinguished from *Cyrtodonta* by the more nearly terminal position and greater prominence of the beaks, but the final and only reliable test lies in the position and character of the anterior adductor scar. This, in being excavated out of the hinge plate instead of being placed on the floor of the valve, makes so obvious a difference that I cannot see, now that it is pointed out, how any one can fail to discriminate between the two genera.

Between twenty and twenty-five valid species of *Vanuxemia* are known to me. They are all Lower Silurian and, although Billings has placed a Devonian shell here, I am almost satisfied that the genus became extinct with the close of the Hudson River deposits.

### VANUXEMIA DIXONENSIS *Meek and Worthen.*

PLATE XXXVIII, FIGS. 1–5.

*Vanuxemia dixonensis* MEEK AND WORTHEN. Pro. Chicago Acad. Sci., vol. i, p. 16; also 1868, Geol. Sur. Ill., vol. iii, p. 297, pl. 1, fig. 5*a*, *b*.

Shell beneath medium size, very gibbous, obliquely acuminate-ovate, the narrowly rounded rostrum forming the small end of the oval. Outline gently arcuate dorsally, and usually rather sharply rounded at the posterior extremity of the hinge; from this point around the lower half of the shell, the outline sometimes forms a regular semicircle, but it is more common to find that the center of the base is more or less produced. (See fig. 4.) Anterior end rounded, projecting very little, if at all, beyond the nearly terminal beaks. Beneath the latter the outline is insinuated often strongly, but in most cases more gently than in fig. 5; in a front view an undefined heart-shaped lunule-like depression. Umbones tumid and prominent, with the beaks curving strongly inward and forward. An obtuse curving ridge extends from each beak backward along the depressed hinge line. These dorsal ridges form a broad flattened or rather concave back to the closed valves. Just within them an impressed line, defining a lanceolate escutcheon-like area, is sometimes distinguishable. Surface marked with strong, but unequal concentric lines of growth.

In casts of the interior the beaks stand far apart (much more so than in the shell), are very prominent, broad, much compressed, concave on the inner side, sharp-edged in front and very little incurved, while a more or less strong and nearly vertical sulcus and ridge marks the anterior half. The dorsal ridges are sharper than on the shell itself, and a flattening of the surface beneath them is usually distinguishable. Anterior muscular impression distinct, reniform, the pair forming a strongly defined lobe at the base of the beaks. Posterior scar large, but very faint. Pallial line rather indistinct, except in the anterior part.

Shell substance very thick in the anterior third. Ligamental area with good definition, strongly concave, long, high, but not wide in a dorsal view. Posterior lateral teeth, three in each valve, the upper often much the smallest; in many cases more nearly horizontal than shown in fig. 4. Cardinal teeth normally three in each valve, subequal, nearly horizontal, slightly curved. Occasionally the upper one is more slender than usual, and one or both of the others divided so that their number may be four or even five in each side.

This species, which is one of the most abundant and best marked fossils of this class found in Minnesota, was at first believed to be identical with *V. inconstans* Billings, but a second comparison with the original description and figure of that species seemed to throw some doubt upon their identity. This doubt was strengthened to conviction when a few days ago I received from Prof. Jas. M. Safford an authentic example of Billing's species. This shows that, despite the close agreement of the two species, Meek and Worthen were fully justified in separating their shell. The principal difference lies in the anterior part of the shells, which in *V. inconstans* is more obtuse than in *V. dixonensis,* and in the upper part just beneath the beaks presents a small protuberance where the latter has a lunule-like excavation. This difference is due to the shape of the anterior extremity of the hinge, this being angular in *V. inconstans* and well rounded in *V. dixonensis.*

Compared with other species, *V. rotundata* Hall, sp., and *V. suberecta,* and *V. crassa* are all less oblique and of rounder outline; in *V. obtusifrons* the dorsal outline is concave instead of convex.

*Formation and locality.*—Very common in the upper beds of the Trenton limestone at Minneapolis and St. Paul; less abundant at Cannon Falls and other localities in the state. In the "Lower Blue beds" at Janesville, Wisconsin, and Dixon, Illinois.

*Mus. Reg.* Nos. 202, 320, 670, 5030, 5098, 5525, 5527, 5676, 8322, 8330, 8331.

### VANUXEMIA DIXONENSIS, var. INSUETA, *n. var.*

PLATE XXXVIII, FIGS. 6 and 7.

This name is proposed provisionally for one or two casts differing from the ordinary form of *V. dixonensis* apparently in one important respect only, namely, the sulcus and ridge which should traverse the anterior part of the cast from the umbones downward is wanting except above the anterior muscular scar where a slight flattening of the umbones may represent the sulcus. The beak also is more incurved than in any specimen of the typical form of the species seen.

*Formation and locality.*—Upper part of the Trenton limestone, Minneapolis, Minnesota. The illustrated specimen was found by Mr. A. D. Meeds and kindly given by him to the author. The other, a much smaller and doubtful cast, belongs to the survey collection and bears the museum register number 8329.

### VANUXEMIA ROTUNDATA *Hall.*

PLATE XXXVIII, FIGS. 8–14.

*Cypricardites rotundata* HALL, 1861. Rept. Supt. Geol. Sur., Wis. p. 29; 1862, Geol. Rept. Wis., vol. i, p. 38, fig. 7, and p. 437.

*Cypricardites rotundatus* (part.) WHITFIELD, 1874. Geol. Rept. Wis., vol. iv, p. 208. (Not the specimen illustrated—pl. V, fig. 11—which belongs to *V. suberecta* ULRICH.)

This species is very similar to *V. dixonensis* Meek and Worthen, and in another direction quite as much like *V. suberecta* Ulrich. Still, as it is very constant in its peculiarities, and not at all difficult to distinguish, it should be recognized as a distinct species. From the first it differs in being shorter from the beaks to the base and therefore circular rather than ovate in outline. The form of the casts, the only condition in which the species has been observed, is more erect, the beaks curving much less forward so that the anterior margin projects considerably beyond them. The anterior sulcus is on the whole stronger, the pallial line more distinct, and the average size of the shells little more than half what it is in *V. dixonensis.* In other respects, including the hinge, the two species are practically indentical. Hall says there are two posterior lateral teeth in each valve, and Whitfield one or two, but in all the specimens seen by me (about fifty), their number was not less than two and oftener three.

Compared with *V. suberecta*, a form that was united by Whitfield with *V. rotundata*, the latter is found to be more oblique, with the anterior end longer and more rounded above, the sulcus stronger, more curved, narrower, and without the small ridge which is included in the sulcus in that species. Nor is the anterior boundary of the sulcus, especially beneath the muscular scar, so much thickened. There are furthermore some differences in the backs of the two species, the hinge line being less sunken, the dorsal ridges more obtuse, and the outline, in a side view, straighter and even a little concave behind the beaks in some casts of *V. suberecta.* The hinge of the latter is not fully known, but so far as our knowledge goes, it adds another difference in the greater obliquity of the cardinal teeth. The survey collection contains two examples (Mus. Reg. No. 8321) of an unusually convex small variety of this species. Four views are given of one of these on plate XXXVIII.

*Formation and locality.*—Very common in the "Lower Blue Beds" of the Trenton formation at Janesville and Beloit, Wisconsin. A few specimens from the upper part of the limestone at Minneapolis, are doubtfully referred here.

*Mus. Reg.* Nos. ?5101, 8319, 8321.

## Vanuxemia suberecta, *n. sp.*

PLATE XXXVIII, FIGS. 20–22.

*Cypricardites rotundatus* (part.) WHITFIELD, 1874. Rept. Geol. Sur. Wis., vol. iv, p. 208, pl. V. fig. 11.

Casts of the interior subcircular, strongly convex, suberect, with strong erect and scarcely incurved beaks situated nearly one-fourth of the length of the shell behind the anterior extremity. Back (without hinge) nearly straight; flattened sulcus wide, distinct, yet not deep, vertical, causing a marked compression of the anterior part of the umbones; usually includes one or two obscure vertical ridges. Hinge plate strong, with several (?3 or 4) strongly oblique cardinal and three posterior lateral teeth in each valve.

There is no doubt in my mind respecting the specific distinctness of this shell and the smaller and much more abundant *V. rotundata*. As I have already pointed out the difference, I shall not repeat them, but will refer the reader to the remarks on that species. The next species *V. media*, though very similar in its general expression, is not I believe so closely related. The beaks are smaller and more incurved, and there is a decided concavity in the dorsal outline behind the beaks, while the anterior margin has a slight backward direction that is not seen in *V. suberecta*.

*Formation and locality.*—Upper Buff limestone of the Trenton formation at Beloit, Wisconsin. *Mus. Reg.* No. 8328.

## Vanuxemia media, *n. sp.*

PLATE XXXVIII, FIGS. 23–26.

Shell small, strongly convex, rounded, a little the highest posteriorly; anterior margin slightly oblique, dorsal outline distinctly concave behind the beaks. Umbones of moderate size and prominence, but little compressed, beaks incurved. Hinge plate of moderate strength, the details of its structure not well determined. Anterior muscular scar rather small, and not so strongly defined as usual for the genus. Pallial line indistinct except for a short distance beneath the anterior muscle.

This species, though smaller, seems to be intermediate in its character between *V. suberecta* Ulrich and *V. hayiana* Safford, sp. It is of more rounded form and has larger and more prominent umbones than the latter, while in these same features it fails to equal the former. The anterior muscular scar is smaller and unusually shallow. Other differences may be noticed but those mentioned will, it is believed, suffice for the recognition of the species.

*Formation and locality.*—Trenton limestone, Minneapolis and Cannon Falls, Minnesota.

## Vanuxemia crassa, *n. sp.*

PLATE XXXVIII, FIG. 27.

This species, seems, on the whole, to have been much like *V. suberecta*, but is readily distinguished by the remarkable strength of its hinge and the great internal thickening of its shell in the umbonal and anterior parts. The beak is compressed in the cast, very prominent and not at all incurved; the anterior muscular scar strongly defined, large, of subcircular form with the inner side truncated; the pallial line is distinguishable all around and, for some distance beneath the anterior muscle, strongly defined by a deep and unusually wide furrow, out of which the anterior side of the body of the cast rises very abruptly. Ligamental area high and strongly striated longitudinally; cardinal teeth strong, comparatively long and slightly curved, three in number; posterior lateral teeth three, strong and a trifle more oblique than the cardinal teeth. Dorsum of cast broad and flat.

The external characters of the shell are unknown, but as the species doubtless belongs to the most typical section of the genus, they will probably prove much as in *V. inconstans*, *V. dixonensis* and *V. rotundata.*

*Formation and locality.*—Middle third of the Trenton shales, St. Paul, Minnesota.

## VANUXEMIA OBTUSIFRONS *Ulrich.*

PLATE XXXVIII, FIGS. 15–19.

*Cypricardites obtusifrons* ULRICH, March 3, 1892. Nineteenth Ann. Rep., Geol. and Nat. Hist. Sur. Minn., p. 233.
*Cypricardites vicinus* SARDESON, April 9, 1892. Bull. Minn. Acad. Nat. Sci., vol. iii, p. 339.

Shell rather large, moderately ventricose, very oblique, subovate, much the highest and broadly rounded posteriorly, with the beaks subterminal, incurved, not very prominent nor large, and the umbones strongly rounded. Anterior end obtuse, the upper part forming nearly a right angle with the hinge line, the slightly projecting junction between the two lines rather sharply rounded; postero-basal half of shell broadly semielliptical; dorsal outline very gently concave. Surface markings consisting of irregular, fine and coarse, sublamellose lines of growth.

Casts of the interior with the beaks large, very prominent, compressed and strongly incurved at their apices; umbonal ridge and sulcus of moderate definition, nearly parallel with the anterior margin. Anterior muscular scar large and strongly defined, excavated out of the hinge plate, in the cast having the appearance of a strong process projecting from the under side of the base of the beak forward and upward to the anterior extremity of the hinge; posterior scar illy defined, large, ovate, situated close to the posterior end of the hinge. Pallial line distinct.

Hinge with three cardinal and three posterior lateral teeth in each valve, both sets strong. The cardinal teeth are situated under the beaks, finely toothed on their sides, slightly curved and usually oblique, ranging at an angle of 45° or more with the hinge line.*

*The original figure of the interior of this species is faulty in its representation of the cardinal teeth. The type specimen has been injured at this point and in such a manner that I quite overlooked the actual remains of the teeth

The species may be compared with *V. inconstans* Billings, *V. niota* Hall, sp., *V. hayniana* Safford, sp., *V. sardeson* and *V. umbonata*. None of these forms, however, seem to me sufficiently similar to render the separation of the present species troublesome.

*Formation and locality.*—Blue limestone of the Trenton at Minneapolis, Minnesota.

*Mus. Reg.* No. 5524.

### VANUXEMIA SARDESONI *Ulrich.*

PLATE XXXVII, FIGS. 17–19, and PLATE XXXVIII, FIG. 45

*Cypricardites sardesoni*; ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 231.

Shell a little above the medium size, known only from casts of the interior, and the impression of the hinge and free margins on the limestone matrix. The outline was subrhomboidal, with the cardinal and anterior margins nearly straight, and the two lines forming an angle of about 62°; anterior extremity subacuate or sharply rounded, hinge line equaling nearly three-fourths of the entire length, postero-ventral margin broadly rounded, almost semicircular; above this the posterior outline is somewhat straightened and slopes forward rapidly, meeting with the cardinal line to form an angle of about 135°; the immediate junction however is not perceptibly angular.

In the casts the beaks project strongly, are nearly terminal, pointed, slightly incurved, greatly compressed, and somewhat twisted. A strong sulcus extends from the beaks to the postero-basal part of the casts; this sulcus occupies the larger part of the anterior slope, and from its inner side the umbonal ridge, constituting the highest portion of the surface, rises abruptly. For the reasons mentioned the anterior slope appears flattened and in part concave, while the posterior is almost uniformly convex to the margin. Cardinal slope abrupt, especially near the hinge.

Gutta-percha impressions bring out the internal characters in a very satisfactory manner. They show a wide and faintly striated ligamental area, two lateral and two cardinal teeth, both pairs large and distinctly crenulated on the sides. The cardinal pair are considerably curved and the lower one forms the upper boundary of the very sharply impressed anterior muscular scar. On the whole the hinge impresses one as being unusually strong. The posterior muscular scar is large, ovate, slightly prolonged below and but faintly impressed.

Comparing casts with the associated *V. obtusifrons,* which is nearer than any other now known, the present species differs in its greater obliquity, narrower anterior end, much stronger umbonal sulcus, broader and better defined ligamental area, and stronger as well as more coarsely crenulated hinge teeth.

*Formation and locality.*—Blue limestone of the Trenton at Minneapolis, Minnesota.

*Mus. Reg.* No. 8335.

## VANUXEMIA UMBONATA, *n. sp.*

PLATE XXXVIII, FIGS. 28–31.

Shell of medium size, tumid in the rostral and central parts, the hight about one-seventh greater than the length; obliquely subovate, hinge line rather short, the anterior extremity subangular and projecting a short distance beyond the beaks. Anterior margin gently convex, vertical, rounding neatly into the semicircular base; posterior margin broadly convex, the junction with the hinge line obtusely angular. Umbones evenly tumid, very prominent, the beaks curving forward and down to the hinge. Cardinal slope, concave; postero-cardinal portion of shell compressed. Surface not well preserved in any of the specimens seen, apparently marked with rather strong and somewhat irregular concentric lines of growth. Shell substance comparatively thin, so that the internal rostral and anterior thickening produces but a very obscure sulcus on internal casts. Anterior muscular scar sharply defied, reniform, of good size; posterior scar not observed; pallial line distinct in the anterior and basal parts. Hinge plate rather strong, with a narrow ligamental area posterior to the beaks; cardinal teeth long, nearly horizontal though distinctly curved, two in the right valve; posterior lateral teeth four in the right valve, slender, oblique.

This species is doubtless closely allied to *V. obtusifrons* but may be distinguished at once by its thinner shell, the greater projection of the anterior extremity of the hinge, and the greater length and more nearly horizontal arrangement of the cardinal teeth. Of the latter also there are only two instead of three, and they are not crenulated as in the species. The posterior teeth again are more slender. *V. hayniana* Safford, sp., is shorter and has a longer hinge line. One of the specimens is imperfect, so that it resembles *Cyrtodonta cingulata*, a rare species, occurring in the same beds, and having similar surface markings. However, a comparison of external characters alone reveals sufficient difference to render confusion between them highly improbable, especially when the possibility of such an occurrence is borne in mind. The hinge line of the *Cyrtodonta*, namely, is longer, the shell is more erect, the anterior end much longer, and the umbones, though more strongly convex, are on the whole much less tumid.

*Formation and locality.*—Upper part of the middle third of the Trenton shales, Minneapolis and St. Paul, Minnesota. Also in the Black River horizon of the Trenton formation in Mercer county, Kentucky.

## VANUXEMIA TERMINALIS *Ulrich.*

PLATE XXXVIII. FIGS. 33 and 34.

*Cypricardites terminalis* ULRICH, 1892. American Geologist, vol. x, p. 98.

Shell of medium size, moderately ventricose, extremely oblique, with the beaks terminal, rather small, strongly incurved and projecting but little above the hinge line. Umbo full, and the whole surface neatly rounded. Outline obliquely acuminate-ovoid with the anterior end narrowly rounded and projecting scarcely, if at all, beyond the beaks, from which the margin slopes backward with a gentle curve into the base; posterior end broad, uniformly rounded; cardinal margin straight, about three-fifths as long as the diagonal length of the shell, rounding into the posterior margin. Surface with faint wrinkles of growth and probably with finer concentric lines. Shell substance thin. Hinge plate rather narrow, with two long posterior and two or three short cardinal teeth in each valve. The latter are difficult to see because of the closely incurved beaks. Anterior muscular impression, as seen in casts of the interior, scarcely visible in a side view, being overhung by the side of the Umbo. In an end view they appear like two narrow vertical lobes tapering upward and placed just beneath the free portion of the beaks. Posterior scar very faint, large, ovate, situated a short distance beneath the extremity of the hinge. Pallial line distinct considering the thinness of the shell.

In the thin shell, its general form, and particularly in the character of the anterior muscular impressions, *V. terminalis* reminds strongly of *Ambonychia.* It is possible that this resemblance is merely coincidental, but I must say that I do not believe it, even if I can not now present plausible arguments to show that it expresses natural relationship. As a rule, it is not good policy to speculate in paleontological questions, but in the present instance I may be pardoned when I state my conviction that the *Ambonychiidæ* are an off-shoot from the same line of development that produced *Vanuxemia* and the rest of the *Cyrtodontidæ.*

Seven of the species of *Vanuxemia* described in this report are found at Minneapolis in the same beds that have furnished *V. terminalis.* All of them occur as casts of the interior, yet not one of the others is at all likely to be confounded with the present species. The principal peculiarities of the latter are the terminal beaks, almost hidden anterior muscle scars, the thin shell and the absence of the internal ridge-like thickening which in nearly all species of the genus produces a more or less well marked sulcus across the umbonal and anterior parts of casts.

*Formation and locality.*—Trenton limestone, Minneapolis and Cannon Falls, Minnesota. Also in the "Lower Blue beds" of the Trenton near Beloit, Wisconsin.

*Mus. Reg.* Nos. 5100, 8320.

### Vanuxemia hayniana *Safford.*

PLATE XXXVIII, FIG. 32. ALSO FIG. 36-VI, P. 479.

*Cyrtodonta hayniana* Safford, 1869. Geol. Tenn., pl. F., fig. 1.
*Cypricardites haynianus* Ulrich, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 240.
*Cypricardites triangularis* Sardeson, 1892. Bull. Minn. Acad. Nat. Sci., vol. iii, p. 338.

Shell of medium size, moderately convex, oblique, broadly subovate or obscurely quadrate, narrowing anteriorly, the hight and length respectively as nine is to ten;

hinge line nearly straight, rather long, terminating subangularly behind; posterior margin broadly rounded, slightly oblique, generally forming, with the basal margin a semicircle drawn to a diameter but little shorter than the length of the shell, and equalling the greatest hight; anterior end projecting very little beyond the beaks, nicely rounded from the end of the hinge, sloping backward in the lower half and passing very gradually into the basal line. Beaks only moderately prominent, strongly incurved, approximate; umbones full, uniformly convex to the beginning of the faintly concave dorsal and posterior slopes. Surface marked with more or less obscure and unequal concentric lines, some of them often, especially near the margin of old shells, being of a strongly lamellose character.

Hinge of moderate strength, the plate varying between 2 and 3 mm. in width at the middle in adult specimens; about half of the width taken up by a long and very finely lined ligamental area. Posterior lateral teeth constantly three in each valve, nearly straight, ranging at an angle of about 40° with the hinge line. Cardinal teeth varying in number and size. As a rule they are at least 10° more oblique than the posterior ones and normally of nearly equal size, finely toothed or striated and three in each valve. The variations are evidently due to irregularity of development, Rarely there are two large ones with a small one on each side; more commonly one. two, or even all three will be divided, so that the total number may reach six. Anterior muscular scar sharply defined, semicircular; posterior scar ovate, as usual very faintly impressed; pallial line quite distinct, except in the posterior part. Umbonal cavity small, compressed; anterior internal thickening of the valves generally rather sharply defined on the inner side.

Casts of the interior, the only condition in which the species has been found in Minnesota, have small compressed pointed and scarcely incurved beaks, projecting slightly beyond the hinge line and situated farther behind the anterior extremity of the shell than is the case on the exterior. The ridge immediately behind the anterior flattening or sulcus is well marked, as is also the pallial line and the anterior muscular scar. Indeed the natural casts correspond exactly with artificial ones prepared from typical Tennessee and Kentucky specimens of the species.

This is a widely distributed and well marked form, about which a number of closely related species or varieties are grouped. One of these, *V. subrotunda,* occurs in Minnesota, but in lower beds than the typical form. It is distinguished by its more circular outline. Another, *V. abrupta,* from the Galena of Fillmore county, is more easily separated by its more nearly terminal beaks, very obtuse anterior side, thinner shell, and in wanting the ridge which marks the casts of *V. hayniana.* A third form is found in the upper Trenton of Kentucky. Being a smaller shell I called it *nana* (*Cypricardites nanus* Ulrich, 1892. Nineteenth Ann. Rep. Geol. and Nat.

Hist. Sur. Minn., p. 239.) On comparison it proved to have a thinner shell, to be more erect and more rounded in outline, also more ventricose and with a stronger umbonal ridge, while there are only two cardinal teeth instead of three or more. A fourth form I propose soon to describe, in one of the periodicals, under the name of *V. gibbosa.* It is from the lower Trenton of central Kentucky, and differs from the present species in being more gibbous, in having larger umbones, almost terminal beaks and more obtuse anterior side. A fifth is associated with the preceding in Kentucky, and also occurs in Tennessee. It is a very thick shell and attains to larger size than *V. hayniana*, from which it differs further in its form which is higher and straighter and more obtuse in front. But the principal difference lies in the ligamental area which is at least twice as high as in adult examples of Safford's species. The area is shown in four specimens and in all of them its hight is 4 mm. or more at the middle and in one it is quite 5 mm. For this form I propose the name *Vanuxemia cardinata.* Finally a sixth form of this type is known to me from about twenty very perfect specimens that I owe to the liberality of Prof. J. M. Safford. He collected them at "Haynies," the locality in Smith county, Tennessee from which he obtained also the types of his "*Cyrtodonta hayniana.*" For the present I shall arrange these specimens as a small variety of *V. gibbosa*, since they agree much better with that species than with true V. *hayniana.*

*Formation and locality.*—The types of this species are from the Trenton limestone (middle Nashville beds of Safford) in Smith county, Tennessee. In Kentucky the species occupies two narrow horizons separated by more than 100 feet of strata. The first is at the base of the Trenton limestone in Mercer county at a point about three miles south of High Bridge, where the decomposed limestone has left numerous silicified shells and cystidrans. The second horizon, which is near the top of the Trenton, is exposed at several points along the Cincinnati Southern railroad between Burgin and Danville. In Minnesota the species seems to be restricted to the Galena shales, in which it occurs as casts of the interior at several localities in Goodhue county and at St. Paul. Good specimens are rare.

## VANUXEMIA SUBROTUNDA *n. sp.*

PLATE XXXVIII, FIGS. 36–38.

This species differ from *V. hayniana* Safford sp., to which it is doubtless very closely allied, in its more uniformly rounded outline, broader anterior end and shorter hinge line, and in having the beaks smaller and situated farther behind the anterior extremity. The convexity of the valves also is less, and the shell is thinner, particularly in the umbonal and anterior parts where the internal thickening is so little that no perceptible sulcus nor ridge is left in casts of the interior. For the same reason the beaks on casts must be more rounded and larger, so that however much the exterior of the two shells may resemble each other, casts of the interior would be distinguished very readily. V. *nana* Ulrich, from the upper Trenton in Kentucky, is a smaller shell; with more ventricose valves, better defined umbonal ridge, and longer hinge line. Of associated species, *Crytodonta glabella* Ulrich, has a similar outline, but there is no relationship between them since that species is as true a *Crytodonta* as this is a *Vanuxemia.*

*Formation and Locality.*—In the upper part of the middle third of the Trenton shales, Goodhue county and Chatfield, Minnesota.

### VANUXEMIA ABRUPTA *n. sp.*

PLATE XXXVIII, FIG. 39—44.

Shell a little beneath the medium size for the genus averaging 20 mm. high and 24 mm. long; rounded or subquadrate in outline, with subterminal beaks, tumid in the umbonal region and in front of the center, the anterior end very obtuse, the surface in the upper part rounding abruptly inward to the edges of the valves so that in a side view of casts of the interior the sharply defined anterior muscular scar is quite hidden beneath the filling of the umbones. Hinge line straight, long, terminating more or less abruptly posteriorly; posterior margin broadly rounded, occasionally nearly erect, usually a little oblique; anterior side truncated above, rounding below; base rounded. Casts have full and rounded and well incurved beaks, and the convexity of the surface continues without a sign of the sulcus and ridge exhibited by the casts of so many species of this genus. As near as can be determined from the impressions, the hinge plate was narrow and bore two, in one case apparently three slender posterior lateral teeth and two cardinal teeth in each valve. Pallial line and posterior muscular impression very obscure. Surface almost smooth, the best specimens only showing remains of fine concentric lines.

This well marked species is believed to be related to *V. nana* and *V. hayniana*, but the subterminal beaks and obtuse anterior end will distinguish it at once. From *V. terminalis* of the lower Trenton, which certainly is also very much like it and perhaps a more natural ally, it is separated by the more erect form.

*Formation and locality.*—Middle Galena, Fillmore and Goodhue counties, Minnesota.

### VANUXEMIA NIOTA *Whitfield (?Hall).*

PLATE XXXVIII, FIG. 35.

*?Cypricardites niota* HALL, 1861, Rep. Supt. Geol. Sur., Wis., p. 20; also 1862, Geol. Rep., Wis., vol. i, p. 38, Fig. 8, p. 438.
*Cypricardites niota* WHITFIELD, 1882, Geol. Rep., Wis., vol. iv, p. 208.

I am very much inclined to doubt that this species, a specimen of which was submitted to Prof. Whitfield, is the same as the one described by Prof. Hall. If it is, then the original description is anything but accurate.*

* Hall's original description of *Crypricardites niota* reads as follows: "Shell broadly subovate, broadest at the posterior end; umbones very gobbous, beaks incurved, little elevated, situated about one-fourth of the length of the shell from the anterior end. Cardinal line straight or little curved; anterior, posterior and basal margins rounded. Anterior muscular impression situated near the cardinal line, well defined; posterior imprint obscure. Surface of the shell marked by concentric lines of growth. This species differs from *C. rotundata* in being more oblique, in the straighter cardinal line, and less ventricose form. It is intermediate between that species and *C. ventrecosa*, from which it differs in less obliquity and the greater length from beak to base." "Length, one inch and a quarter; hight, one inch."

As it reads I should say that he refers to a species of *Cyrtodonta* like *C. glabella* or *C. persimilis* and not to a *Vanuxemia* which the shell here under consideration undoubtedly is. The latter differs in at least two important respects from the characters brought out in Hall's description, and either one would in my opinion, be sufficient to defeat specific identity. Thus, he says the beaks are "situated about one-fourth the length of the shell from the anterior end," whereas in Whitfield's *niota* they are much nearer the anterior extremity; then he gives the impression that the anterior, posterior and basal margins are almost uniformly rounded, while in the present species, the outline is always more or less quadrangular. Under the circumstances I might have been justified in proposing a new name, but as the questions involved would still be open (a study of the original of Hall's description alone can answer them), it seemed best to refer to the species provisionally as above.

*Vanuxemia niota* Whitfield (?Hall) sp., is closely related to *V. hayniana* Safford sp., and *V. gibbosa* Ulrich. From the first it is distinguished by its greater convexity and length, more anterior and larger beaks, and almost rectangular instead of rounded anterior side. The cast figured on plate XXXVIII preserves the impressions of the hinge teeth. The cardinal teeth were rather small, oblique, and numbered four in each valve. The posterior teeth were slender, nearly horizontal, and three in number. In V. *gibbosa* the anterior margin forms a wider angle with the hinge line, the shell was a little thicker, the hinge stronger, and the cardinal teeth larger, not exceeding three in number and less oblique. In artificial casts of that species the anterior muscular scar proved to be comparatively larger, and to project farther anterior to the filling of the beaks, which again are of larger size than in *niota*. *V. wortheni* of the Galena belongs to the same group of species but is a much larger and rounder shell, and in casts has more compressed and less incurved beaks.

*Formation and locality.*—Top of the "Lower Blue Beds," and base of the "Upper Buff Beds" of the Trenton formation at Beloit and Mineral Point, Wisconsin, and Rockton, Illinois.

*Mus. Reg.* No. 8321, 8325.

### VANUXEMIA WORTHENI *Ulrich.*

PLATE XXXIX, FIGS. 6 and 7.

*Cypricardites*, sp., undet., MEEK and WORTHEN, 1868. Ill. Geol. Sur., vol. iii, p. 311.
*Cypricardites wortheni* ULRICH, 1888. Amer. Geol., vol. 1, p. 180.

Shell large, moderately ventricose, suberect, subcircular, the length a little greater than the hight, the beaks nearly terminal, the dorsal margin almost straight, rather long and with the extremities rounding abruptly, the anterior one scarcely projecting beyond the point of the beaks; the rest of the outline rounded with the postero-basal part a little more curved than elsewhere. Surface rather uniformly convex in the central and umbonal regions, with the point of greatest convexity a trifle in front of the middle and unusually low.

Casts of the interior show that the shell was thickened internally on the anterior part, that the posterior side of the thickening was margined by a slightly oblique narrow groove or sulcus which left a blunt though well marked ridge on the cast extending down from a little behind the beaks to below the middle of its sides. Beaks very prominent in the casts, greatly compressed, but little incurved, hollow upon the inner side, an unusually large space left between them, showing that the hinge plate was much thickened in this part. The exact width of the hinge plate is unknown, but it must have been considerable and probably greater than the average, especially at the ends where it was bent down to make room for the large teeth. Of the cardinal teeth there were three in the right valve and the same number or only two in the left. They were of large size and rather strongly curved and oblique. The posterior teeth were strong, scarcely curved and oblique, but their number is unknown. Anterior muscular impression of medium size, rounded, sharply defined, but not very deep, excavated out of the anterior end of the hinge plate, the pair forming (in an anterior view of the cast) a narrow lobe partly between, but mostly in front of the filling of the beaks. Pallial line sharply defined in the anterior half, obscure behind. Posterior muscular impression very faint, large, situated immediately beneath the lateral teeth. A large cast has a hight of over 50 mm.

This shell is the largest known to belong to the genus. It belongs to the group of species of which *V. hayniana* Safford may be regarded as typical, but differs from them all in having the point of greatest convexity situated at the center instead of above the center. It is scarcely necessary to compare the species in detail with the numerous forms to which it is more or less nearly related, since ordinary specimens are distinguished at once by their unusual size.

*Formation and locality.*—Middle or upper part of the Galena, Mount Carroll, Illinois.

## VANUXEMIA DECIPIENS, *n. sp.*

PLATE XXXIX, FIGS. 1–5.

Shell rather small, strongly convex, obliquely ovate, highest posteriorly, the length of a large specimen 23 mm., its hight 18 mm. Hinge line straight, two-thirds as long as the shell, terminating subangularly behind, rounded in front; posterior margin slightly oblique, strongly rounded and somewhat prominent in the lower half; basal line moderately convex, ascending from the posterior third or fourth; anterior end narrowly rounded, very short, the greater part of it occupied by the muscular scar. Beaks of moderate size and fullness, incurved, the anterior half slightly flattened in the casts. This flattening, which is produced by the usual internal thickening of the anterior part of the shell, extends obliquely backward and downward from the beaks toward the middle of the ventral edge. Anterior muscular scar somewhat uniform, not as sharply defined below as is usual for the genus, very distinct, however, and partly overlapped above by the filling of the beaks. Pallial line sharp in the anterior two-fifths, obscure behind. Posterior muscular impression too light to be determined with certainty. Hinge plate narrow, with two slender horizontal posterior lateral teeth in the left valve and three in the right. Cardinal teeth unknown.

This species is associated with several of *Cyrtodonta* that, under ordinary conditions, are not easily distinguished. The feature to be chiefly relied upon in separating them (*i. e.*, the character of the anterior muscular scar) is usually obscured by crystallized remnants of the shell. When these are removed and a clean cast of the inteior has been produced the difficulties will have been overcome, since the *Vanuxemia* may then be distinguished at once from the *Cyrtodonta* by the much greater distinctness and character of the anterior muscular scar. (Comp. figs. 3 and 42 on plate XXXIX.)

*Formation and locality.*—Trenton limestone, Minneapolis, Minnesota.

*Mus. Reg.* No. 5100.

## Genus MATHERIA, Billings.

*Matheria*, BILLINGS, 1858. Can. Nat. and Geol., vol. iii, p. 440.

Shell equivalve, very inequilateral, oblong quadrate or suboval; beaks small anterior. Surface marked with concentric growth lines only. Hinge of moderate, strength or rather weak, with external linear ligamental area posterior to the beaks, two small, divaricating cardinal teeth beneath the beak of the left valve and only one in the right; no lateral teeth. Adductor impressions two; the anterior one smaller and better defined than the posterior. Pallial line simple, obscurely defined.

Type: *Matheria tenera* Billings.

Only four or five species known to me have the characters of this genus. They are all small shells and with one exception belong to the Trenton. *M. tenera* is from that horizon in Canada, one or two undescribed species occur in Kentucky, and *M. rugosa* in Minnesota, while the *Modiolopsis recta* Hall, which is a true *Matheria*, belongs to the Niagara of Wisconsin and Illinois.

### MATHERIA RUGOSA *Ulrich.*

PLATE XXXVI, FIGS. 29 and 30.

*Matheria rugosa* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur., p. 241.

Shell large for the genus, trapezoidal, widest posteriorly, with the beaks nearly terminal, small, incurved, projecting slightly above the hinge; a strongly convex umbonal ridge. Anterior end descending abruptly from the beaks, below rounding sharply into the nearly straight ventral border; posterior margin produced and strongly rounded in the lower half, obliquely subtruncate above, forming an obtuse angle at the junction with the hinge line; the latter very gently arched. Surface marked with strong concentric wrinkles and finer lines of growth. Shell substance of moderate thickness.

Hinge plate strong, flat, slightly arcuate, the upper half of the width posterior to the beaks, finely striated lengthwise. Cardinal teeth small, situated just beneath the beaks, directed toward the postero-basal margin, with one in the right valve and on each side of it a deep socket for the reception of the two teeth of the left valve. Anterior muscular scar rather distinct, subcircular, situated immediately beneath the teeth.

Several additional specimens of this well marked species were collected during the summer of 1892, among them an entire left valve showing the hinge. This has two cardinal teeth and no posterior laterals, so that there can be no longer any question as to the generic position of the shell. Only two other species belonging to this genus are known to have been described. These are *M. tenera* Billings and *M. recta* (Modiolópsis recta Hall), from both of which *M. rugosa* differs in the much greater hight of the posterior end. The shape of the shell reminds one greatly of *Ischyrodonta* and certain species of *Cyrtodonta*, but in the former the cardinal teeth are much stronger and the ligament internal instead of external. The hinge of *Cyrtodonta*, with its posterior lateral teeth and curved, more numerous, and longer cardinal teeth, is quite different, but when the interior is hidden the collector may experience some trouble in distinguishing the species from the associated *Cyrtodonta affinis*. Still, there is one difference that will serve his purpose very well, namely, the anterior end of the latter is rounded and somewhat produced beyond the beaks, whereas it descends abruptly from the beaks in the *Matheria*.

*Formation and locality.*—Upper part of the middle third of the Trenton shales, about six miles south of Cannon Falls, Minnesota.

## Genus WHITELLA, Ulrich.

*Whitella*, ULRICH, 1890, Amer Geol., vol. vi, p. 176.

Shell thin, obliquely quadrangular or suboval, equivalve, inequilateral, more or less ventricose. Umbones very prominent, the beaks strongly incurved; umbonal ridge prominent, subangular or sharply rounded. Cardinal margin straight or slightly convex, the edges inflected to form a sharply defined escutcheon extending beyond the beaks sometimes quite to the anterior extremity of the shell; area finely striated longitudinally. Hinge line straight, from one-half to two-thirds the length of the shell, with two to five rather obilque folds or teeth in front of the beaks. Posterior portion of hinge apparently edentulous. Ligament probably both external and internal, the latter only along the posterior third of the hinge line, where it was supported by an internal ridge in each valve. Two simple adductor impressions, the posterior one very faint; pallial line simple, marginal; interior of shell lined with a nacrous film. Surface of shell with fine concentric lines, and sometimes with stronger concentric undulations.

Type: *W. obliquata* Ulrich.

No more easily recognized genus of Lamellibranchiata than this is known from the Lower Silurian rocks, and of those restricted to that system, none is more important in the way of species and distribution. Twelve species, nine of them Trenton, the rest from the Hudson River group, are described and figured in this work. Two others were described by me in 1890, from the Cincinnati group of Ohio as *W. umbonata* and *W. subovata*, while another pair, *hindi* and *plebeia*, from the Hudson River rocks of Anticosta, were doubtfully referred by Billings to his genus *Cyrtodonta.* With the latter species Billings describes two others as *Cyrtodonta? sigmoidea* and *C. acutumbona* (1866, Catal. Sil. Foss. Anticosti, pp. 13 and 49), which may turn out to belong to *Whitella.* The *Cypricardites carinata* Meek, from Cincinnati, Ohio, also belongs here, while a very large species from the upper beds of the same formation remains to be described. Species of this genus have been referred to *Dolabra* McCoy, *Cypricardites* Conrad, and *Cyrtodonta* Billings.. McCoy describes his genus as containing inequivalve shells in which the hinge is edentulous. *Cypricardites* and *Cyrtodonta* both have well developed posterior lateral teeth and quite different cardinal teeth. In the latter also the shell is thicker and the ligamental area never so well developed, nor is the umbonal ridge ever so prominent as is commonly the case in *Whitella.*

## WHITELLA OBLIQUATA *Ulrich.*

PLATE XL, FIGS. 31 and 32.

*Whitella obliquata* ULRICH, 1890. Amer. Geol., vol. vi, p. 177.

Shell large, oblique, subrhomboidal in outline, produced in the postero-basal region, ventricose, with point of greatest convexity above the middle; beaks rather small, prominent, slightly incurved, situated nearly one-third of the length of the hinge line from its anterior extremity; umbonal ridge well marked, the cardinal slope concave. Anterior end small, narrowly rounded above, merging gradually into the evenly and only moderately convex ventral margin. Posterior end sharply curved and produced below, gently convex and sloping forward in the upper half to meet the slightly convex, cardinal margin. Escutcheon well marked, wide, shallowest in front of the beaks. Anterior muscular scar elongate. Hinge thin, simple posterior to the beaks, in front of them, with one long and slender horizontal tooth and several slightly oblique short teeth above it. The dimensions of a cast of the interior, of the average size, are as follows: greatest length, 50 mm.; greatest hight, 38 mm.; greatest convexity, 24 mm. A large specimen is 59 mm. long and 42 mm. high.

In *W. sterlingensis* M. and W. sp., the umbonal ridge is much stronger, the cardinal area much wider, the anterior end short, the posterior margin different, especially below where it is narrower, and the length from the beak to the postero-basal extremity comparatively greater. *W. quadrangularis* Whitfield, sp., is a more convex shell, not so oblique, and has a wider cardinal area, and larger beaks. For comparison with Trenton species see their descriptions.

*Formation and locality.*—Hudson River group, near Spring Valley, Minnesota. In Ohio and Indiana the species is not uncommon in the upper beds of the Cincinnati group.

## WHITELLA QUADRANGULARIS *Whitfield.*

PLATE XL, FIGS. 28–30.

*Cypricardites quadrangularis* WHITFIELD, 1878. Jour. Cin. Soc. Nat. Hist., vol. i, p. 138.

Shell of medium size, gibbous, rather erect and nearly rounded or quadrangular in outline, with very large incurved, though widely separated, subcentral beaks, overhanging the proportionally short but unusually wide ligamental areas. Length and hight subequal, the latter probably a little the greater; thickness more than two-thirds of the hight. Umbonal region very prominent, rounded anterior to the obtusely angular and rather inconspicuous umbonal ridge; behind the ridge the surface is a little concave and slopes abruptly toward the magin; anterior slope similarly abrupt and concave. Anterior end sharply rounded and most prominent at the extremity of the hinge; ventral and posterior margins sometimes forming a regular semicircle, but usually a slight prominence is perceptible in the postero-basal regions, causing a straightening of the posterior margin. Surface marked with somewhat irregular concentric lines and wrinkles of growth.

In casts of the interior the anterior muscular scar is uncommonly well defined for the genus, and immediately above them, a pair of depressions forming the anterior end of the cardinal area, is also an unusual feature. Furthermore, a slight vertical furrow on the umbones reminds of *Cyrtodonta.* Yet, despite these peculiarities, I am convinced that the species belongs to *Whitella* rather than to *Cyrtodonta.* This view is strengthened by the facts that the shell was very thin and covered on the inner side by a delicate pearly nacre, parts of which are preserved on the cast represented by figure 29. Such a film has been observed on casts of other species of *Whitella,* but has never been noticed on similarly preserved species of *Cyrtodonta.*

In drawing up the above description I have made use of the original type of the species which was borrowed from the museum of the Cincinnati Society of Natural History. This specimen is a mold of the exterior and has been compressed in such a manner that the outline is now unnaturally quadrangular, the umbonal ridge too prominent and the beaks too narrow. I have compared it very carefully with the northwestern specimens, which are casts of the interior, and while I admit freely the the possibility of error, my conclusion for the present is that they are specifically identical.

Compared with other species of *Whitella* it will be found that the shell is more erect and shorter, and the cardinal area wider than in any other known. An associated form, *Cyrtodonta grandis*, var *luculenta* Sardeson, has much smaller beaks, while they are also nearly in contact, the ligamental area being very much narrower.

*Formation and locality.*—Upper beds of the Cincinnati group at Clarksville, Waynesville and other localities in Ohio. The northwestern specimens were obtained from an equivalent horizon at Savannah, Illinois, and Spring Valley, Minnesota.

## WHITELLA STERLINGENSIS *Meek and Worthen.*

PLATE XLI, FIGS. 27 and 28.

*Dolabra sterlingensis* MEEK and WORTHEN, 1866. Proc. Acad. Nat. Sci. Philad., p. 260; also 1868, Geol. Sur. Ill., vol. iii, p. 339.
Not *Cypricardites sterlingensis* ? MEEK, 1873. Pal. Ohio, vol. i, p. 133.

*Original description:* "Shell rhombic-cordate, being cordate in outline, as seen in an anterior and posterior view, and obliquely rhomboidal, as seen from either side. Posterior margin obliquely truncated, with a long slope, which is slightly convex above and faintly sinuous near the middle; posterior basal extremity produced obliquely backwards and downwards, with a more narrowly rounded or subangular outline; basal margin ascending forward, with a moderately convex curve, and rounding up more or less gradually into the very short or almost obsolete anterior side; hinge line short; cardinal area moderately developed. Beaks prominent, placed nearly over the anterior margin, strongly incurved and compressed antero-posteriorly. Umbonal ridges very prominent, subangular, and extending from the beaks obliquely to the posterior basal extremity at an angle of about 45° below the horizon of the hinge, thus dividing each valve into two subequal areas, of which the one behind is flattened or slightly concave between the ridge and the moderately prominent postero-dorsal edge, and that in front and below it convex. (Hinge and interior unknown.)

"Greatest length, measuring obliquely from the beaks to the posterior basal extremity, 2.20 inches; diameter, at right angles to the same, 1.50 inches; convexity of the two valves when closed, 1.50 inches."

The great prominence and sharpness of the umbonal ridge, the decided flattening of the postero-dorsal region and the narrowness of the posterior extremity are the features that distinguish the species from all the others referred to the genus, except *W. hindi* Billings sp., *W. carinata* Meek sp., and *W. truncata* Ulrich. The first of these exceptions is not so high, less gibbous, less oblique; has a more prominent and less broadly rounded anterior side, straighter posterior margin, narrower beaks and a cardinal area or escutcheon that is a little longer but not nearly so wide. The other two are sufficiently distinguished by their much smaller size.

The specimen described by Meek in the Ohio Paleontology (*loc. cit.*) and doubtfully referred to this species is certainly distinct. It my belong to *W. hindi* Billings, or to *W. umbonata* Ulrich, both of which it resembles more closely than *W. sterlingensis*, especially in the prominence of the anterior end, which of itself precludes all possibility of its identity with the present species. That it really belongs to one or the other of the two species mentioned it would not now be safe to say, since I have no means of learning to what extent the specimen may have suffered from compression.

*Formation and locality.*—The type specimen was found in the upper beds of the Cincinnati group at Sterling, Illinois. A small distorted shell from the Hudson River group near Spring Valley, Minnesota, may belong here, but I cannot say as much for any specimen seen from the equivalent strata of Ohio and Indiana, despite the fact that the species is commonly believed to occur there.

## WHITELLA COMPRESSA *Ulrich.*

PLATE XLI, FIGS. 6–9.

*Whitella compressa* ULRICH, 1890. Amer. Geol., vol. vi, p. 180.

This shell has an outline very similar to that of *W. obliquata*, yet differs conspicuously from that species in having much less gibbous valves, the thickness in that species equalling about one-half of its greatest length, while in *W. compressa* the length is more than two and one-half times the convexity. And yet the length of the latter is comparatively a little less than in the Hudson River group species. Comparing the two species critically we find further that in *W. compressa* the umbonal ridge is much less developed and the outline at the extremities of the hinge somewhat different, the posterior part being a little more sharply rounded, while anteriorly the hinge projects farther beyond the beaks and in a straighter line, so as to form an angular junction with the anterior margin. An undescribed form found associated with *W. obliquata* in Ohio, and which I shall call *W. ohioensis*, attains a greater size, but agrees in all its specific characters much more closely with the present species. Indeed the agreement is so close that we may be justified in regarding it as a reapparition of *W. compressa*, the only difference so far detected with certainty being a slight one in the outline. The Ohio form, namely, is a little narrower across the posterior half of the shell. I expect, however, that when more perfect material can be compared other differences will become apparent, especially in their hinges and muscular impressions, these parts appearing to be somewhat stronger in the Trenton shales species.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis and St. Paul, Minnesota.

### Whitella concentrica *Ulrich.*

PLATE XLI, FIGS. 2 and 3.

*Whitella concentrica* Ulrich, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 247.

Shell rather beneath the medium size, oblique, ventricose, widest posteriorly, trapezoidal; beaks large, prominent, incurved; umbones full, with a sharply rounded ridge or line of gibbosity extending backward from the beaks to the posterior extremity of the shell. Cardinal and posterior slopes slightly concave. Anterior end short, narrowly rounded; ventral edge very gently convex; posterior end produced and sharply rounded in the lower half, more gently convex and sloping rapidly forward above, merging gradually into the curve of the dorsal side. Hinge line about half as long as the shell, with the edge inflected so as to form a narrow escutcheon, extending but little, if at all, in front of the beaks. Internal ligamental supports leave a distinct impression on each side of the postero-cardinal margin in casts of the interior. Anterior muscular scars distinct though faintly impressed, situated in the antero-dorsal angle. Surface of casts, especially in the lower and posterior parts, marked with fairly distinct, rounded, concentric folds.

The concentric undulations are stronger in this species than in any other known to me. It is shorter than *W. præcipta*, more ventricose than *W. compressa*, and has much fuller umbones than *W. obliquata*. In *W. scofieldi* the surface is not undulated, the anterior end is subangular above, and the umbonal ridge sharper.

*Formation and locality.*—Middle third of the Trenton shales at Minneopolis, Minnesota.

### Whitella rugatina, *n. sp.*

PLATE XLI, FIG. 1.

Shell subovate or obscurely trapezoidal, moderately gibbous, with well shaped and prominent umbones and strongly incurved beaks situated one-fourth of the length of the shell behind the anterior extremity. Umbonal ridge moderate, rounded except immediately behind the beaks. Escutcheon narrow, not extending in front of the beaks. Surface of casts marked with numerous, rather small, concentric furrows, which in parts may be quite regular, but in others are thrown into bundles so as to produce obscure undulations. Hinge unknown, muscular and pallial impressions very faint.

The specimen figured has the following dimensions: From the postero-basal margin to the antero-cardinal angle, 33 mm.; from the same point to the umbones, 31 mm.; from the postero-cardinal margin to the antero-basal margin, 26.5 mm.; greatest or posterior hight, 24.7 mm.; greatest convexity, 16.5 or 17 mm.

Though comparable in a general way with a number of species referred to the genus, the relations are not very close in any case. In the matter of outline it agrees best with *W. compressa* and *W. ohioensis*, but the umbones are larger, the valves more convex, and the surface markings much better defined, especially on casts of the interior. The umbonal ridge is not strong enough for *W. scofieldi*, and the umbones too small for *W. concentrica*, while in the outline it differs in a similar manner from both of those species. Finally, in *W. subcarinata* and *W. ventricosa* Hall, sp., the anterior end is shorter.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis, Minnesota.

### WHITELLA MEGAMBONA *Whitfield.*

PLATE XLI, FIGS. 4 and 5.

*Cypricardites megambonus* WHITFIELD, 1877. Ann. Rep. Geol. Sur. Wis., p. 73. Also 1882, Geol., Wis., vol. iv, p. 210.
*Whitella megambona* ULRICH, 1890. Amer. Geol., vol. vi, p. 384.

Shell of medium size or less, oblique, subelliptical in outline, very gibbous, the convexity of the closed valves equalling very nearly the shorter of the oblique diameters, and about two-thirds of the distance from the beaks to the postero-basal extremity. Umbones very large, tumid, with the beaks strongly and obliquely incurved, their points being brought into close proximity; umbonal ridge prominent, subangular near the beaks but becoming obtuse in receding from them; point of greatest convexity somewhat behind the middle of the shell. Hinge line very short, posteriorly passing rather gradually into the posterior margin; the latter is somewhat oblique and broadly rounded to the base where the outline turns rather sharply forward into the basal line, which continues with a uniform curve to the narrowly rounded—almost angular—anterior extremity; the latter projects about one-ninth of the longer diameter of the shell beyond the anterior side of the umbones. Surface marked by irregular concentric lines of growth, and distant obscure undulations. Anterior to the umbonal ridge the surface is rather strongly convex, while the posterior and cardinal slopes are flattened and exhibit along the center a more or less distinct sulcus. Escutcheon very short and narrow. Internal ligament supports, unusually long, in casts leaving a well defined furrow on each side of the hinge line, extending from the upper part of the posterior margin almost to the beaks. Cardinal teeth apparently as in *W. scofieldi*. Anterior muscular scar shallow, rather small, rounded, situated in the antero-dorsal angle. Posterior scar and pallial line undetermined.

In most specimens there are two or three, thin, parallel and oblique ridges on each side at the extremity of the hinge. These opposed sets of ridges are separated by an interval in adult examples, but it is scarcely to be questioned that in an earlier stage in the development of the shell they represented posterior lateral teeth similar to those of *Cyrtodonta.* This fact must have an important bearing upon the question of genealogy, but, in the absence of any knowledge of similar types in earlier strata, it is not now possible to discuss it with anything like certainty of arriving at a true solution of the question.

This is a well marked species and one that is not likely to be confounded with any of the associated shells. Its nearest congeners seem to be *W. scofieldi* and *W. sterlingensis* M. and W., sp., the latter particularly, but in both of these species the umbonal ridge is more conspicuous and the outline different. The former again has a longer escutcheon and hinge, much larger anterior end and more prominent postero-cardinal angle, while in the latter the shell is more oblique, the posterior angle narrower, the cardinal area much wider and the beaks farther apart.

*Formation and locality.*—Lower Trenton limestone, near Beloit, Wisconsin and Minneapolis, Minn.

### WHITELLA SCOFIELDI *Ulrich.*

PLATE XLI, FIGS. 17–21.

*Whitella scofieldi* ULRICH, 1890. Amer. Geol., vol. vi, pp. 181 and 382.

Shell of medium size, strongly convex, moderately oblique, subtrapezoidal in outline, with the hinge line longer, straighter and better defined than usual. Anterior end unusually long and wide, the outline gently rounded from the subangular junction with the hinge line; basal margin slightly convex, oblique, descending to the strongly rounded postero-basal angle; posterior margin subtruncate, slightly oblique and but little convex in the upper half. Umbones prominent, subcarinate behind, with the beaks approximate, obliquely enrolled and situated a little more than one-third of the length of the hinge line behind its anterior extremity. The umbonal ridge is a conspicious feature, although becoming obsolete before reaching the postero-basal margin. Posterior to the ridge the surface is distinctly concave; in front and beneath it convex. Surface marked by rather distinct concentric lines of growth, of which the marginal ones may, in old examples, assume a sublamellose character. Escutcheon high but narrow in a dorsal view, finely striated longitudinally and not extending anterior to the beaks. Internal ligamental supports appearing as a double ridge in each valve beneath the posterior half of the escutcheon. Anterior hinge teeth two in each valve, elongate, slightly curved, nearly horizontal. Muscular scars and pallial line faint, not well determined.

This species is more convex and has a more distinct umbonal ridge than *W. compressa*, and a longer hinge line and larger anterior end than *W. megambona*, while the basal margin is more oblique and the anterior end much larger than in *W. subcarinata.*

*Formation and locality.*—Upper part of middle third of the Trenton shales, St Paul, and near Cannon Falls, Minnesota. Also in the Trenton limestones ("Upper Buff beds") near Beloit, Wisconsin.

### Whitella truncata *Ulrich.*

PLATE XLI, FIGS. 10–14.

*Whitella truncata* Ulrich, 1890. Amer. Geol., vol. vi, p. 385.

Shell small, very oblique, ventricose, subrhomboidal in a side view. Beaks nearly terminal, prominent, of moderate size, obliquely enrolled; umbones and umbonal ridge full, the latter angular and traceable to the postero-basal angle. Cardinal slope sharply defined and distinctly concave; anterior and basal slopes slightly convex and very rapid. Anterior end very short, scarcely projecting beyond the beaks, narrowly rounded, then sloping rapidly backward and uniting very gradually with the gently curved basal margin. Posterior end truncated, straightened, forming nearly a right angle with the hinge line, and one of from 75° to 80° with the ventral edge. Escutcheon narrow, not extending anterior to the beaks. In casts of the interior, the internal cartilage support leaves two narrow impressions, one on each side of the posterior half of the hinge line. Dentition of hinge not observed. Muscular scars very faint.

Dimensions of a large cast of the interior: Greatest hight, 13 mm.; greatest convexity (near center of shell), 15 mm.; length from beaks to postero-basal angle, 19 mm.; length from anterior extremity to upper portion of posterior margin, 15 mm. In a small specimen only 6 mm. high, the other dimensions are in proportion, except that the convexity is comparatively less.

This species is closely related to *W. scofieldi*, but may be distinguished by its smaller size, greater convexity, truncated posterior end, shorter anterior end and more pronounced postero-ventral angle.

*Formation and locality.*—Galena shales, Goodhue county, Minnesota.

### Whitella subcarinata, *n. sp.*

PLATE XLI, FIGS. 22 and ?23.

This species is in many respects like *W. truncata*, but is readily distinguished by its lesser gibbosity, smaller beaks and more rounded shape. The umbonal ridge is angular or sharply rounded and distinct quite to the postero-basal margin. An obscure furrow in the middle of the flat cardinal slope. From *W. ventricosa* Hall, sp., which seems to be its nearest congener, it differs principally in the greater sharpness and prominence of the umbonal ridge. The anterior end is much too small and short for *W. rugatina, W. concentrica* and *W. scofieldi.* In each case other differences might be mentioned, but those selected will, it is believed, suffice.

Greatest length, 23 mm.; distance from beaks to posterior extremity, 22.5 mm.; posterior hight, 16.5 mm.; thickness, 13 mm. Antero-ventral—postero-cardinal diameter, 17 mm.

Figure 23 is taken from a doubtful left valve, obtained from the lower Trenton in Jo Daviess county, Illinois. As viewed now, this specimen represents an ancestral form or variety of the present species from which also *W. ventricosa, W. truncata* and perhaps other species as well have been evolved. More and better material, however, is necessary before such a view of its relations can be consdered either as proved or disproved.

*Formation and locality.*—The typical form is from the middle Galena near Wykoff, Minnesota.

### WHITELLA VENTRICOSA *Hall.*

PLATE XLI, FIGS. 24—26.

*Edmondia ventricosa* HALL, 1847. Pal. N. Y., vol. 1, p. 155.
Not *Palæarca ventricosa,* HALL, 1859. Pal. N. Y., vol. iii, p. 271, and Twelfth Rep. State Cab., pp. 10, 68 and 95. (?=*Cyrtodonta huronensis* BILLINGS.)
Not *Cypricardites ventricosus* HALL, 1862. Geol. Rep. Wis., vol. 1, p 438; nor WHITFIELD, 1882. Geol. Rep. Wis., vol. iv, p. 209. (=*Cyrtodonta,* sp., undet.)

Believing that this species is represented among the undetermined fragmentary shells from Minnesota, I thought it well to give illustrations of authentic specimens from the Trenton of New York. These were received in an exchange some time ago. Quite recently I sent two of them to Prof. R. P. Whitfield, of the American Museum of Natural History, who compared them with the original types of the species and verified the identification.

An examination of the New York examples established what I had already suspected from the original figures, namely, that the species is a true *Whitella* and not, as is commonly believed, a *Cypricardites* or *Cyrtodonta.* Its place in the genus will be seen at once, when compared with other species of the genus figured on plates XL and XLI. The shell was thin, the beaks were full and prominent, the umbonal ridge, though not as sharply defined as in many other species of the genus, is still a more conspicuous feature than in any species of *Cyrtodonta,* the hinge has a narrow external ligamental area or escutcheon, and ridge-like supports for a posterior internal ligament, but no posterior lateral teeth. In short, the species presents every essential characteristic of the genus *Whitella*. We cannot, however, say this of the specimens which were referred to the species by Hall in 1859 and 1862, and Whithfield in 1882, since in these cases we are dealing with inequivocal types of *Cyrtodonta*. The interior figured by Hall in vol. iii, Pal. N. Y., as *Palæarca ventricosa*, is very different from the original *Edmondia* (now *Whitella*) *ventricosa*. That shell seems to belong to the species previously described by Billings as *Cyrtodonta subcarinata*. The cast figured by Whitfield, if correctly represented, belongs to a species of *Cyrtodonta* as yet unknown to me. In his description, however, he included the species which I have named and described on page 537 as *Cyrtodonta janesvillensis*.

Comparing *W. ventricosa* with other species of the genus, *W. subcarinata* will be found to have a sharper and more prominent umbonal ridge. In *W. rugatina* and *W. concentrica* the anterior end is much larger; *W. præcipta* is much narrower posteriorly and a more elongate shell.

*Formation and locality.*—In New York the species occurs in the Trenton limestone at Watertown, Middleville and other localities. If it really occurs in Minnesota, it will be, I think, in the middle Galena of Goodhue and Fillmore counties.

## WHITELLA PRÆCIPTA *Ulrich*.

PLATE XLI, FIGS. 15 and 16.

*Whitella præcipta* ULRICH, 1890. Amer. Geol., vol. vi, p. 386; more fully described and figured in 1892, Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 246.

Shell of medium size, ventricose, very oblique, elongate-ovate or subrhomboidal in a side view, produced and sharply rounded in the postero-basal region. Beaks of moderate size, prominent, strongly incurved; umbones full; umbonal ridge well marked, traceable almost to the posterior extremity. Anterior end small, short, narrowly rounded; ventral margin gently convex; posterior end produced and narrowly rounded in the lower part; from the point of greatest extension to the posterior side of the projecting umbones the outline is gently and almost uniformly convex. Hinge line comparatively short, its length less than half the length of the shell, the edge inflected to form a distinct escutcheon, extending somewhat in front of the beaks. In casts of the interior the internal ligament supports have left distinct impressions of unusual width on each side and behind the impression produced by the escutcheon. An obscurely defined ridge and sulcus is also to be seen running through the middle of the cardinal slope. Anterior muscular scar faint, subovate, acuminate below, situated very near the anterior extremity. Pallial line represented by a thin raised line running parallel with the margin of the cast.

This species is very similar to *W. obliquata* Ulrich, from the upper beds of the Cincinnati group, yet I do not doubt that they are really quite distinct species. That species grows to a larger size, is less elongate, wider posteriorly and with the umbones less tumid and not so prominent. The impressions of the internal ligament supports also are very much less distinct. *W. subcarinata* is not so oblique, shorter and has a longer hinge and narrower escutcheon.

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

## Family ?MEGALODONTIDÆ, Zittel.

### Genus PLETHOCARDIA, Ulrich.

*Plethocardia*, ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 243.

Shell thin, inequilateral, oblique, tumid, with margins closed; beaks large, prominent, spirally enrolled and curving forward. Posterior cardinal margin with a narrow escutcheon or lunette. A strong and large process projects forward and downward from the underside of the hinge just beneath the beak in each valve; one strong linear lateral tooth, or thickened internal cartilage support, beneath the posterior extremity of the hinge line and close to the margin. Anterior muscular scar strongly impressed, situated in the antero-dorsal angle, margined on the inner side by a curved ridge extending from the under side of the cardinal process. In casts of the interior the filling of the anterior impressions forms a small but sharply defined lobe. Posterior muscular scars indistinct, much larger than the anterior, situated just behind the center of the postero-cardinal slope. Pallial line simple, submarginal, faintly impressed.

Type: *P. umbonata* Ulrich.

In the original description of this genus and of the typical species, I called the subrostral process a cardinal tooth. This view I now believe to be at variance with the facts, for the reason that the supposed tooth does not project beyond the plane of the margins of the valve and therefore could not have interlocked with a corresponding tooth or teeth in the opposite valve. In the left valve, upon which the genus and *P. umbonata* was established, this process was somewhat injured in clearing away the adhering matrix. It is, however, sufficiently preserved to show that it had one large transverse depression in the lower part (for which reason it was described as bifid) and probably one or two in the upper part. In an imperfect right valve, recently obtained from Kentucky, the process is similarly marked with a large depression in the lower part and two (perhaps three) smaller prominences above. In neither specimen are the upper prominences in a sufficiently good state of preservation to admit of positive declarations respecting their character and purpose. Still it is reasonable to suppose that they represent hinge teeth perhaps similar to those of *Whitella*, especially since they lie just within the line of the hinge. As to the lower part of the process, why should it not have supported an internal cartilage?

The shells of this genus present considerable external resemblance to those of *Whitella*, Ulrich. As a rule they will probably prove shorter, more erect and comparatively more ventricose. I believe also that *Whitella* offers closer affinities than any other genus yet known, and I can see that it may prove difficult in some cases to distinguish species of the two genera when the internal characters are not available. Of course such difficulties cannot obtain when the diagnostic characters of the hinge are preserved, since the strong subrostral process of *Plethocardia* is too marked a feature to be overlooked in comparing the two genera. Good casts of the interior even are easily distinguished by the presence of the small lobe beneath and in front of the beaks of *Plethocardia*, the muscular impressions being very much less distinct in the casts of *Whitella*. In the posterior part of the hinge, however, as well as in other respects, the two genera are practically the same.

It seems to me more than doubtful that *Plethocardia* belongs to the family *Megalodontidæ*. A general resemblance to those heavy and strongly-hinged Devonian and Triassic shells, which are included in the family by Zittel, may at first strike one, but a critical comparison brings out too many important differences. I adopted the above provisional arrangement chiefly that attention may be directed to the genus as a possible progenitor of a remarkable family of shells.

### PLETHOCARDIA UMBONATA *Ulrich.*

PLATE XL, FIGS. 22–24.

*Plethocardia umbonata* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 244.

Shell about 25 mm. in length, strongly ventricose, obliquely subovate in a side view, widest posteriorly; beaks large, very prominent, inrolled; umbonal ridge angular, traceable to the postero-basal margin; cardinal slope narrow, rather sharply defined, concave. Anterior end very short, nearly ventrical, sharply rounded above; dorsal margin arcuate, graduating into the posterior curve; the latter is produced slightly in the lower part and accelerated as it turns into the broadly convex ventral margin. Surface marked with concentric lines of growth, some of them strong.

Escutcheon narrow, extending backward from the beaks nearly to the posterior extremity of the hinge. Subrostral cardinal process large, projecting obliquely forward from the lower side of the hinge, with one large depression (? internal cartilage pit) in the lower half and several smaller ones (? teeth sockets) above. A strong, ridge-like thickening of the shell, probably representing either a postero-lateral tooth or the support of an internal ligament, occurs just within the postero-cardinal margin. Anterior adductor muscular scar situated in a cup-like depression formed by a curved ridge which proceeds from the under side of the cardinal process and the antero-cardinal margin of the shell; posterior scar indistinct, larger than the anterior, situated a short distance beneath the post-cardinal margin. Pallial line faint, simple, submarginal.

It is possible that this species is not distinct from the *Cyrtodonta cordiformis* of Billings. His figures of that species looks so much like the shell above described that I am nearly satisfied that they must be congeneric at least. It might be a *Whitella*, but it is not a true *Cypricardites*. Compared with *P. umbonata* it appears that in the Canadian shell the beaks are situated farther back from the anterior extremity, the umbonal ridge is rounded instead of angular and the outline different, especially that of the posterior end, which is also wider.

*Formation and locality.*—Upper part of the middle third of the Trenton shales six miles south of Cannon Falls, Minnesota. Also in cherty limestones of the age of the Black River limestone of New York, in Mercer county, Kentucky.

## Plethocardia suberecta *Ulrich.*

PLATE XL, FIGS. 25–27.

*Plethocardia suberecta* Ulrich, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 245.

Shell small, but little oblique, exceedingly ventricose, short, subelliptical in a side view, with the dorso-ventral diameter much the longest. Beaks very prominent, large, strongly incurved, nearly terminal; umbonal ridge strong, sharply rounded, with the cardinal and posterior slopes very abrupt and nearly flat. Anterior end very short, the part in front of the beaks of casts consisting chiefly of the sharply defined lobe-like filling of the anterior muscular impressions. Anterior and posterior margins gently convex, subparallel; ventral edge sharply rounded. Hinge line short, scarcely extending posterior to the umbonal ridge, as seen in a side view. In the casts there is a depression beneath each beak that is prolonged on each side around the muscular scar. The escutcheon seems to have been narrow, but the internal ligament supports at the posterior end of the hinge line have left two strong grooves, one on each side.

This species, though clearly congeneric with *P. umbonata*, is so readily distinguished that comparisons are unnecessary.

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

## Family NUCULIDÆ.

### Genus CTENODONTA, Salter.

*Nucula*, HALL, 1843. Geol. Rep. Fourth Dist. N. Y., p. 76; Amer. Jour. Sci., vol. XLVIII, p. 292; 1847, Pal. N. Y., vol. 1, pp. 150 and 316.
*Lyrodesma* (part.), HALL, 1847. Pal. N. Y., vol. 1, p. 302.
*Tellinomya*, HALL, 1847. Pal. N. Y., vol. 1, p. 151; 1857, Tenth Ann. Rep. Reg. Univ. N. Y., p. 181; also of the majority of American paleontologists since that date. (Not *Tellinomya*, the correct form of *Tellimya*, BROWN, 1827, as given by AGASSIZ in 1846 in his "Nomenclator Zoologicus.")
*Ctenodonta*, SALTER, 1851. Rep. Brit. Assoc., p. 36; 1859, Can. Org. Rem., Decade i, p. 34.
*Palæoconcha*, S. A. MILLER, 1889. North Amer. Geol. and Pal., p. 498.

Shell equivalve, closed, usually largest anteriorly,* occasionally subequilateral, with the beaks situated sometimes behind the middle, but usually more or less in front of that point; surface marked by concentric lines of growth; beaks approximate, generally small and never very prominent. Ligament external, rather small, situated immediately behind the beaks; no striated area nor internal cartilage pit. Hinge more or less arcuate, sometimes very gently, at other times bent almost at a right angle; with series of small curved or geniculated transverse teeth, which diminish in size more or less gradually from the extremities to the beaks; the series are continuous and gradually pass into each other in the typical section of the genus, but in other sections they are often interrupted beneath the beaks. Adductor muscular impressions two in each valve, subequal, nearly always readily distinguishable, and sometimes very deeply impressed, situated just beneath the anterior and posterior extremities of the hinge; scars of small foot-muscles have been observed in a number of species, one immediately above or in front of each of the adductor scars; pallial line indistinct, simple, submarginal.

Type: *C.* (*Tellinomya*) *nasuta* Hall.

Several reasons have operated in the rejection of Hall's earlier name *Tellinomya* in favor of Salter's *Ctenodonta*. First among these is the fact that *Tellinomya* was used for a totally different group of shells at least one year previous to the date of publication of the first volume of Hall's Paleontology of the state of New York, namely, in 1846 by Agassiz, in his "Nomenclator Zoologicus," when he catalogued the correct form of the incorrectly constructed generic name *Tellimya*, which had been proposed by Brown in 1827. Believing that such corrections are allowable, I am obliged to hold that *Tellinomya*, Hall, cannot stand under the rule relating to

*It is quite difficult to establish which is the anterior end in these shells. For the sake of uniformity I have, in each case, assumed that the higher end (it is usually also the rounder) is the anterior. It may be well to state, moreover, that I am not at all satisfied that this rule should apply in the *C. recurva* section of the genus, nor that Salter, Meek and Worthen, Hall and others who have described species of that section, are right in assuming that the side toward which the beaks are turned is the posterior. Though I have followed these authorities, I have done so chiefly because it seemed desirable, at any rate until the genus was worked up monographically, to have our descriptions as uniform as possible. Had I followed my own inclination it would have been to reverse, in this case, the present application of anterior and posterior, upon the ground that the external ligament was situated upon the covex half of the hinge instead of the concave. That this is really a fact is, I believe, conclusively shown in *C. recurva*. (See plate XLII, fig. 101.)

preoccupied names. Salter objected to the adoption of Hall's name, because it was inappropriate and conveyed "an entirely erroneous view of the affinities." This of itself certainly would not be sufficient to invalidate the name, yet some weight attaches to it when considered in connection with other defects. Salter justly observes that "the chief characters of the genus reside in the hinge and teeth, which are neither figured nor described by him (Hall), casts only of the interior and external surface having been given in the plates of his excellent work, nor was the external ligament observed." This is all strictly true and, what is more, it is scarcely to be doubted that if Hall had observed the nuculoid character of the hinge he would not have proposed *Tellinomya*. He would have placed the species under *Nucula* or possibly *Lyrodesma*, that being the arrangement adopted by him in all cases where he did see the ctenodontoid hinge. Nor can we doubt that *Ctenodonta* was acceptably described at least five years before *Tellinomya*, Hall, was redefined in accordance with the true character of the shells upon which the genus was founded originally. Finally, the original description of *Tellinomya* was so totally at variance with the facts that Salter could not for a moment be blamed for failing to recognize the identity of *T. nasuta* and the shell which he proposed to call *Ctenodonta*.

Taking all these defects of *Tellinomya* into consideration, I do not see how we can do otherwise than adopt *Ctenodonta* in preference to Hall's name. Had *Tellinomya* not been preoccupied I would have suggested another solution of the difficulty, namely, to subdivide the genus so that both names might be used, at least provisionally, *Tellinomya* for the typical group of species and *Ctenodonta* for the higher and round or subtriangular forms like *C. astartiformis* Salter. But being preoccupied, there is no room for *Tellinomya* in this connection.

Taken as a whole, the genus *Ctenodonta* is a remarkably complex group of species. This may perhaps be accounted for by the great number of the recognizable forms, yet it is more likely the result of too great an expansion of the generic limits. Indeed, the variety of characters exhibited in the genus as now accepted is so great that it is difficult to draw up a satisfactory description without becoming unusually circumstantial. Thus, there are elongate shells and others in which the length is exceeded by the hight. In many the outline is elliptical, in some subrhomboidal, in others rounded and in a few subtriangular. In some the umbones are compratively large and full, in others very small, and the beaks may be turned either forward or backward. Internally the structure is equally diverse. The hinge plate may be narrow or broad, nearly straight or bent rectangularly, and with outwardly or inwardly bent denticles. The latter, though always smallest near the beaks, may form a continuous series from one end of the hinge to the other, or the continuity of the series may be interrupted beneath the beak. This interruption may be produced, without materially affecting the arrangement of the teeth, by the development of a small pit immediately beneath the beak (see plate XLII, fig. 80), or the teeth may be so arranged that the two series of teeth are directed at almost right angles to each other (see plate XLII, figs. 39, 90, 101 and 102). Finally, the shell is often very thin and the muscular scars barely distinguishable, while in other forms the shell may be thick and the muscular imprints exceedingly strong.

In the present work I have allowed all these divergent types to remain under the single genus *Ctenodonta*. This does not, however, say that I could not have subdivided the genus into several, nor that I do not believe that such a course will eventually be considered not only possible but desirable. Meek and Worthen long ago* expressed themselves as favoring a separation of the subtriangular forms like *C. alta* Hall, from the more typical ovate or elongate species. And Dr. S. A. Miller† quite recently proposed the new genus *Palæoconcha* for one of the species of that group. He did so, however, under the misapprehension that the hinge of the species described by him is edentulous; so his evidence on the point is much weakened, for he would, most likely, not have proposed his genus had he understood the hinge fully.

For the reason about to be mentioned, I am probably in a better position than any one else to speak of the possible subdivisions of this genus, namely, my efforts to collect a large mass of material have been successful, not only in the way of individuals, but in adding very greatly to the number of known species. Indeed, the Lower Silurian species in my cabinet outnumber the forms described previous to 1890 more than two to one. I believe, therefore, that with the careful study that has been given to this abundance of material, I am able to discriminate in a fairly trustworthy manner between the important and unimportant characters, to approximate truth in my views of the inter-relations of the species and to understand some of the genetic questions involved in the development of the family.

The Lower Silurian species may be arranged in six more or less well marked groups, as follows:

I. *C. nasuta group.*

Elongate shells, narrow posteriorly, beaks subcentral; muscular scars moderately or distinctly impressed, hinge but slightly arcuate, teeth in a continuous series, straight or bent outwards.

Species: *nasuta* Hall, *nasuta*, var. *robusta* Ulrich, *subnasuta* Ulrich, *oviformis* Ulrich, *cuneiformis* Ulrich, *regia*, n. sp., ‡*tennesseensis*, n. sp., *appressa*, n. sp., *crandalli*, n. sp., *iphigenia* Billings.

* Geol. Sur. Ill., vol. iii, p. 309; 1868.

† North American Geology and Paleontology, p. 498; 1891.

‡ The new species, which are not described in this work nor in vol. vii of the Ohio Geological Survey reports, are marked simply as n. sp. Descriptions of these forms will, it is hoped, be published at an early date, the plate on which they are illustrated being ready for publication.

II. *C. gibberula group.*

Shells usually short, thick, with very strongly defined muscular impressions; hinge strongly bent, with the series of denticles interrupted beneath the beaks; teeth straight or curving outward.

Species: *gibberula* Salter, *contracta* Salter, *angela* Billings, *carinata* Ulrich, *planodorsata* Ulrich, *longa* Ulrich.

III. *C. levata group.*

Shells usually of ovate form, rather thin, with muscular scars moderately distinct; denticles converging inward, forming a continuous series in the Trenton species. In the Hudson River forms, however, the series is more or less interrupted by the development of a small and undefined pit just beneath the beak.

Species: *levata* Hall, *donaciformis* Hall, *abrupta* Billings, *nitida* Ulrich, *medialis* Ulrich, *scofieldi* Ulrich, *socialis* Ulrich, *hartsvillensis* Safford, *danvillensis*, n. sp., *retrosa* Ulrich, *filistriata* Ulrich, *albertina* Ulrich, *simulatrix* Ulrich, *tumida*, n. sp., *madisonensis* Ulrich, *fecunda* Hall, *calvin* Ulrich, *mundula*, n. sp., *perminuta* Ulrich, *nunculiformis* Hall, ? *hilli* Miller.

IV. *C. pectunculoides group.*

Shells subcircular, compressed-convex, beaks very small; hinge plate strong, regularly arcuate; teeth in a continuous series.

Species: *subrotunda* Ulrich, *circularis*, n. sp., *pectunculoides* Hall, *cingulata* Ulrich, *pulchella* Hall.

V. *C. recurva group.*

Shells high, the lower half semicircular, the upper subtriangular; hinge plate rather strong, bent at nearly a right angle, the (?) anterior part convex, the (?) posterior concave; denticles in two distinct series, arranged transversely on the plate and therefore at widely different angles on the two parts of the hinge.

Species: *compressa* Ulrich, *arstartiformis* Salter, *intermedia* Ulrich, *alta* Hall, *obliqua* Hall.

VI. *C. logani group.*

Thin gibbous shells, with subcentral large beaks; muscular scars faint; hinge but little arcuate, the denticles in continuous series, bent inward.

Species: *logani* Salter, *dubia* Hall, *gibbosa* Hall, ? *ovata* Hall.

Group I, the typical section of the genus, seems to be strictly confined to Lower Silurian deposits and embraces the largest known representatives of the family *Nuculidæ*. Group II appears to be even more restricted in its range, being unknown above the top of the Trenton. Group III is by far the largest section of the genus both in its specific and individual development. It may justly be called the nuculoid section, since not only the general expression of the shell is decidedly like *Nucula*, but its internal characters likewise approach those of that remarkably persistent type more closely than is the case with any of the other groups here defined. I think that the evidence indicates very strongly that *Nucula* was developed from this stock. As is well known, that genus is distinguished from *Ctenodonta* chiefly in having a small but well defined internal cartilage pit immediately beneath the beaks. Now, although in the Trenton forms of Group III the hinge denticles form a perfectly continuous series, this cannot be said of the Hudson River species. In many, if not all, of these, namely, the series of teeth are more or less distinctly interrupted beneath the beaks by the incipient development of an at least similar pit. So far as it is possible to say, true species of *Nucula* occur in the Devonian, so it is but natural to assume that the missing links between them and the Ctenodonta levata group of species are to be found in the intervening Upper Silurian deposits. But here we meet with an obstacle in the fact that none of the Upper Silurian shells that have been referred to *Ctenodonta* (*Tellinomya*) and *Nucula**, with the possible exception of *Tellinomya curta* Hall, of the Clinton group, belong to the *C. levata* section. It does not, however, follow that such species did not exist, though we must admit that it is a strange, if not a significant fact that they have not yet been found. Still, the significance of their absence is lessened when we consider that the Upper Silurian deposits throughout are relatively poor in remains of Lamellibranchiata. It is also to be remarked that the forms which have occurred belong chiefly to families widely different from the *Nuculidæ*. It is possible that the Devonian genera *Palæoneilo* and *Nuculites* also came from this stock, such a development being faintly indicated by *C. fecunda* and *C. nuculiformis;* but taking all the characters into consideration, and the direction of the variation that may be followed into the lower divisions of the Upper Silurian, *Clidophorus* seems to me a more likely ancestor for those genera.

Group IV may be a departure from the *C. recurva* group, but, as it seems to me to be a more primitive type, I would rather consider the relation as reversed. The only objection to the latter arrangement may be removed at any time, since it is nothing more than that *C. compressa*, a typical species of the *recurva* group, has been found somewhat lower in the Trenton formation than the earliest known member of the pectunculoides group.

*Very little is known of the hinge of the Up. Sil. species that have been referred to *Tellinomya* by Hall and others, so that we are justified in doubting that they really belong to the genus. Those known to possess a denticulated hinge are much more like *Palæoneilo* than *Ctenodonta*.

Group V is probably the most distinct of all these sections. It is certainly the least variable and the easiest to recognize, the Astarte-like form of the shells alone being sufficiently diagnostic. The subrostral interruption of the hinge denticles is very distinct and the point is often marked by a sort of pit, quite undefined, however, that may have lodged an internal cartilage. *Nucula* may really have been evolved from this type, since it would have required but a slight modification of the hinge, a depression or lengthening of the form, and a filling of the umbones. As it is, *C. recurva* is nearer *Nucula* than it is to *C. nasuta,* but several species of the levata section approximate that genus even more closely, so that we are obliged to regard the balance of the evidence to be in favor of the levata group, unless both the groups have contributed to make *Nucula* as now understood.

Of Group VI only *C. logani* is well known, so we cannot say much about affinities. The species are all Trenton, and their general aspect is quite different from the other groups.

It is an interesting fact that all of these sections are represented already in the lowest geological division (considering the Birdseye and Black River limestones as one) in which the genus makes its first known appearance; the nasuta group with the species *tennesseensis* and *nasuta,* the gibberula group by all of its species except *C. carinata,* the levata group by at least five species, the petunculoides group by the species *subrotunda,* the recurva group by *C. compressa,* and the sixth group by *C. logani.* Each group again is as sharply marked in these first species as it is at any subsequent time; nor have we any evidence to aid us in deciding which of the six groups is the most like the primitive stock. It is evident, therefore, that a long line of forms of this type must have existed in the ages preceding the Birdseye of which we now have no knowledge whatever. The same remarks apply almost equally well to the other families of Lamellibranchiata, and one of the most remarkable facts in paleontology is the almost total absence of the class in the Calciferous, especially when we consider that that formation abounds in Gastropoda and Cephalopoda.

I have carried on a number of very interesting comparisons between the species of *Ctenodonta* and certain forms of recent genera like *Neilo, Malletia* and *Sarepta,* three nuculoid genera, and *Axinæa* and other *Arcidæ.* If this work was not already growing beyond the limits alloted to it, I would gladly give the results of these comparisons here fully, but under the circumstances I am obliged to restrict myself to a few general remarks. The three nuculoid genera mentioned are very similar indeed to the *C. nasuta* group of species, the first and second differing chiefly in having a sinuated pallial line, while the third has an internal cartilage pit beneath the beaks like *Nucula.* Certain Cretaceous species of *Axinæa* (*e. g. A. sulplanata Stoliczka*) are strikingly similar to the C. pectunculoides section, the only difference of real consequence being the presence of a low triangular striated area between the beaks and the hinge in the *Axinæa*. Other *Arcidæ* present almost equally close resemblances to *C. logani*. Aside from the ligamental area the principal characters of *Arca* and *Isoarca* are practically the same as in one or another species of *Ctenodonta*.

We have then three families of recent shells (as defined by Stoliczka) any one or all of which, and I believe it is the latter, may have been derived from this early type.

*C. nasuta section.*

### CTENODONTA NASUTA *Hall.*

PLATE XLII, FIG. 30.

*Tellinomya nasuta* HALL, 1847. Pal. N. Y., vol. 1, p, 152; 1857, Tenth Rep't. Reg. Univ. N. Y., p. 183, ? fig. 2. (Figures 1 and 3 not strictly *nasuta*,)
*Ctenodonta logani* SALTER, 1851. British Asso. Rep., p. 63. (Not *C. logani* Salter, 1859.)
*Isoarca logani* WOODWARD. Manuel Shells, p. 269.
*Ctenodonta nasuta* SALTER, 1859. Can. Organic Remains, Dec. I, p. 35.

Shells transversely elongate subovate, the length one-twentieth or more greater than twice the greatest hight; beaks rather small, not very prominent, incurved, situated about one-twelfth of the entire length in front of the middle; anterior end large, broadly and regularly rounded; posterior end produced, tapering, rather narrowly rounded at the extremity; cardinal margin nearly straight, basal line broadly convex except for some distance behind the middle where it is straight or more often gently sinuate. Greatest thickness near the middle of the anterior half, equalling about one-third of the length of the shell. Umbones moderately inflated, the posterior cardinal slope defined by an obscure umbonal ridge, very abrupt for a short distance behind the beaks, more so than on the anterior side; a broad and very shallow sulcus crosses the valves obliquely from the umbones to the contraction in the base. Ligament attached in a sharply defined groove on each side of the hinge line, extending from the beaks about one-third of the distance to the posterior extremity. Surface marked with obscure concentric lines.

The test being thin, casts of the anterior look much like the exterior of the shell itself. The muscular scars are faintly impressed and usually determined with difficulty on all except the largest casts. The denticulated part of the hinge is comparatively short, being but 21 mm. in length in a specimen 56 mm. long. Its upper margin is nearly straight, but the lower side is rather distinctly biconvex, the plate being constricted beneath the beaks to little more than half of its width on each side. The denticles form a continuous series, are small and vertical beneath the beaks, slightly oblique in front of them, and strongly curved outwards behind them. The entire series, so far as observed, contains twenty-seven to twenty-nine teeth, divided almost equally with respect to the beak.

None of the northwestern specimens of this species seen by me quite reach a length of 40 mm., the average being about 25 mm. In Canada they grew to much greater size, some of the specimens from Pauquette's Rapids on the Ottawa river having a length of more than 60 mm.

Associated with this species in Wisconsin and at Pauquett's Rapids there is a form which, though it has been identified unreservedly with *C. nasuta* by Hall and others, I find to be not strictly identical with that species. The anterior end is higher and larger, and the posterior end shorter, so that the beaks, instead of being in front of the midlength, are a trifle behind that point, the muscular impressions are deeper, and the hinge plate is on the whole narrower and much less constricted in the middle. This form, for which I propose the varietal designation *robusta*, was figured by Prof. Hall in the Tenth Annual Report of the Regents of the University of New York on page 183 as *Tellinomay nasuta*. He figures two specimens of which the smaller may belong to *nasuta*. The larger example, however (figures 1 and 3), I refer to the variety *robusta*, and I do so with the utmost confidence, the specimen being in my possession at this moment. At Pauquette's Rapids the variety attains about the same size as the typical form of species, but in Wisconsin it is much the larger.

Near the top of the Trenton in Kentucky there is a form, that I shall call *C. regia*, which seems to represent the culmination of the differentiation begun in the variety *robusta*. In this Kentucky species the hight is even a trifle greater, the base is not sinuate, the muscular scars are very deep, and the hinge plate stronger than in both the variety and the typical form of *nasuta*.

*Formation and locality.—C. nasuta* occurs sparingly in the lower Trenton limestone at Minneapolis and in the middle third of the Trenton shales in Goodhue county, Minnesota. In Wisconsin the species is more abundant in the "Lower Blue" and the "Upper Buff" limestones at Beloit, Janesville and Mineral Point. It has also been found in the same beds at Dixon and other localities in Illinois. In Canada it occurs in the Black River and Trenton limestones at Ottawa and numerous other points. The original types of the species came from the Trenton limestone at Middleville and Trenton Falls, New York, and it is catalogued by Prof. J. M. Safford among the fossils of his "Central," "Glade" and "Carter's Creek" limestones in Tennessee. Variety *robusta* occurs at Pauquette's Rapids near Ottawa, Canada, and in the "Upper Buff" limestone at Beloit, Wisconsin.

*Mus. Reg.* No. 8317; var. *robusta*, 8315.

## CTENODONTA SUBNASUTA, *n. sp.*

PLATE XLII, FIGS. 34–36.

This shell is no doubt closely related to *C. nasuta*, but, aside from its much smaller dimensions, it differs in several particulars that have seemed of sufficient importance to merit specific recognition. Thus the posterior end is somewhat longer, the beaks being placed farther in front of the middle, the anterior end is more obtuse in a dorsal view, the beaks are turned anteriorly rather than backward, the lower margin of the hinge plate is almost straight instead of biconvex, while the denticles are relatively more numerous on the posterior part, there being about sixteen or seventeen on this side of the beaks to about ten in front of them. Casts of *C. nasuta* again exhibit a rather well marked lanceolate depressed area extending posteriorly from the beaks about half way to the extremity of the cast. In *C. subnasuta* the corresponding area is not lanceolate, but consists of a furrow on each side of the raised hinge line running backwards almost to the extremity. The following two species also are rather closely related, but are readily enough distinguished by their shorter form and lesser convexity.

Since the above was written, I have found among my unworked material from the middle third of the Trenton shales in Goodhue county, two valves that may represent an earlier form of this species. Artificial casts of the interior of these valves closely resemble the Galena shales type of the species, the only difference being that the central part of the casts is not quite so full and the basal line less straightened in the posterior half. There is also a flattened rim along the ventral border that is not seen in the type. In these features the valves remind somewhat of *C. oviformis*, but they cannot belong to that species, since they are too narrow posteriorly and have the beaks situated more anterior to the center. The hinge is rather well preserved on both the valves, each having about twenty-six denticles, nine of them in front of the beaks. Of the latter the anterior five are larger than any of the others. The hinge, on the whole, resembles that of *C. cuneiformis*, but the anterior teeth are larger and the beaks situated farther forward.

*Formation and locality.*—The type is from the Galena shales near Cannon Falls, Minnesota.

### CTENODONTA OVIFORMIS, *n. sp.*

PLATE XLII, FIG. 29.

Shell small, compressed convex, transversely ovate, the ends rather narrowly rounded, subequal, the anterior a trifle wider and shorter than the posterior, the base almost regularly convex, the hinge line gently arcuate, and the beaks rather small, scarcely prominent and situated slightly in front of the midlength. Muscular scars comparatively distinct. Number of teeth and surface unknown, but the cast is marked with several obscure concentric furrows. Length, 9.2 mm.; hight about 6 mm.; thickness, 3.8 mm.

This small shell is relatively shorter, less produced and wider posteriorly, and more rounded in the basal outline than *C. nasuta* and *C. subnasuta*. Collectors will, I think, find little trouble in recognizing it.

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

## Ctenodonta cuneiformis, *n. sp.*

PLATE XLII, FIGS. 31–33.

Shell small, compressed convex, transversely somewhat acuminate-ovate, tapering posteriorly to a narrowly rounded extremity; anterior end shorter than the posterior, but much higher and broadly rounded, except in the antero-cardinal region, where the outline projects slightly beyond the path of a uniform curve; base rather prominently rounded in the middle, convex throughout the anterior half, straight or very faintly sinuate in the posterior half; beaks small, not prominent, situated about 4 mm. behind the anterior extremity in a specimen 11 mm. long; posteriorly from the beaks the cardinal outline is straight, in front of them gently concave. Behind the center the shell is more or less distinctly contracted. Surface with obscure concentric striæ. Hinge plate of moderate strength, comparatively long, very gently bent, and just appreciably contracted beneath the beaks, with about twenty-seven nearly vertical teeth in each valve, twelve in front of the beak. The posterior six or seven teeth are stronger than the rest and bent inward. Test thin, muscular scars not observed. The largest specimen seen, a right valve, is 12 mm. long, 7.4 mm. high and 1.8 mm. thick.

The contraction and narrowness of the posterior end gives to this species somewhat the appearance of *C. contracta* Salter, but the two species are really widely different. The Canadian shell is higher, more convex and its cardinal outline much more angular, the hinge plate strongly bent and very narrow under the beaks, the teeth larger and not so numerous, and the shell much thicker. The affinities of *C. cuneiformis* are probably with *C. nasuta* and *C. subnasuta.* The former, being a much larger shell, is not likely to be confounded with it. The latter is narrower anteriorly and wider posteriorly, is more convex, especially in a front view, its posterior half is not contracted in the same manner, and the anterior outline more uniformly rounded.

*Formation and locality.*—Four specimens were found at a point about six miles south of Cannon Falls, Minnesota, where they occurred in the upper part of the middle third of the Trenton shales. The same locality and bed has furnished numerous other Lamellibranchiata.

### *C. gibberula section.*

## Ctenodonta gibberula *Salter.*

PLATE XLII, FIG. 37.

*Ctenodonta gibberula* Salter, 1857. Canadian Organic Remains, Dec. I, p. 38.
*Tellinomya ventricosa* Hall, 1861. Rep. Supt. Geol. Sur. Wis., p. 27; 1862, Final Report of same, p. 38, fig. 3; Meek and Worthen, 1868, Geol. Sur. Ill., vol. iii, p. 307.

Shell rhombic subovate, ventricose, the hight, length and thickness, respectively, as seven, ten and six, with large incurved beaks, situated a little behind the mid-length; antero-dorsal and ventral margins subparallel, the posterior end obliquely truncate above the narrow and sharply rounded lower part; anterior end broadly rounded and continuing into the basal margin; the latter is straight or very gently sinuate and ascends from the prominently rounded anterior part; posterior umbonal ridge inconspicuous in a lateral view, rather sharply defined, however, in a dorsal view by a narrow furrow which outlines a wide lanceolate flattened area, equally divided by the hinge line, and in the upper part of which (immediately behind the beaks) the ligament is attached to distinct fulcra; anterior dorsal slope abruptly rounded; entire anterior half of valves strongly ventricose, while between this part and the posterior umbonal ridge a slight sulcus crosses from near the beak to the base. Surface marked by rather distinct, closely arranged, subequal concentric striæ of growth, tending to irregularity in the basal parts of old shells.

Impressions of adductor muscles extremely deep, the anterior pair larger than the posterior. A small, though distinct, pedal muscle scar is always present on the upper part of the strong ridge which forms the inner boundary of the anterior adductor, (in casts it lies at the bottom of the deep cavity produced by this ridge), but the corresponding posterior scar is rarely distinguishable. Hinge plate very narrow at the beaks, but widening rapidly on each side, the anterior half somewhat the stronger and slightly concave along its inner margin, both terminating abruptly at the muscular scars; denticles twelve behind and ten or eleven in front, those near the beaks very small, all interlocking deeply, especially those of the anterior set, which are also somewhat larger than the posterior. The shell is very thick and the rostral filling so considerable that in casts of the interior the beaks appear obtuse and widely separated.

I have very carefully compared a large series of the northwestern form which Hall named *ventricosa* with authentic Canandian examples of Salter's *C. gibberula*, and I can say, with perfect confidence, that there is not the slightest reason for considering them as distinct species. The only difference that I can detect is that the northwestern specimens grow to a larger size than the Canadian. Tennessee specimens also attain greater dimensions than the latter, though their average size scarcely equals that of Wisconsin examples. Meek and Worthen suggested (*op. cit.*) that *Tellinomya ventricosa* may be the same as *C. contracta* Salter, but in this they were mistaken, since that species is certainly distinct and, so far as known, does not occur at any of the northwestern localities.

*Formation and locality.*—In Canada this species occurs in the Black River limestone at Pauquette's Rapids. In Tennessee it occupies an equivalent or lower position near Murfreesboro. In Wisconsin, at Beloit, Janesville and Mineral Point, and at several localities in Illinois and Iowa, it forms one of the most striking fossils of the limestones beneath the Galena, particularly the "Upper Buff." In Minnesota it seems to be a rare fossil, being, so far, known only from Minneapolis, where it occurs in the Trenton limestone a few feet beneath the shales.

*Mus. Reg.* Nos. 8309, 8316, 8339.

CTENODONTA CARINATA, *n. sp.*

PLATE XLII, FIGS. 41–43.

Shell rather small, gibbous in the anterior and rostral portions, the ends obtuse in a dorsal view, the beaks large, prominent, strongly incurved, situated near the midlength and turned decidedly toward the posterior end; the outline may be described as subtriangular or obscurely quadrate; anterior margin most prominent and strongly rounded in the lower half, the upper two-thirds more gently curved and sloping backward to the beaks, being continuous with the antero-dorsal margin; ventral margin straight or broadly sinuate, curving abruptly into the subtruncate posterior margin and forming, with the latter, an angle of about 80°; cardinal outline distinctly concave behind the beaks; post-cardinal region slightly produced, though too blunt to be called alate; posterior umbonal ridge prominent, angular, extending to the post-ventral angle; point of greatest convexity on the rounded anterior umbonal ridge; between the two ridges a wide, undefined sulcus, extending from the umbones to the base. Surface marked with distinct and rather irregular concentric lines of growth. Hinge plate arcuate, in other respects apparently as in *C. gibberula* Salter. Shell thick, muscular scars not observed.

*C. gibberula* is the only shell known to me with which *C. carinata* might be compared. Although imperfectly known, I am quite confident that its affinities lie chiefly with that species. Still, though the resemblances are sufficient to prove that the two forms belong to the same section of the genus, it is scarcely likely that any one will fail to distinguish them specifically, the outline in the two species being different in several respects. Thus, in *C. carinata* the posterior end is wider, the post-cardinal region produced and subcuneate instead of flattened, the anterior margin is more prominent below, and above curves more regularly into the dorsal outline, while the basal margin is not so prominent anteriorly and on the whole more nearly horizontal. The posterior umbonal ridge also is more prominent, the mesial sulcus or flattening is a more pronounced feature and the anterior slope more abrupt. Finally, the hinge plate is less bent and curved rather than geniculated.

*Formation and locality.*—Middle Galena, about one mile east of Fountain, Minnesota.

CTENODONTA PLANODORSATA *Ulrich.*

PLATE XXXVII, FIGS. 25–28; PLATE XLII, FIGS. 38–40.

*Tellinomya planodorsata* ULRICH, 1892. Nineteeth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 217.

Shell small, moderately convex, subtriangular or trapezoidal, the hight, length and thicknes, respectively, ten, fourteen and five mm.; beaks small, incurved, scarcely projecting above the hinge, situated nearly one-third of the entire length from the anterior extremity. Posterior end long, subtriangular in outline, with the extremity subacute and the dorsal side almost straight (faintly convex) from the beaks backward; ventral margin broadly rounded, semielliptical; anterior margin nicely rounded. Post-cardinal side thick, with a large, sharply defined and slightly concave area reaching from the beaks to near the posterior extremity of the shell. Surface gently convex, scarcely sloping toward the postero-cardinal area, marked with exceedingly fine concentric striæ and a few stronger lines of growth. Hinge plate strong, abruptly bent, the posterior part nearly twice as long as the anterior, the two parts forming an angle of about 105°; denticles very little curved, in two distinct series, those in each row set transversely on the hinge plate, about eleven in the anterior series and nineteen or twenty in the posterior series. Muscular impressions very deep, bordered on their inner sides by strong ridges and set into the wide excavated ends of the hinge plate; pallial line simple, faint, submarginal.

The interior of this strongly marked species proves to be quite different from what I expected when I described it from the exterior alone. Instead of showing relations to *C. levata*, excellent valves since obtained prove the species to be nearer *C. gibberula* and *C. contracta*. Still, *C. planodorsata* occupies a somewhat isolated position. In the first place, casts of the interior, with their very prominent muscular scars, remind at once of the present section of the genus. The hinge, however, is very different from that of the typical members of the section, the plate being widest under the beaks instead of much the narrowest, and the series of denticles very abruptly divided into two sets, the whole hinge, therefore, being much more as in the C. recurva section. *C. longa* has similar characters, as appears to be the case also with an undescribed species from the Trenton of Tennessee, so that it might have been well to institute another section of the genus. But as these sections are merely temporary natural groupings of the species, pending a more thorough study of the whole family, the ommission cannot be of much consequence.

The species is so easily recognized by the flat dorsum that comparisons are quite unnecessary.

*Formation and locality.*—In the upper part of the middle third of the Trenton shales at several localities in Goodhue county, Minnesota.

## Ctenodonta longa *Ulrich.*

PLATE XXXVII, FIGS. 30 and 31.

*Tellinomya longa* Ulrich, 1892. Amer. Geol., vol. x, p. 103.

Shell small, compressed, elongate-elliptical, the length equalling a little more than twice the greatest hight. Beaks small, situated about one-fourth of the entire length from the anterior extremity. Cardinal line, on the whole, very slightly convex, straight behind the beaks; anterior end short, semicircular; ventral margin gently convex; posterior end a little narrower than the anterior and more sharply rounded. Surface with obscure concentric lines; sloping rapidly at the cardinal margin, but very gently to the ends and ventral edge. Hinge plate of moderate strength, bent a little beneath the beak and with a thickening on the lower side in front of same. Posterior to the beak the plate is long, straight and bears twenty or more small teeth, while on the anterior part only nine are to be counted. In the vicinity of the beak the teeth, especially those on the posterior side, are very small, and as they are all set at right angles to the hinge plate, the continuity of the series is interrupted where the two series come together. The interruption is easily overlooked, because of the slight bend in the hinge plate. Anterior muscular impression deep, situated immediately beneath the end of the hinge. Its posterior side is defined by a strong vertical thickening of the shell, in the upper part of which the scar of a small pedal muscle is to be observed. Posterior scar distinct, but less sharply impressed than the anterior, situated at the end of the hinge just within the thin post-cardinal border of the shell.

The characters of the hinge and the deep muscular impressions show that this species is related to *C. planodorsata*, with which it is also associated in the shales. There is, however, room for several intermediate species, the form being much more elongate, the back not flattened, the posterior end rounded instead of subacute, and the hinge much less bent. In *C. subnasuta* the shape is somewhat similar, but the hinge is different, the muscular impression not nearly so distinct, the beaks larger and situated farther from the anterior end, while the anterior half is relatively higher.

*Formation and locality.*—Middle third of the Trenton shales, Goodhue county, Minnesota; associated with *C. planadorsata*, *C. compressa*, *C. socialis* and *C. scofieldi.*

### *C. logani section.*

### Ctenodonta logani *Salter.*

PLATE XLII. FIGS. 26–28.

*Tellinomya dubia* Hall, 1857. Tenth Ann. Rep. Reg. Univ. N. Y., p. 183, figs. 4 and 5. (Not *T. dubia* Hall. 1847, Pal. N. Y., vol. 1, p. 153.)
*Ctenodonta logani* Salter, 1859. Canadian Organic Remains, Dec. i, p. 36. (Not *C. logani* Salter, 1851, Rep. Brit. Assoc., p. 63, which proved to be the same as *Tellinomya nasuta* Hall, 1847.)

Shell of the medium size, rather elongate, subovate, strongly convex, very gibbous in the umbonal region, with the strongly incurved beaks turned slightly forward and situated near the midlength; posterior end a little the narrower, rounded, but not quite uniformly, the lower part being usually a trifle prominent; basal margin gently arcuate, the posterior half somewhat less convex than the anterior; anterior end regularly rounded, or this is so only in the lower two-thirds, the curve of the outline sometimes increasing in rapidity as it turns into the cardinal margin. Posterior umbonal ridge prominently rounded; in front of it a very obscure mesial sulcus; post-cardinal slope rather abrupt, with two obscure curved furrows, and in the upper part the fulcra to which the external ligament was attached. Surface marked by unequal concentric lines of growth. Hinge plate of moderate strength, gently arcuate, slightly contracted in the middle, 15 mm. long in a specimen 25 mm. in length, bearing a continuous row of teeth curving strongly inward, the whole number in each valve about seventeen, of which nine are posterior; as usual, the central ones are the smallest. Shell comparatively thin; muscular impressions faint.

The gibbosity of the shell and the unusual prominence of the umbones removes this species from the *C. nasuta* section, while the thinness of the test and the faint delineation of the muscular scars will not allow it to be placed in the *C. gibberula* section. The natural position of the species may, however, still be considered as intermediate between those two sections.

*Formation and locality.*—"Upper Buff limestone" of the Trenton formation, Beloit, Wisconsin. In Canada the species occurs in the Black River limestone at Pauquette's Rapids, near Ottawa.

*Mus. Reg.* No. 8316—1.

### *C. levata section.*

### CTENDONTA NITIDA *Ulrich.*

PLATE XLII. FIGS. 44—47.

*Tellinomya nitida* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 215.

Shell small, thin, moderately ventricose, trapezoidal or somewhat obliquely subtriangular, the antero-cardinal region somewhat alated; umbones full, beaks small; closely incurved, directed slightly backward. Posterior extremity oblique, rather abruptly truncated, flattened, nearly straight, pinched and projecting slightly beyond the convex part of the shell in the upper half and narrowly rounded below. Ventral margin gently convex, usually curving rather sharply upward at the ends. Anterior end wide, rounded and most prominent in the lower half, straightened above, the junction with the hinge-line subangular. Surface, excepting a few indistinct lines of growth, smooth.

Casts of the interior have strongly projecting beaks. The internal characters of the shell, so far as they can be made out from these casts, are as follows: Hinge line very slightly arcuate, with eight to ten strong teeth behind the beaks and fifteen or sixteen smaller ones in front of them. Anterior and posterior muscular impressions subequal, distinct, the posterior one drawn out along the hinge margin. Above the anterior pair there is another much smaller elongated pair lying close to the hinge.

This species is distinguished from *C. levata* Hall, sp., by its shorter form, abruptly truncated posterior end and subalate antero-cardinal region, and in the posterior instead of anterior position of the beaks. In casts of the interior the beaks are also smaller and more prominent. *C. abrupta* Billings, is more ventricose, longer and not so high anteriorly. The two species next described are more closely related.

*Formation and locality.*—Good specimens of this species are exceedingly rare, but illy preserved casts of the interior, which are provisionally referred here, are not uncommonly associated with *C. socialis* in the middle third of the Trenton shales at Minneapolis and other localities in the state of Minnesota.

### Ctenodonta medialis, *n. sp.*

PLATE XLII, FIGS. 50—52.

This species seems to occupy an intermediate position between *C. nitida* and *C. scofieldi*. From the first it differs in having the beaks situated about midway between the extremities, the posterior end longer, more oblique and more narrowly rounded at the extremity, and the anterior end shorter and blunter in the antero-cardinal region. The posterior part of the back is wider, because the umbonal ridge is somewhat stronger and extends farther downward. Finally, the hinge plate is more curved and appears relatively wider. From *C. scofieldi* it differs in having the beaks centrally situated instead of one-third of the length from the anterior extremity, the umbonal ridge less sharp, the posterior end shorter and wider, and the hinge plate stronger and more numerously denticulate. A careful estimation of the value of the differentations leads me to believe that the form under consideration is more closely related to *C. nitida* than to *C. scofieldi*. Perhaps it would be sufficiently distinguished as a variety of the former.

Another form of this type is represented by two casts of the interior in the Survey collection (Mus. Reg. No. 8311) from the "Lower Blue" limestone at Janesville, Wisconsin. In these specimens there is an antero-cardinal wing as in *C. nitida*, but the posterior end is too long for that species, the beaks being slightly in front of the midlength instead of behind. *C. leveta* Hall, sp., also seems to belong here, but it is not safe to say anything positive about that species till the original New York types have been subjected to a critical examination.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis and near Cannon Falls, Minnesota. A cast of the interior from the Galena shales of Goodhue county, probably belongs here.

### Ctenodonta scofieldi, *n. sp.*

PLATE XLII, FIGS. 53—58.

Shell small, strongly convex, transversely somewhat acuminate ovate, broadly rounded in front and below, narrow behind, with small, prominent, incurved beaks, directed posteriorly and situated about one-third of the length from the anterior extremity; umbones carinate behind, the ridge having a distinctly concave outline in a side view; posterior end of hinge projecting slightly beyond the ridge, so that the post-dorsal region is not quite flat. Hinge plate comparatively short and weak, widest posteriorly, very narrow beneath the beak and in front of same; denticles small, seventeen or eighteen in each valve, in a continuous series, about eight of them posterior and larger than the others.

This neat and constant form is readily distinguished from *C. nitida* and *C. medialis*, its nearest congeners, by the posteriorly carinate umbones, the less central position of the beaks, its narrower posterior extremity and much weaker hinge plate. The denticles also are less numerous. Casts of the interior of these three forms are difficult to distinguish, but the task is not by any means hopeless when the specimens are in a good state of preservation. The species is named for my colaborer on the Gastropoda, Mr. W. H. Scofield, of Cannon Falls, Minnesota.

*Formation and locality.*—An entire example and nine valves were collected in the middle third of the Trenton shales in the vicinity of Cannon Falls, Minnesota. A cast of the interior was obtained at Minneapolis from the same beds. The species has not been observed in the upper third of the shales, but the overlying Galena shales have furnished a number of casts that I have not succeeded in distinguishing. These were collected at Cannon Falls and near Kenyon.

### CTENODONTA SOCIALIS, *n. sp.*

PLATE XLII, FIGS. 59 and 60.

Shell very small, moderately convex, transversely subovate, rarely exceeding 6 mm. in length, the average size about 3.8 mm. high by 5 mm. long; beaks small, turning slightly toward the short posterior extremity behind which it is situated between one-fourth and one-third of the entire length; umbonal ridge inconspicuous, the convexity of the valves being relatively uniform. Surface almost smooth, no markings save a few obscure concentric lines having been observed. Hinge plate narrow, especially so under the beaks, widest posteriorly, comparatively long, arcuate, the amount of curvature varying according to the length of the posterior end of the shell, being greater when this part is shorter than usual; denticles small, nineteen or twenty in each valve, six or seven of them posterior, several of the latter considerably larger than any of the others.

In a shell of this kind it is very difficult, if not impossible, to decide beyond the possibility of error which end is the anterior and which the posterior. In this case I have assumed that the short side is the posterior, because this end of the hinge plate is the wider and bears the largest denticles, that being the prevailing condition among species of this section.

The small size, rather regularly ovate outline, moderate convexity and the posterior position of the beaks are features that render the identification of this species unusually easy. I hesitated to say whether it should be regarded as nearer *C. nitida* or those ovate shells, like *C. albertina*, in which the larger side is undeniably the posterior.

*Formation and locality.*—This small shell occurs in great numbers in certain layers of the middle third of the Trenton shales at St. Paul, Minneapolis, Cannon Falls, Chatfield and other localities in the state. The surface of a layer may be completely covered by separated valves or by casts of the interior. The latter condition is the prevailing one at the two localities first mentioned, but in Goodhue and Fillmore counties testiferous examples are the rule. In central Kentucky the species is occasionally met with in the Modiolodon oviformis beds of the Trenton.

*Mus. Reg.* No. 8627.

### CTENODONTA FECUNDA *Hall.*

PLATE XLII, FIGS. 67–73.

*Nucula (Tellinomya) fecunda* HALL, 1862. Geol. Sur. Wis., vol. 1, p. 55. (Figured, but not described.)

Shell small, 9 mm. to 13 mm. in length, rather ventricose, transversely ovate or obscurely subrhomboidal in outline, with the umbones rather prominent and full, and the beaks incurved, directed slightly forward and situated about one-third of the length behind the anterior extremity; base usually a little prominent in the middle, somewhat straightened, or at any rate less convex in the posterior than in the anterior half; posterior end narrower than the anterior, the outline sloping forward rapidly above the produced lower part and merging almost gradually into the post-cardinal margin; antero-cardinal outline more or less distinctly concave; posterior umbonal ridge rounded. Surface marked by very fine, regular concentric striæ and strong wrinkles of growth, crossed by delicate radial lines, the network thus formed requiring a magnifying lens to make it plainly visible. The radial lines, however, are not often preserved.

The majority of the specimens seen are casts of the interior, mostly in an excellent state of preservation. As a rule, they are marked by a limited number of obscure concentric furrows. The muscular scars and pallial line are always faintly defined Hinge plate rather narrow, arcuate, nearly two-thirds as long as the shell, with about eighteen denticles in each valve; denticles very small under the beaks, where the series seems also to have been interrupted by a small space; on each side of the beaks they become larger gradually and at the same time assume an oblique direction, the upper ends of the teeth being turned away from the beaks.

Three specimens, illustrating slight variations, have the following dimensions: Length, 10.5, 11.0 and 13.0 mm.; hight, 7.0, 8.0 and 10.0 mm.; thickness, 4.5, 6.5 and 6.8 mm.

This very common shell is certainly distinct from *C. levata*, *C. nitida* and *C. scofieldi*, the anterior end being narrower and in two cases also shorter, while the hinge, with its oblique teeth, is very different. In *C. socialis* the outline is more regularly oval and the beaks situated as much behind the center as they are in front of that point in *C. fecunda*. In *C. simulatrix* the anterior end is wider, the muscular scars deeper and the hinge more numerously denticulated. Similar differences distinguish *C. albertina*, a well marked species having also a stronger hinge and geniculated teeth. The following species, *C. calvini*, is probably nearer than any other species now known.

*Formation and locality.*—Very abundant in the lower so-called Maquoketa shales near Dubuque, Iowa; Scale's Mound, Illinois, and Platte's Mound in Lafayette county, Wisconsin. The species occurs also in Fillmore county, Minnesota, in equivalent beds (Hudson River group), though but rarely.

### CTENODONTA CALVINI, *n. sp.*

PLATE XLII, FIGS. 61–64.

Shell subquadrate-ovate, about 15 mm. long, 12 mm. high and 6 mm. thick; anterior end rounded, a trifle narrower than the slightly truncate posterior end; the latter is a little oblique, gently convex except below, where the outline turns rather sharply into the broadly rounded base; above it forms an obtusely angular or rounded junction with the straight post-cardinal margin; in front of the scarcely prominent beaks, which are situated about one-third of the entire length behind the anterior extremity, the outline is more or less concave. Surface of valves rather uniformly convex, with the posterior umbonal ridge strongly rounded, though in no case conspicuous. External surface markings not observed. Casts of the interior exhibit a few concentric undulations, and in the central and ventral parts a variable number of obscure rays. The test seems to have been unusually thin. Hinge plate very narrow, bent at the beak, straight behind, gently concave in front; denticles small, oblique, about sixteen posterior and eight or ten anterior in each valve. Adductor muscular scars very slightly impressed, the posterior one extended above, larger and longer than the anterior, and placed in the middle of the cardinal slope, so that its long axis is parallel with the umbonal ridge; several small umbonal scars may be observed.

This fine species, though closely related, is at once distinguished from *C. fecunda* by its greater posterior hight and larger size. The convexity of the valves also is somewhat less, and other differences may be detected in comparing the figures of the two species on plate XLII. A nearer form, perhaps it ought to be called a variety, occurs in the lower beds (Utica horizon) of the Cincinnati group at Covington, Kentucky. This has exceedingly fine and crowded concentric striæ, crossed by more distant radiating lines. Casts of the interior have about the same shape as *C. calvini*, but they are all much smaller, the largest having a length of only 7 mm.

The concentric undulations also are more numerous. In a paper soon to be published I shall propose the name *Ctenodonta mundula* for this small form.

The three species mentioned in the preceding paragraph occupy an isolated position in the genus, and, though they may resemble some of the species of the levata section, I am satisfied that they are widely removed from them all. The shape of the anterior end is peculiar, as is also the reticulate surface ornamentation and the thin hinge plate with its oblique teeth.

The species under consideration is named for Prof. Samuel Calvin, State Geologist of Iowa.

*Formation and locality.*—Maquoketa shales (Hudson River group), at Graf and other localities in northern Iowa. Also at Scale's Mound in northwestern Illinois.

*Mus. Reg.* No. 8628.

### Ctenodonta madisonensis, *n. sp.*

PLATE XLII, FIGS. 65 and 66.

Shell subovate, slightly oblique, moderately convex, 12.5 to 15 mm. in length, 10 to 12 mm. in hight, and 5.6 to 7 mm. in thickness; anterior end very short, rounded, posterior margin a little oblique, base broadly rounded and continuing into the anterior margin; dorsal outline slightly concave. Beaks anterior, small, scarcely prominent, incurved; posterior umbonal ridge rounded, inconspicuous; greatest convexity of valves in front and above the center. Surface almost smooth, only two or three obscure lines of growth having been noticed. Test rather thick, hinge strong, posterior denticles geniculated.

This shell was included in this report and figured under the erroneous impression that it represented a variety of *C. calvini*. Since the plates were prepared, however, another examination showed differences not before noticed, and when finally the shell was removed from one of the specimens so that a part of the hinge was uncovered, it became fully evident that it was not only distinct but belonged to quite another group of species. It is namely not far removed from such species as *C. albertina* and *C. filistriata* of this report, while it is especially near an unpublished form from the middle beds of the Cincinnati group in Kentucky and Ohio which I shall call *C. tumida*. From these three species *C. madisonensis* is distinguished by the more uniform curvature of the anterior margin, the antero-cardinal region in those forms being more or less prominent and subangular in outline.

*Formation and locality.*—The specimens upon which the species is founded were collected in the Cincinnati group at Madison, Indiana, where they occurred in association with *Orthis retrosa.*

## CTENODONTA ALBERTINA, *n. sp.*

PLATE XLII. FIGS. 76–80.

Shell subovate, widest in the anterior half, 10 to 18 mm. in length; beaks moderate in size and prominence, situated about 4.5 mm. behind the anterior extremity in a specimen 16 mm. long; antero-cardinal region compressed, slightly alated, subangular in outline; anterior margin nearly vertical and rather gently convex above the lower part, where it turns somewhat rapidly backward into the broadly rounded base; the curvature of the basal outline is often not quite uniform, being, in these cases, a little stronger in the anterior than in the posterior half; posterior margin somewhat obliquely rounded-subtruncate; as shown in the figures the width of the posterior end is somewhat variable; cardinal margin nearly straight; umbonal ridge rounded, inconspicuous. Surface almost entirely smooth.

In casts of the interior the beaks are prominent, compressed and very little incurved, the adductor muscular scars are distinct, the posterior one being especially prominent and the larger, while the anterior one is drawn out above almost to the point of the beak; the posterior cardinal outline is strongly concave, while the dorsum in this part is formed by a sharp curved ridge running backward from each beak to the adductor scars and enclosing the area that had been occupied by the hinge plates. The hinge plate is strong, contracted and bent beneath the beak, the posterior part one-third longer than the slightly declining anterior part; denticles strongly geniculated and deeply interlocking, the continuity of the series distinctly interrupted under the beaks by an illy defined pit-like space. In five valves the total number of denticles ranged from twenty-nine to thirty-two, with thirteen, fourteen or fifteen anterior and sixteen or seventeen posterior. In a sixth valve, unusually short and possibly not belonging to this species, there are only eleven anterior and thirteen posterior teeth.

Length of an average example, 12 mm.; hight, 9.5 mm.; thickness, 6 mm. In a large specimen these dimensions are respectively 16, 12.2 and 7 mm.

The type of structure exhibited in this species and in *C. filistriata*, *C. madisonensis* and two as yet unpublished forms from the Cincinnati group of Ohio and Kentucky, stands somewhat apart from the other two types (*i. e.*, *C. nitida* and *C. fecunda*) included in this section of the genus. The geniculated hinge teeth and the pit beneath the beak are peculiar features, while another difference, when compared with the *C. nitida* type, appears in the absence of the small accessory scars over the adductors. That some importance attaches to the absence of these small scars is indicated by their constant presence in the species which pertain strictly to the *nitida* type in other respects. These scars seem to be wanting in the shell of the

*C. fecunda* type as well, but this, unless we agree that the short side in those shells is really the posterior, does not bring them much nearer to the *C. albertina* type, since the adductors are reversed, the acuminate-ovate scar being anterior in the latter and posterior in the former.

*Formation and locality.*—A common species in the upper beds of the Cincinnati group at Clarksville and other localities in Ohio. I am not entirely satisfied that the species occurs in Minnesota, but there are good reasons to believe that it may be found in the Hudson River strata near Spring Valley.

CTENODONTA FILISTRIATA, *n. sp.*

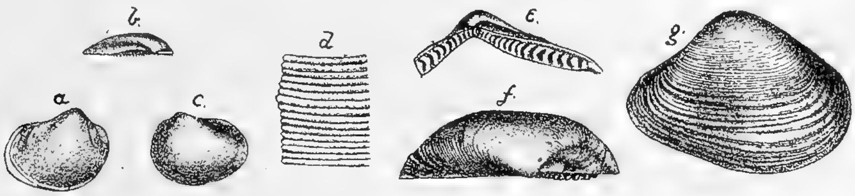


Fig. 44. *a*, right side of a cast of the interior of *Ctenodonta filistriata*, n. sp.; *b* and *c*, cardinal and lateral views of left valve of same; *d*, small portion of surface of same, highly magnified; *e*, hinge of a right valve of same, ×2; specimens from lower beds of the Cincinnati group at Covington, Kentucky; *f* and *g*, cardinal and lateral views of a large right valve of *Ctenodonta gibberula* Salter, from the lower Trenton near Murfreesboro, Tennessee.

*Tellinomya levata* HALL and WHITFIELD, 1875. Pal. Ohio, vol. ii, p. 82. (Not *Nucula levata* HALL, 1847, Pal. N. Y., vol. 1, p. 150.)

This species may be distinguished at once from *C. albertina*, with which it agrees more closely than any other known, by the delicate, crowded, thread-like concentric lines which cover the entire surface. Twelve to twenty of these lines may be counted in a space 1 mm. wide. The shape and general appearance of the shell is very similar in the two shells, but the basal margin in the present form is always uniformly rounded, while the antero-dorsal angle is a trifle blunter. The latter fact is due to the greater bend in the hinge. The pit beneath the beak is scarcely so distinct as in that species, and as the hinge is a little shorter the number of denticles is less than the average number for *C. albertina*, there being usually twelve anterior and fifteen posterior. Finally, in perfect casts of the interior the beaks are not so much compressed and the ridges running posteriorly from them less sharp.

This species is generally identified with Hall's *Nucula* or *Tellinomya levata*, originally described from the Trenton limestone of New York, and closely related to *C. nitida* of this report. The error of this identification is so palpable that it is really not worth the while to refute it. Any one at all capable of distinguishing species must, now that attention has been directed to the matter, see at once that the two shells are very different.

*Formation and locality.*—In the lower beds of the Cincinnati group at numerous localities in and near the city of Cincinnati. A single specimen was collected by Mr. Charles Schuchert in equivalent beds at Granger, Minnesota.

*Mus. Reg.* No. 8378.

CTENODONTA SIMULATRIX, *n. sp.*

PLATE XLII, FIGS. 74 and 75.

In its general aspect this species greatly resembles *C. albertina*, and yet it is a widely distinct form, the hinge being quite different in the two forms. The hinge plate in *C. simulatrix* is much narrower and more uniformly arcuate, the denticles are more numerous and the majority straight and very small. Posterior to the beak, beneath which the continuity of the series is slightly interrupted, there are about twenty-five denticles; in front of the beak the specimen preserves only six teeth, but, judging from other species, their number on this part of the hinge cannot have been less than twelve and probably was quite as many as fifteen, making a total for the entire hinge of from thirty-seven to forty. Comparing outlines, it will be found that in the present species the ends are more regularly curved and the beaks situated a little farther from the anterior extremity.

*Formation and locality.*—Upper part of the Hudson River group near Spring Valley, Minnesota.

*C. recurva section (Palæoconcha,* Miller.)

CTENODONTA COMPRESSA *Ulrich.*

PLATE XXXVII, FIG. 29; PLATE XLII, FIGS. 88—90.

*Tellinomya compressa* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 216.

Shell rather small, somewhat oblique, compressed convex, the length and hight respectively as twelve or thirteen is to fourteen; convexity about half the length; upper half triangular, the lower somewhat obliquely semielliptical; beaks small, compressed, acuminate, curving backward; umbones rather flat, the convex part of the valves terminating somewhat abruptly along the anterior and posterior cardinal margins. In the outline these two margins, meeting at the beaks, form an angle of about 85°, with the anterior gently convex and the posterior correspondingly concave, or a little straighter. Antero-dorsal edge flattened but unusually narrow, with an obscure furrow on each side of the raised contact line; posterior lunette obscurely defined. Surface with very fine, regular, raised, concentric lines, six to eight in 1 mm.

Hinge plate bent rectangularly, very wide in the central part; denticles mostly transverse to the hinge, arranged in two distinct series, increasing gradually in size and curvature away from the beaks, about twenty-two anterior and twelve posterior. A wide crescent-shaped flat space, over which the teeth do not extend, forms the inner border of the hinge plate. Just in front of the point of the beak, and separating the two series of denticles, is the narrow end of an obscurely defined, curved depression, extending more than two-thirds the distance across the hinge plate.

Adductor scars subovate, situated immdeiately beneath the ends of the hinge, distinct, the posterior one the deeper and margined on the inner side by an obtuse ridge-like swelling. Small accessory scars have not been observed.

A single imperfect valve was all I had seen of this species when I first described it. During the summer of 1892, however, I succeeded in collecting an excellent series of specimens, so that I am now enabled to present the shell in all its characters and to point out those which are really distinctive. Compared with *C. astartiformis* Salter, of which an authentic example is now before me, it differs externally in its greater proportional width, somewhat narrow posterior curve, less convex valves, finer concentric lines and in wanting the coarse wrinkles of growth which seem to be a constant feature of the ventral half in that species. Internally the muscular scars and the denticles of the hinge are about the same in the two species, but the hinge plate is considerably wider in the Minnesota form, while the flat space beneath the denticles of the latter is scarcely represented in Salter's species. Casts of the interior of the two species are not easily distinguished, the only reliable differences between them, so far as observed, being the lesser prominence and more uniform curvature of the anterior margin and the slightly greater convexity of the casts of *C. astartiformis.*

*Formation and locality.*—Upper part of the middle third of the Trenton shales at several localities in Goodhue county, Minnesota. Casts belonging to this species or to *C. astartiformis*, the latter probably, have been found in the upper part of the Trenton limestone at Minneapolis and at Janesville, Wisconsin, and I have specimens of a very similar, though smaller, form from the upper third of the Trenton shales.

## Ctenodonta intermedia *Ulrich.*

PLATE XLII, FIGS. 95–97.

*Tellinomya intermedia* Ulrich, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 218.

Shell thin, of medium size, moderately ventricose, rather erect, the hight a little greater than the length. Outline subtriangular, at the beaks, which are obtusely acuminate and incurved, forming very nearly a right angle; anterior cardinal margin very gently convex, posterior cardinal edge correspondingly concave, ventral margin together with the curve into the ends forming a semicircle. Ends subequal, the posterior sometimes a little the longest. Umbones full, the remainder of the surface sloping uniformly to the free margins. An obscure sulcus may be detected near the anterior margin, and along the dorsal part of this end the surface descends abruptly to the hinge plate. Surface with strong, closely arranged, thread-like, concentric lines, about twelve in 5 mm. At intervals of about 2 or 3 mm. generally a fold stronger than the rest.

Casts of the interior exhibit a faint ridge and sulcus in the anterior end, and two sharply defined muscular scars and pallial line in each valve.* Hinge plate rather narrow, the teeth numerous, over thirty, as usual very small centrally, growing larger gradually towards the ends of the hinge.

This species is distinguished from *C. astartiformis* Salter, by its larger size, greater width, more erect form, and comparatively coarse and regular concentric lines. *C. compressa* is not so convex, especially in the umbonal region, has more pointed beaks and much finer striæ.

*Formation and locality.*—Not uncommon in the middle division of the Galena at Wykoff and other localities in Fillmore county, Minnesota.

### CTENODONTA ALTA *Hall.*

PLATE XLII, FIGS. 93 and 94.

*Tellinomya alta* HALL, 1861. Rep. Supt. Geol. Sur. Wis., p. 27; MEEK and WORTHEN, 1868, Geol. Sur. Ill., vol. iii, p. 309.

Shell (internal cast) small, rather strongly convex, nearly erect, subtriangular, the length, hight and convexity, respectively, about 11.2, 11.5 and 6.3 mm.; base broadly rounded, semielliptical; beaks elevated, nearly central, arching slightly backward; anterior and posterior sides nearly equal, sloping abruptly from the beaks at an angle of about 85°, the anterior dorsal outlines very gently convex, the posterior correspondingly concave; beneath the ends of the hinge the outline on both sides curves rapidly into the base. Muscular scars large and comparatively distinct, the posterior one nearly rounded, the other more oval; the anterior one lies in the wider lower end of a shallow sulcus which may be traced almost to the beaks. The hinge, Prof. Hall says, is marked by from twenty to twenty-five very small curved teeth on the anterior (posterior) side and from ten to fifteen on the posterior (anterior) side.

This rare species is a little smaller, not quite as high, more erect and less convex in the basal outline than *C. intermedia.* In the latter, as well as in all the other species of this section of the genus, save *C. recurva*, the anterior half of the outline is more uniformly rounded.

*Formation and locality.*—The specimen described by Meek and Worthen came from the Galena near Mount Carroll, Illinois, while Hall's original type is from, presumably, an equivalent horizon at Dodgeville, Wisconsin. The specimen here used, which is precisely like the Illinois example, is from the shaly lower beds of the Galena near Fountain, Minnesota.

*In the original description it is stated that a small pair of scars is situated above the posterior adductor impressions. This statement I now believe rests upon faulty observation.

## Ctenodonta recurva *Ulrich.*

PLATE XLII, FIGS. 98–101.

*Tellinomya recurva* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 221.

Shell small or of medium size, compressed-convex, slightly oblique, subtriangular, the length and hight almost equal, the thickness equalling about one-third of the hight. Rostral portion strongly recurved, ends narrowly rounded, base nearly semi-elliptical, with more curvature in the posterior half than in the anterior. Beaks prominent, posterior to the center of the shell; umbones with an unusually small degree of convexity. Cardinal margins sharply inflected, forming an elongate depressed area on the anterior side and a shorter, narrowly cordiform one behind or rather beneath the beaks. A shallow and gradually widening sulcus extends from the beak along the antero-cardinal margin to the antero-ventral border. Surface marked by several strong lines of growth and between them fine concentric striæ, about ten in 3 mm. Hinge plate strong, bent at a right angle, the posterior part nearly straight (gently concave), somewhat shorter than the anterior, with about twenty small, curved transverse teeth, decreasing, as usual, gradually in size and curvature toward the beak; anterior part convex, with about thirty teeth. Considering the strength of the hinge plate, the teeth are very small. Immediately in front of the beak, in the angle of the hinge, a narrow oblique space breaks the continuity of the series of denticles. Hinge plate margined on the outer side by a delicate sharp ridge; just within it a narrow furrow which has considerable width and depth for some distance in front of the beak. In front of the beak and above the marginal line of the hinge plate a small area is defined apparently for the reception of an external ligament. (See note, p. 578.) Anterior and posterior muscular scars distinct, though not very strongly impressed; as usual for this section of the genus in size and form.

The compressed form reminds of *C. compressa*, but the shape is different, the length being greater, the ends more narrowly rounded and the rostral part more strongly recurved. The surface markings also are coarser and the posterior lunettes much better defined, while a number of important differences may be observed in their hinges. Hall's *C. alta* is similar in the basal part, but is a more convex shell and much less curved in the rostral part.

*Formation and locality.*—Upper beds of the Hudson River group, at several localities in Fillmore county, Minnesota. It is associated with the next species *(C. similis)*, but is not nearly so abundant. The species occurs, though so far as observed only in the condition of casts, also at Oxford, Waynesville and other localities in Ohio, and at Richmond, Indiana.

### CTENODONTA SIMILIS *Ulrich.*

PLATE XLII. FIGS. 102—106.

*Tellinomya similis* ULRICH, March 3, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 220.
*Tellinomya (Nucula) lepida* SARDESON, April 9, 1892. Bull. Minn. Acad. Nat. Sci., vol. iii, p. 339.

Shell small to medium size, moderately ventricose, subtriangular, the length and hight respectively as five or five and a half is to six. Umbones full, rounded, the rostral portion rather strongly recurved, with the beaks small and projecting slightly above the hinge. Antero-dorsal edge convex, thick, flattened, but not sharply defined. Postero-dorsal edge rather strongly concave, impressed so as to form an illy-defined imperfect lunette. Anterior outline almost uniformly convex, curving neatly into the well rounded ventral margin; posterior side rather narrowly rounded. Surface of valves almost uniformly convex, highest a little above the center, generally with a few well marked varices of growth and with finer concentric lines in the lower part. Hinge plate of moderate strength, with numerous small teeth (thity-five to forty-two); in the largest examples seen with about twenty-seven anterior and fifteen posterior to the beak; posterior teeth the largest. Muscular scars moderately impressed, always distinguishable.

The shape of this shell is exceedingly like that of *C. astartiformis* Salter, though as a rule proportionally a little longer and scarcely so ventricose. The posterior lunette also is somewhat deeper, but the principal differences lie in the hinge. The hinge plate, namely, in Salter's species, is somewhat stronger, while the denticles are more bent, larger and less numerous. The teeth, furthermore, are largest on the anterior side, while in *C. similis* the opposite is the case. It is also very much like the associated *C. recurva*, but is distinguished by being a little higher, more uniformly rounded on the anterior side and without the anterior sulcus. More important differences are the greater tumidity of the umbones, less prominent beaks, less strongly defined anterior and posterior lunettes and weaker hinge plate. Casts of the interior are separated chiefly by the greater thickness of the rostral portion. They are also nearly always of smaller size than those of *C. recurva.*

*Formation and locality.*—Upper beds of the Hudson River group, Spring Valley and other parts in Fillmore county, Minnesota, and at Blanchester, Ohio.

### CTENODONTA OBLIQUA *Hall.*

PLATE XLII. FIGS. 83—87.

*Nucula obliqua* HALL, 1845. Amer. Jour. Sci. and Arts, vol. xliii, p. 292.
*Tellinomya ? obliqua* MEEK, 1873. Pal. Ohio, vol. i, p. 139.
*Palæoconcha obliqua* and *P. faberi* MILLER, 1889. North Amer. Geol. and Pal., p. 498.

Shell very small, broadly acuminate-subovate; or, without the triangular rostrum, the outline may be called subcircular, the basal half, as a rule, being quite regularly curved; length and hight nearly equal, the latter dimension commonly a little the greater. Beaks prominent, situated behind the center, turned backwards. Surface marked by comparatively strong concentric lines.

On casts of the interior, and this is almost invariably the condition in which the species is preserved, the muscular scars are nearly always distinguishable and the posterior one is often sharply defined and prominent on the upper side. They are situated just within the ends of the shell and each near the wider and lower end of an obscurely defined sulcus. The two sulci, of which the anterior one is usually the better marked, begin near the beak and extend down on each side to the base of the muscular scars. A small accessory scar has been observed immediately above the posterior adductor. Pallial line simple, rather distinct. Hinge plate comparatively strong, with numerous (at least thirty) small denticulations.

The size of this shell varies greatly. Many of the specimens found at Cincinnati and localities in the vicinity of that city are less than 2 mm. in diameter, but others are occasionally met with that range from that size to a diameter of 5 mm. In the northwestern localities the species grew to a larger size, specimens having a diameter of from 5 to 7 mm. being in the majority. Aside from the matter of size, however, the specimens from these two regions are practically identical.

Dr. S. A. Miller, in the work above referred to, erects a new genus, *Palæoconcha*, and a new family for the reception of the present species, which he divides into two species, giving to the larger form the specific name *faberi*. But this new genus and family have no right to recognition, since they are based entirely upon erroneous observation, he having come to the conclusion that the hinge in these shells was not denticulated and probably edentulous. Through the kindness of Dr. Miller I had an opportunity to examine a number of the specimens (excellent casts of the interior) used by him in defining his genus. Even among these I noticed several that retained undeniable evidence of the denticulate hinge.

*Formation and locality.*—Very abundant at Cincinnati, Ohio, and numerous other localities in the the vicinity of that city. In the northwest it is one of the rare fossils of the so-called "Nucula bed" of the Maquoketa or Hudson River shales.

### CTENODONTA HAMBURGENSIS *Walcott.*

PLATE XLII, FIGS. 91 and 92.

*Tellinomya? Hamburgensis* WALCOTT, 1884. Pal. Eureka District, p. 76.

Shell small, rather convex, rounded-subrhomboidal in outline, with the hight and length subequal and the beak comparatively large, incurved and situated in front of the center; posterior dorsal margin somewhat straightened. Surface marked by regular sharp, though fine, concentric striæ in the posterior half, the anterior half appearing smooth. Hinge and interior unknown.

The single specimen of this form seen from Minnesota, agrees so well in its outline and general appearance with Walcott's figures of *T. hamburgensis* that I am obliged to refer it to his specieis. It should be remarked, however, that the surface of the Nevada types of the species is described as presenting "a smooth, glistening appearance," giving them "the character of some of the Linguloid shells," and that it is marked by not only concentric lines but also by "very fine, often scarcely perceptible radiating striæ,"—all of which is wanting on the Minnesota specimen under consideration. But, as these differences may all be due to different methods of preservation, I have not taken them into account.

Respecting the generic position of the shell there may be some doubt, because we have as yet no knowledge of the interior. Nor does the species seem to fit very well into any of the sections into which the genus has been divided. Certain it is that it is not very closely related to any of the numerous species described. Perhaps it is the most like *C. socialis*, with which it is also associated, but it will be distinguished readily enough by its shorter and rounder form, fuller umbones and more distinctly striated surface.

*Formation and locality.*—Upper part of the middle third of the Trenton shales, Chatfield, Minnesota. The types of this species are from the upper part of the Pogonip group, Eureka District, Nevada.

## Genus CLIDOPHORUS, Hall.

*Clidophorus*, HALL, 1847. Pal. N. Y., vol. i, p. 300.
Compare *Nuculites*, CONRAD, 1841. Ann. Rep. Geol. N. Y., p. 49; and *Cucullella*, MCCOY, 1855.

I prefer not to characterize this genus at the present time, nor to express any definite opinion respecting its relations to *Cucullella*, McCoy, and *Nuculites*, Conrad, for the simple reason that I have had no opportunity to study the typical species of the genera. It should be stated, however, that many authorities regard the three names as synonymous and that, unless new distinctive features are brought out, their views cannot be successfully combated.

### CLIDOPHORUS CONSUETUS *Ulrich.*

PLATE XXXVII. FIGS. 32 and 33.

*Clidophorus consuetus* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 223.

Shell above the medium size for the genus, transverse, moderately elongate-ovate, rather strongly convex, the length equaling nearly twice the hight. Beaks small, incurved, flattened. Dorsal line convex, sloping downward behind the beaks to the narrowly rounded posterior extremity. Anterior end neatly rounded, wider than the posterior. Ventral margin gently convex in the middle, more strongly and almost equally curved at the ends. An obscure umbonal ridge traceable from the beaks three-fourths of the distance to the posterior basal edge. Above it an impressed narrow line, beyond which the surface descends rapidly to the dorsal margin. Casts of the interior with a narrow, slightly curved, clavicular impression just in front of the beaks, extending but little more than one-third of the distance to the antero-basal margin. Surface of casts with a few obscure growth lines or folds. Point of greatest convexity a little above and behind the center of the shell. In a dorsal view the central half of the outline is very slightly flattened.

Length, 17.2 mm.; hight, 9.0 mm.; thickness of both valves, 5.3 mm.

This shell appears to be related to *C. cuneatus* and *C. elongatus*, described by Hall from the Silurian rocks of Nova Scotia (Can. Nat. and Geol., vol. 5, pp. 148 and 150, 1860). It is, however, specifically distinct, the shape being different and the posterior sinus situated higher up and very much less defined. *C. planulatus* (Conrad) and *C. ellipticus* Ulrich, also have somewhat different outlines and have the cardinal slopes less abrupt, the whole surface in those species being more uniformly and less convex.

*Formation and locality.*—Middle Galena near Wykoff, Minnesota, where it is associated with *Ctenodonta intermedia.*

## CLIDOPHORUS NEGLECTUS *Hall.*

PLATE XLII, FIGS. 20—25.

*Clidophorus neglectus* HALL, 1862. Geol. Sur. Wis., vol. 1, p. 55. (Figured but not described.)
Compare *Clidophorus (Nucula) fabula* HALL, 1845. Amer. Jour. Sci. and Arts, vol. xliii, p. 295.

Shell varying greatly in size, the smallest observed having a hight of only 2.5 mm., with a length of 5 mm., while in the largest seen (from Graf, Iowa,) these dimensions are respectively 8.5 mm. and 16 mm.; thickness of the latter about 6 mm.

Shell transversly subelliptic, rather strongly convex; ends subequally rounded, the anterior generally a little narrower than the posterior; the outline of the latter, however, often exhibits a tendency to become angular just beneath the middle and obliquely subtruncate above; basal and dorsal margin broadly convex. Beaks small, somewhat tumid, placed about one-third of the length of the shell behind the anterior extremity. Surface marked by fine concentric lines and several stronger varices of growth; the latter show through the shell so as to be visible on casts of the interior. Hinge plate narrow, not over half the length of the shell, minutely toothed; denticles twenty or more in each valve, three-fourths of the number being posterior to the beaks, placed obliquely and so that they converge inwardly, the direction of the anterior series being nearly at right angles to that of the posterior series. Clavicle strong, nearly straight, almost vertical, sharply defining the somewhat semicircular and large anterior muscular scar and leaving a strong furrow in casts of the interior just in advance of each beak. The furrow extends beyond the middle of the distance to the basal margin. Posterior scar faint, smaller than the anterior, occupying a central position on the post-cardinal slope. Several small umbonal scars may be observed on good casts, and obscure rays are occasionally visible on their sides.

Hall's *C. fabula*, described from Cincinnati specimens less than 2 mm. in length, seem to me to be nothing more than a dwarfed variety of this species.

*Formation and locality.*—In the so-called "Nucula Beds" of the Maquoketa (Hudson River) shales at several localities in Lafayette county, Wisconsin; Jo Daviess county, Illinois, and near Dubuque and Graff in Iowa. It is to be found, I think, in the equivalent beds in Fillmore county, Minnesota.

*Mus. Reg.* No. 7336.

## Family LYRODESMIDÆ, Ulrich.

A reconsideration of the genera included in this family, on page 486 of this work, has convinced me fully that they are improperly associated and that the family must for the present rest solely on the typical genus. Dr. S. A. Miller was, I now believe, right in proposing a new family for his genus *Technophorus* (N. A. Geol. and Pal., p. 458, 1889), but he should have included the closely related *Ischyrina*, Billings, a genus doubtfully referred by him to the *Trigoniidæ*. The new genus *Allodesma* proves to be related to *Cyclochoncha*, Miller, rather than to *Lyrodesma* and should therefore be removed to the provisional family *Cycloconchidæ*.

The proper arrangement of these three families in a scheme of classification is a point upon which it is very difficult to come to a satisfactory determination. Considerable agreement in structure is to be traced between them, and at times I might go so far as to say that they should be regarded as closely related. Still, in view of the fact that each in one way or another resembles types classed in such widely distinguished families as the *Trigoniidæ*, *Crassatellidæ*, *Cyrenidæ* and *Myidæ* more closely than they do known Devonian and Carboniferous forms, it would obviously be an expression of opinion quite insufficiently supported by facts.

### Genus LYRODESMA, Conrad.

*Lyrodesma*, CONRAD, 1841. Ann. Geol. Rep. N. Y., p. 51; HALL, 1847, Pal. N. Y., vol. 1, p. 302.
*Actinodonta*, PHILLIPS, 1848. Mem. Geol. Sur. Great Britain, ii.

Shell moderately convex, larger than high, ovate to subquadrate, rounded in front, usually obliquely truncate behind and more or less angular post-basally.

Beaks small, placed in front of the midlength; posterior umbonal ridge generally prominent, often angular; post-cardinal slope frequently with radiating lines, the rest of the surface with concentric striæ only. Hinge consisting of from six to eight prominent, subequal, transversely striated teeth, radiating regularly from the beak and placed on a thick plate, which leaves a large oblong depression in the dorsal edge of casts of the interior. Adductor scars rather faintly impressed, the posterior one larger than the anterior. Two pairs of small pedal muscles, the anterior pair situated immediately above the anterior adductors, the posterior pair on each side of the hinge line just behind the hinge teeth. Pallial line slightly sinuate posteriorly.

Type: *L. planum* Conrad.

Of this excellently marked genus I know eleven or twelve American specific forms. Eight of these occur in the various horizons of the Cincinnati group, the remainder in the Trenton. Two additional species are catalogued by Bigsby among the European Lower Silurian shells.

### LYRODESMA ACUMINATUM, *n. sp.*

PLATE XLII. FIGS. 1–5.

Shell obliquely acuminate-ovate, the outline being drawn out to an acuminate extremity posteriorly; in the typical form (fig. 1), the hinge line is arcuate and passes gradually into the posterior margin, which, because of the flattening of this region projects, in a side view, but little beyond the sharply angular umbonal ridge; anterior end broad, regularly rounded; base straight posteriorly. Beaks small, arcuate, strongly incurved, not very prominent, situated somewhat less than one-third of the length from the anterior extremity. Surface with obscure, distant, concentric lines; on the posterior cardinal slope four or five radiating lines. Hinge with six teeth of which the anterior ones are considerably shorter than the posterior one, and the central ones curved backward. Posterior adductor impression unusually distinct; sinus in pallial line very small.

The specimen represented by figures 3 and 4 (plate XLII), is one of several that I refer to this species with considerable doubt. The posterior end is too short causing the beaks to be more central, and the post-cardinal margin is more prominent and subalated. The umbonal ridge is even sharper and more prominent, its greater distinctness being due to a somewhat greater flattening of the flanks of the valves. The hinge is injured in the specimen, but it is quite evident that the teeth have not that backward sweep which marks the typical form. Precisely the same form (see figure 45-*h*, page 611) occurs in the Trenton of Kentucky, but, so far as known, it is not, as is the case in Minnesota, there associated with the typical form. The variety, which may take the name of *intermedium*, connects *L. acuminatum* with *L. cincinnatiense* Hall, being as nearly as possible intermediate between these species. The form of the shell and the prominence of the umbonal ridge will distinguish *L. acuminatum* from all of the other species.

*Formation and locality.*—Middle third of the Trenton shales, Chatfield and near Cannon Falls, Minnesota. The var. *intermedium* occurs at the same localities and in the Trenton limestone near Burgin, Kentucky.

### LYRODESMA CANNONENSE, *n. sp.*

PLATE XLII. FIGS. 6–8.

*Nucula poststriata* HALL, 1847. Pal. N. Y., vol. 1, p. 151, pl. 34, fig. 2*a*, 2*b*. (Not p. 301, pl. 82, figs. 10*a*, *b*.)

This small species of which only casts of the interior have been seen, is similar in shape to *L. acuminatum* var. *intermedium.* Critically compared it proves to be longer, and has the beaks farther anterior. The hinge line also appears to have been somewhat longer. Then there is a slight depression on the posterior side of the umbones which is not seen on casts of that species. In all these respects *L. cannonense* agrees very closely with *L. subplanum*, a new species from the Utica horizon of the Cincinnati group, at Covington, Kentucky, which I am describing in vol. vii of the reports of the Geological Survey of Ohio; and it is with that form that I believe its relations really lie. Comparing it with an excellent cast of that shell, the Minnesota form is distinguished by its shorter hinge line, more oblique posterior margin, more sharply angular umbonal ridge, and wider beaks. Though also smaller it cannot be denied that the two forms are very closely related, and probably nothing more than varieties of one species.

The Trenton shell referred to by Hall in 1847 *(loc. cit.)* to *Nuculites* (now *Lyrodesma*) *poststriatum* Emmons, is not the same as the Hudson River type of that species, but probably belongs to *L. cannonense.*

*Formation and locality.*—Galena shales near Cannon Falls, Minnesota. Also in the Trenton limestone, Carlisle, Pennsylvania.

## LYRODESMA MAJOR *Ulrich.*

*Cleidophorus major* ULRICH, 1879. Jour. Cin. Soc. Nat. Hist., vol. ii, p. 25.

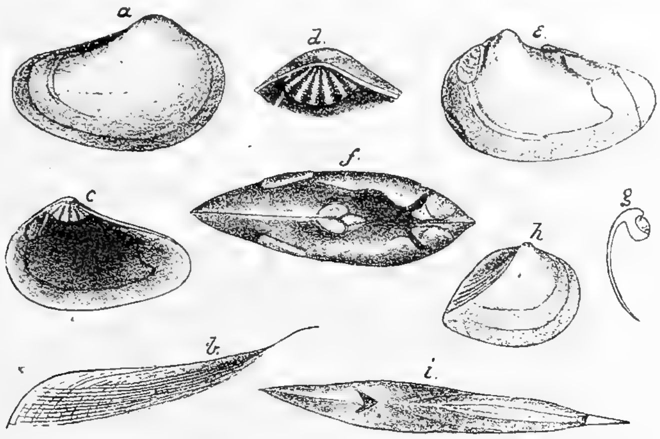


Fig. 45. *a*, right valve of *Lyrodesma major* Ulrich; *b*, cardinal slope of same, × 2, showing the fine radiating striæ; *c*, interior of a right valve; *d*, hinge of same, × 2; *e*, left side of a cast of the interior of same, showing the muscular scars and pallial line with unusual distinctness; *f*, dorsal view of same, slightly enlarged; *g*, vertical section through a valve at the beak, showing thickness of hinge plate and why the beaks in casts are widely separated; specimens from upper beds of the Cincinnati group at Clarksville, Ohio. *h*, right valve of *Lyrodesma acuminatum*, var. *intermedium*, from the Trenton near Burgin, Kentucky. *i*, dorsal view of a cast of the interior of *Technophorus extenuatus* Ulrich, × 2, showing the united beaks, the flattening of the posterior dorsal edge and other features.

Shell transversely subovate, unusually elongate for the genus, narrow posteriorly; length of three testiferous examples 17, 24 and 28 mm., greatest hight of same (from beaks to basal margin) respectively, 11, 15 and 18 mm.; greatest thickness subcentral, somewhat greater than half the hight; anterior margin rounded, most prominent immediately above the middle of the hight, often straightened in the upper half to the beaks; base broadly yet rather strongly convex; posterior end long, somewhat attenuate, narrowly rounded at the extremity; cardinal outline declining each way from the beaks, more or less concave behind them. Beaks rather prominent, small, incurved, situated about one-fourth of the entire length from the anterior extremity; umbones full, sharply rounded on the posterior side where the surface descends abruptly to the cardinal margin; behind the beaks the dorsum is first concave, then flat and finally low ridge-shaped; beneath, or rather in front of them, there is an impressed line on each side which defines an elongated lanceolate area. Surface nearly smooth, in one example exhibiting fine concentric striæ. All of the testiferous specimens however have twelve or more, fine radiating lines on the posterior umbonal ridge and cardinal slope.

Hinge with six teeth in each valve, the four central ones much stronger than the marginal pair. Muscular scars strongly impressed, the anterior adductor sharply defined on the inner side by a thin ridge running down from the hinge, narrowing above and surmounted by deep supplementary scars; posterior adductor elevated anteriorly, situated in the cavity of the umbonal ridge about midway between the beaks and the posterior extremity of the shell; posterior pedal muscles strongly defined, situated on each side of the cardinal edge and just behind the hinge plate. Pallial line distinct, especially in front and along the base, sinuate posteriorly.

This fine shell is in no wise related to *Clidophorus,* to which genus I originally referred the indifferently preserved casts upon which the species was founded. Had I been acquainted with the appearance of casts of the interior of *Lyrodesma,* which are really very distinctive, it is not likely that I should have been led astray by the slit-like vertical depression in front of the beaks. Compared with other species of the genus, *L. major* is unusually long posteriorly and narrow without running to an acuminate extremity, the radiating lines on the umbonal ridge are finer and the muscular scars deeper. The species is so distinct that detailed comparisons are scarcely necessary. Still it may be well to say that *L. acuminatum* and *L. cannonense* are pointed instead of rounded posteriorly and have much stronger umbonal ridges, while they are also less convex in their basal outlines.

*Formation and locality.*—A small valve apparently belonging to this species was found in the Hudson River group near Spring Valley, Minnesota. Casts of the interior are not uncommon near the tops of the hills about Cincinnati, Ohio. These are proportionally a little longer than the geologically higher form of the species which is represented in my cabinet by excellently preserved testiferous examples from the upper beds of the Cincinnati group at Clarksville, Ohio.

## Family TECHNOPHORIDÆ, Miller.

### Genus TECHNOPHORUS, Miller.

*Technophorus*, MILLER, 1889. North Amer. Geol. and Pal., p. 514.

Shell small, equivalve, inequilateral, compressed convex, often attenuate and extended posteriorly; anterior end rather short, wider than the posterior, almost regularly rounded in outline; beaks very small, scarcely, if at all prominent; one or two sharp ridges, with a furrow above each, arise near the beak and extend in a curved direction to the post-basal margin. Anterior part of surface marked with regular concentric lines, generally separated by rows of minute punctæ; on the posterior part, especially the cardinal slope, those lines rarely coincide with the margins of the valves, but assume various arbitrary and sometimes ornamental arrangements. Internally a short and thick rib extends downward in each valve from the hinge directly in front of the beaks, while on the posterior side of same a shorter oblique rib, or a mere thickening of the hinge plate, causes the beaks in casts of the interior to appear much more erect and prominent than they do on the exterior of the shell. In casts the beaks of the two valves are not distinguishable but together form a single pyramidal prominence. Anterior adductor scar small, situated immediately in front of the internal rib; posterior scar and pallial line not observed, although most excellent casts were studied.

Type: *Technophorus faberi* Miller.

The shells included in this genus are in several respects very remarkable. This is true in the first place of their surface ornamentation in which they differ more or less decidedly from all known paleozoic representatives of the class, with the possible exception of *Ischyrina* Billings, a genus that will be discussed presently. As a second, though no less important peculiarity, we have the character of the beaks as these appear in casts of the interior. In all wholly known Lanellibranchiata, namely, the beaks of the two valves are distinguishable in casts as two more or less prominent points separated, as the case may be, by a narrow or wider depressed space originally occupied by the hinge plate. In casts of *Technophorus*, on the contrary, the fillings of the cavities of the two beaks forms a single pyramidal prominence. (See fig. 45-*i*, p. 611). It is evident then that immediately beneath the beaks, the hinge plate must be excavated, and a careful examination of the beaks of casts of *T. extenuatus* brought to light certain faint markings indicating that the excavation was occupied by either an internal cartilage or some peculiar type of muscle. The internal ribs are also unusually short and thick, and peculiar in this, that they meet in the center when the valves are closed so as to completely shut off the space occupied by the anterior adductor muscles from the cavity under the beaks.

Unfortunately, the hinge proper is not shown by any of the specimens seen by me. Still, one of the casts of *T. extenuatus* shows a number of very small papillæ along both the anterior and posterior sides of the hinge line that may have been produced by minute denticles on the hinge plate. But we cannot accept such uncertain evidence, so that for the present the hinge must be regarded as incompletely known. *Ischyrina*, Billings, so far as known to me from the description and figures of the type species, *I. winchelli* (Desc. Catal. Sil. Foss. Island Anticosti, p. 16; 1866) seems to be closely related to this genus. The internal ribs are better developed, the posterior one especially. Billings represents the latter as quite distinct from the hinge plate, which is not the case in *Technophorus*. There are posterior (Billings calls this side anterior) furrows and ridges, but the wing is very short. The beaks are stated to be small and obscure, but I have no means of knowing whether they appear in casts as merged into a single prominence or not. *I. plicata*, described but not illustrated by Billings on p. 52 of the same catalogue, seems to agree much better with *Technophorus faberi*, and it is not improbable that it should be referred to this genus instead of *Ischyrina*.*

* Since the above was written and placed in the hands of the printer, I have had an opportunity, which I owe to the kindness of the officers of the Geological Survey of Canada, of studying the original types of *Ischyrina winchelli* and *I. plicata*. In a cast of the interior of the first, the internal ribs are shown as represented by Billings. It shows further that the beaks are pressed down to the hinge and, though the impression is of one valve only, the evidence is fairly conclusive that the beaks were united in casts as in *Technophorus*. The second species proves to be, as I suspected, a true *Technophorus*, with close relations to *T. subacutus* and *T. punctostriatus*. Its surface markings are minutely puncto-striate, with about eight of the finely pustulose concentric lines in 1 mm.

## TECHNOPHORUS EXTENUATUS *Ulrich.*

PLATE XXXVII, FIG. 34; PAGE 611, FIG. 45—i.

*Technophorus? extenuatus* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 222.

Casts of the interior small, compressed, somewhat elongate, alated and drawn out posteriorly. Beaks small, erect, moderately prominent, together forming a low pyramidal prominence, situated about one-fourth of the entire length from the anterior extremity. Just in front of the beaks the casts of the interior exhibit a deep though not very long impression; the posterior umbonal rib left an obscure furrow on each side of the hinge line. Anterior end broad, rounded, most prominent in the upper third; ventral margin broadly convex and slightly produced a little in front of the middle; behind this point the outline is nearly straight (slightly concave) sloping up toward the narrow (? pointed) posterior extremity. Cardinal line nearly as long as the entire shell, gently concave behind the beaks. A thin sharply defined ridge, slightly curved, extends across each valve from the beak to the lower side of the posterior end. Surface gently convex in the anterior half, faintly constricted in front of the ridge, and marked with obscure, concentric wrinkles of growth. A specimen preserving a small part of the shell, shows that the external surface is marked, at any rate on the sides, by closely arranged, sharp, elevated lines, separated by rows of small punctæ.

Length about 21 mm., greatest hight 10 mm., greatest convexity about 3.5 mm. This species, which I now regard as undoubtedly congeneric with the Cincinnati shell upon which Dr. Miller founded the genus *Technophorus,* is distinguished by the prominently rounded centro-basal margin, and the greatly produced posterior wing.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis and St. Paul, Minnesota.

## TECHNOPHORUS SUBACUTUS *Ulrich.*

PLATE XL, FIGS. 33 and 34.

*Technophorus subacutus* ULRICH, 1892. Amer. Geol., vol. x, p. 101.

Shell small, rather ventricose, alated posteriorly, the hight and length respectively as two is to three. Cardinal margin nearly straight, anterior end uniformly rounded, ventral edge more gently curved, the posterier straight and sloping backward slightly to the acuminate extremity of the hinge line. In a cast of the interior of a left valve, the small beak is erect, projects prominently above the hinge line, and is situated about one-third of the entire length from the anterior extremity. Just in front of the beak there is a strong and deep impression, running almost vertically downward. On the anterior side this slit margins a rather large muscular scar. Extending backward from the beak the cast exhibits another, but in this case, very obscure linear depression. The entire rostrum also is somewhat constricted, presenting an appearance that may have been produced by a slight internal thickening of the shell, extending from the anterior to the posterior umbonal rib. Two curved folds, the posterior one the strongest, extend from the postero-ventral angle toward the beaks, becoming indistinguishable, however, about midway between the two points. Surface markings and hingement unknown.

Length 11.5 mm., hight 6.8 mm., convexity of one valve about 2.2 mm.

This incompletely known species is very similar in both the outline and general expression to *T. punctostriatus* Ulrich, from the middle beds of the Cincinnati group in Ohio and Kentucky. Though doubtless closely related, a careful comparison of internal casts—the only condition in which the present species is known—proves that they can be separated, the Minnesota species having the beaks more anterior and more prominent, the anterior margin more uniformly rounded, and the post-cardinal outline more concave, while the posterior ridges are more oblique and do not, as is the case in casts of the Cincinnati shell, extend beyond the middle of the distance to the beaks. None of the other species are near enough to require comparisons.

*Formation and locality.*—The specimen described was found in the upper part of the Trenton limestone at Minneapolis, Minnesota. The same piece of stone contains numerous specimens of *Orthis perveta* Conrad, and *Zygospira (Hallina) nicolleti* W. and S.

### TECHNOPHORUS FILISTRIATUS *Ulrich.*

PLATE XL, FIGS. 35 and 36.

*Technophorus filistriatus* ULRICH, 1892. Amer. Geol., vol. x, p. 101.

Shell small, though large for the genus, compressed, with the greatest convexity in the anterior half, scarcely alate posteriorly, the hight and length as three is to five. Beaks small, projecting very little, slightly incurved, one-third of the entire length of shell from the anterior extremity. Anterior end much the widest, broadly and uniformly rounded except above where the curve turns rather sharply into the hinge line. Ventral margin rounded in front, straight and sloping upward in the posterior half to the acute extremity. Posterior margin short, apparently straight and sloping forward, cardinal margin straight, except for a slight prominence in the region of the beaks. Anterior half of surface marked with closely arranged, thread-like, concentric lines, between which small punctæ are obscurely visible on the specimen described. These markings seem to be wanting in the posterior half, only a few obscure growth lines being visible here. Posterior ridge sharp and strong, very gently curved in its course from the beak to the produced lower angle of the posterior extremity of the shell. Between this ridge and a line drawn vertically across the shell from the beaks, the surface is depressed, forming a widening shallow sulcus and the straightening of the ventral margin. Postero-cardinal slope concave, narrow, descending rather rapidly, not well preserved in the specimen. Interior unknown; shell substance very thin.

Length 21 mm., hight 12.5 mm., greatest convexity (of a left valve) 2.5 mm.

*Formation and locality.*—Upper part of the middle third of the Trenton shales near Cannon Falls, Minnesota. It is associated with *Plethocardia umbonata*, *Ctenodonta planodorsata*, *Matheria rugosa* and other shells characterizing this horizon.

## Technophorus divaricatus *Ulrich.*

PLATE XL. FIGS. 37 and 38.

*Technophorus divaricatus* Ulrich, 1892. Amer. Geol. vol. x, p. 102.

Shell small, moderately convex, elongate, the length a little more than twice the hight. Beaks small, scarcely projecting above the hinge line, situated about one-third of the entire length from the anterior extremity. Dorsal margin nearly straight, (faintly concave on each side of the beaks) about three-fourths as long as the shell, terminating abruptly where it joins the concave posterior edge, with the upper part of which it forms an angle little short of 90°. Anterior end a little higher than the posterior, strongly rounded in outline, especially above; below rounding neatly into the at first gently convex, then straight and finally concave basal line. Posterior ridge thin but very prominent, curving slightly in its course from the beak to the sharply produced postero-basal angle. Surface uniformly convex and marked with fine, thread-like concentric lines in the antero-basal three-fifths beyond which it first descends into a sulcus and then ascends sharply to the summit of the ridge, dropping on the other side even more abruptly into the wing-like postero-dorsal part of the shell. On each side of the posterior ridge there are distinct divaricating lines, twice as strong as the concentric lines on the anterior part of the shell. They join each other on the ridge, while those on the lower side of the latter meet the concentric lines at angles of about 70°. Finally there is another set of such lines along the dorsal edge, running parallel with the set on the lower side of the ridge. Under a magnifier, with certain lights, these lines appear as though minutely crenulated. Internal characters unknown; shell substance very thin.

Length 12.5 mm., hight at the beaks, 5.8 mm., hight at posterior end of hinge, 5.1 mm., greatest thickness of closed valves, 4.1 mm.

Casts of the interior would be distinguished by having the dorsal and ventral margins more nearly parallel than is the case in any of the other species referred to the genus, except *T. punctostriatus* of the Cincinnati group, which is, however, a shorter shell, and widely different in other respects. With the shell in a good state of preservation the species is distinguished from all Silurian lamellibranchs by the peculiar surface ornamentation.

*Formation and locality.*—Near Cannon Falls, Minnesota, in the upper third of the Trenton shales.

## Family CYCLOCONCHIDÆ, Ulrich.

A full description of the typical genus of this family, and of several species of same, will be found in vol. viii of the reports of the Geological Survey of Ohio.

### Genus ALLODESMA, n. gen.

*Modiolopsis* (part.), ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 226.

Shell small, transversely elongate-elliptical, moderately convex; beaks anterior, small, surface with concentric lines of growth. Hinge apparently with one or two long posterior lateral teeth in each valve, two cardinal teeth in the right valve, and only one in the left; anterior laterals short or wanting. Anterior adductor scar distinct, large, ovate, margined on the inner side by a strong curved ridge extending downward from the hinge at a point immediately in front of the beaks. Just above the adductor impressions and in front of the ridge, a small pedal muscle scar. Posterior adductor impression faint, larger than the anterior, of rounded form, situated near the middle of the posterior cardinal slope. Pallial line simple.

Type: *A (Modiolopsis) subellipticum* Ulrich.

The species upon which the genus is founded has really no relation to *Modiolopsis* with which I provisionally associated it. The original type gave no hint of the character of the hinge, or I would never have thought of the arrangement first adopted. A better specimen, recently collected, at once led to comparisons with the very different genus *Cycloconcha*, Miller, and proved that the relations of the shell were really with that genus. The only features wherein *Allodesma* differs from *Cycloconcha*, so far as data now at hand will admit of judgment, are first, the more elongate form of the shell; second, the anterior position of the beaks; third, the curved ridge forming the inner border of the anterior muscular scar, and fourth, the shortness or entire absence of anterior lateral teeth in the hinge. These differences, though certainly of generic value, are not, as it now appears, of sufficient importance to exclude the new genus from the *Cycloconchidæ*.

#### ALLODESMA SUBELLIPTICUM *Ulrich.*

PLATE XLII, FIGS. 9–14.

*Modiolopsis subelliptica* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 226.

Shell small, elongate-elliptical in outline, the length about twice as great as the hight; ends almost equally rounded, base broadly convex, cardinal outline more gently arcuate. Beaks small, incurved, projecting but little above the hinge, situated about one-fifth of the entire length from the anterior extremity; umbonal ridge rounded, not strong, distinguishable chiefly in the upper third of the shell, where it causes a flattening or slight concavity in the slope to the cardinal edge. Sides of valves moderately convex, with point of greatest convexity a little in front of and above the middle.

Casts of the interior exhibit a strongly defined ovate anterior muscular scar, bounded upon the inner side by a distinct linear depression which must have been produced by an internal ridge in the valves extending downward from the hinge just in front of the beaks. Immediately above the adductor impressions there is a minute but distinct pair of, presumably, pedal muscle scars. Posterior adductor impressions very faint, rounded, situated a short distance within the middle of the post-cardinal margin. Pallial line not very well defined, simple. Dorsum of cast exhibiting impressions of cardinal and lateral teeth, indicating a hinge as shown in figs. 13 and 14 on plate XLII.

So far as known the beds from which this species was obtained contain no lamellibranch with which it is at all likely to be confounded.

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

## Family PHOLADELLIDÆ, Miller.

### Genus RHYTIMYA, Ulrich.

*Orthodesma*, WHITFIELD, 1878. Jour. Cin. Soc. Nat. Hist., vol. i, p. 139; MILLER, 1881, idem., vol. iv, p. 76. (Not *Orthodesma*, HALL and WHITFIELD, 1875, Pal. Ohio, vol. ii, p. 93.)

? *Sedgwickia*, WHITFIELD, 1878. Jour. Cin. Soc. Nat. Hist., vol. i, p. 140. (Not *Sedgwickia*, MCCOY 1844, Synop. Carb. Foss. Ireland, p. 61.)

Shell elongate, moderately ventricose, the dorsal and ventral margins subparallel, gaping slightly at one or both ends. Beaks rather prominent, situated from one-third to one-fifth of the entire length behind the anterior extremity; posterior umbonal ridge rounded, never very prominent; mesial sulcus wide, generally very shallow, often however causing a sinuosity in the ventral margin. Lunule very narrow, true escutcheon wanting, ligament external, attached to the edges of the valves, extending the greater part of the hinge line posterior to the beaks. Hinge apparently edentulous, test very thin. Muscular and pallial attachments exceedingly faint, not satisfactorily observed; posterior scar large. Surface marked with unequal concentric lines and furrows, gathered into a series of strong folds on the anterior end. On the posterior half or more, the ventral part especially, the concentric lines are crossed by closely arranged radiating series of small granules or spines.

Type: *Rhytimya producta* n. sp.

This genus is placed with much confidence into the same family as Hall's two Devonian genera *Pholadella* and *Cimitaria* and the Carboniferous genus *Allorisma*, King. It is with the latter, however, that the implied relationship is easiest established. The general expression of the shells is not much unlike in the two genera, and in both the surface is grano-lineate and concentrically plicated; but here we find one of the peculiarities of the Lower Silurian genus. In the latter, namely, the folds are, when not entirely restricted to the anterior end, at any rate always the strongest there, while in *Allorisma* they are strongest in the umbonal and central parts of the valves. The hinge and the muscular impressions also, in the absence of any knowledge to the contrary, are believed to be very nearly the same in the two genera. The principal difference probably is the absence of a lanceolate escutcheon in *Rhytimya*. A well defined escutcheon is developed also in *Pholadella* and *Cimitaria* and these genera are further distinguished from *Rhytimya* by their large umbones.

In having the concentric surface markings strongest on the anterior end, these shells agree with *Sedgwickia*, McCoy, founded upon Carboniferous species. But after a careful comparison with the figures and descriptions of the species which McCoy himself placed under that genus, I am quite convinced that the Lower Silurian types are not congeneric with the Carboniferous forms. There would be equally good reasons for including them in the same author's genus *Sanguinolites*.

With the exception of *R. sinuata*, which is from the middle Galena of Minnesota and next described, the genus is known only from the rocks of the Cincinnati group. The total number of species known is nine. Of these six are new and three have been described and referred to other genera, namely, S. A. Miller described one under the name of *Orthodesma byrnesi*, and Whitfield two under the names of *Orthodesma mickleboroughi* and *Sedgwickia lunulata*.* The original of the last species has a well developed lunule and is much shorter than any of the other species. But it is evident that the specimen has been much distorted by pressure. Descriptions and figures of all the Cincinnati species except *R. lunulata* are to be published in vol. vii of the reports of the Geological Survey of Ohio.

### Rhytimya sinuata, *n. sp.*

PLATE XXXVI, FIGS. 46 and 47.

Shell rather small, about 25 mm. long, 12 mm. high at the beaks, and 11.2 mm. across the posterior end, with the thickness very nearly equalling the hight. Cardinal outline declining anterior to the beaks, slightly sinuate posterior to them;

* A recent examination of Billings' originaltypes of Canadian Lower Silurian Lamellibranchas proves that his *Cyrtodonta emma*, from the Hudson River rocks of Anticosti, is really a species of *Rhytimya*. It is closely related to *R. sinuata* and *R. producta*.

ventral margin broadly sinuate in the middle, gently convex on each side of the center; posterior margin very slightly oblique, strongly rounded; anterior end subrectangular, most prominent about the middle of the hight, the upper half nearly a straight slope to the beaks, the lower rounding backwards into the base. Beaks strongly incurved, situated almost a third of the entire length from the anterior extremity; umbones large and prominent, constricted by the mesial sulcus which crosses the valves and produces the sinus in the basal line. From the strongly convex posterior umbonal ridge the surface descends abruptly to the cardinal margin. Lunule larger than usual, of moderate depth and definition. Surface markings obscure on the cardinal slope of the cast studied, on the umbones and flanks, consisting of somewhat irregular, shallow, concentric furrows and fine striæ. On the anterior end these markings are strengthened or gathered into about twelve strong folds, terminating at the margin of the lunule, and increasing regularly with the growth of the shell. In having a large lunule, comparatively long anterior end, and unusually prominent umbones, this species approaches *R. lunulata* Whitfield, sp., and reminds somewhat of *Pholadella*, Hall. The characters mentioned readily distinguish the form from all the other species now referred to *Rhytimya*. Of associated shells only *Cuneamya truncatula* has a concentrically furrowed surface but that species differs too widely in other respects to be confused with *R. sinuata*.

*Formation and locality* —Middle Galena near Wykoff, Minnesota.

## Family GRAMMYSIIDÆ, Hall.

### Genus CUNEAMYA, Hall and Whitfield.

*Cuneamya*, HALL and WHITFIELD, 1875. Pal. Ohio, vol. ii, p. 90.

Thin, fragile, closed, bivalve shells, with ventricose valves and strong, prominent incurved beaks, situated but little behind the anterior extremity; outline varying from subcircular to somewhat elongate subrhomboidal; cardinal line very nearly straight behind the beaks. Hinge linear, edentulous: valves probably held together at the hinge solely by an external ligament. Cardinal margin of valves inflected, forming a long escutcheon or false area posterior to the beaks; anteriorly a lunule, varying considerable in depth and shape, but always well defined, is situated beneath the beaks. Muscular and pallial impressions too faint to be determined with cercertainty. Surface marked by more or less distinct concentric plications or wrinkles, which are usually rather obscure on the cardinal and posterior slopes and always the most regular and distinct on the anterior side of the umbonal region. Occasionally the surface is nearly smooth. An undefined, broad and shallow mesial sulcus usually present.

Type: *Cuneamya miamiensis* Hall and Whitfield.

This genus is represented in my cabinet by no less than sixteen, mostly undescribed, Lower Silurian specific forms, all of which, saving the two about to be described, were found above the top of the Trenton at Cincinnati and other localities within a radius of forty miles from that city. Several of these species are represented by casts of the interior in as fine a state of preservation as could be desired, and yet in no case was it possible to reach any satisfactory conclusion respecting the character of the muscular and pallial impressions. Under the circumstances it is not unlikely that the claim of the authors of the genus that the pallial line is simple, may be nothing more than the expression of their opinion and not the record of an observed fact. In their description of the genus Hall and Whitfield state also that posterior to the external ligament "the margins of the valves overlap each other to the extent of the cardinal line." This may be true of the specimens studied by them but, except in several cases where it is evidently the result of accident or compression, it is certainly not true of any specimen seen by me that is sufficiently perfect to admit of judgment on the point. The statement, therefore, wants confirmation before it can be accepted as a fact. So far as my own observation is concerned, I am obliged to dissent from such a view, especially as regards *C. miamiensis* the type of the genus, of which several specimens that seem to have retained the valves in a perfectly normal relation, have the escutcheon divided equally by the straight contact margins of the valves.

As regards the external ligament, it is preserved by only two specimens seen by me. One of these belongs to *C. curta* Whitfield, the other to *C. coriformis* Miller. It is elongate (almost linear), occupies about one-third of the width of the escutcheon and extends from the beaks backward a little more than one-third of the length of the escutcheon. The same specimens preserve also something like a ligament over the margins of the valves in the lunule.

The affinities of the genus are almost certainly with *Grammysia* as that genus is defined by Hall in his great work on Devonian Lamellibranchiata (Pal. N. Y., vol. v, pt. i, pp. xxx and 358–384.) The principal difference between the genera as now recognized lies in the hinge, this being weak and edentulous in *Cuneamya* while it is stronger and presents one or two cardinal folds in at any rate the typical forms of *Grammysia*. Shells probably belonging to this genus have been referred to *Sedgwickia* and *Leptodomus*, but as it seems, upon very insufficient grounds, the types of those genera, as defined by McCoy in 1844, (Synopsis Carb. Foss. Ireland) being of a widely different nature. The new genus *Saffordia* is distinguished by its peculiar hinge, much smaller beaks, and strongly defined anterior muscular scar.

## Cuneamya truncatula, *n. sp.*

PLATE XXXVI, FIG. 39.

Shell of medium size, transversely somewhat elongate, the two ends of nearly equal hight, with broad, compressed, nearly terminal, prominent and incurved beaks; postero-cardinal region subalate, escutcheon less than half the length of the hinge. Cardinal and basal margins diverging slightly posteriorly; anterior end truncate, almost vertical, the upper two-thirds sharply inflected, forming a rather narrow, deep, and unusually long lunule, from whose lower end the outline slopes abruptly backwards into the basal line; the latter is gently convex in the posterior half, straight or very slightly sinuate in front of the middle, very obtusely angular in the anterior third, and straight again when it ascends from the antero-basal angle to the lower extremity of the lunule; posterior margin somewhat produced and strongly rounded in the lower half, and very obliquely subtruncate in the upper. Posterior umbonal ridge rather prominent, strongly rounded, not angular, curved and becoming almost obsolete in the posterior third of the shell; cardinal slope concave, very abrupt near the beaks; a narrow but distinct anterior umbonal ridge descends at right angles to the hinge line from the beak to the antero-basal angle; between it and the edge of the lunule a narrow sulcus; behind it a small well marked mesial sulcus out of which the surface rises more gradually to the summit of the posterior umbonal ridge. The most prominent point of the surface of the valves is situated on this ridge somewhat above the middle of the hight and about two-fifths of the length from the anterior extremity. Surface marked with nearly equal concentric undulations or ridges. These are strongest in the mesial sulcus, somewhat flattened yet distinct in the anterior sulcus, and nearly obsolete on the cardinal slope. Hinge and muscular impressions undetermined.

This species is closely related to *C. coriformis* described by Miller from the middle beds of the Cincinnati group of Ohio. So far as known *C. truncatula* never attains the size of mature examples of that species, while its posterior end is higher, the escutcheon much shorter, the basal outline more convex, and the anterior umbonal ridge narrower and much less prominent. In *C. coriformis* the point of greatest convexity is on the anterior ridge while it is on the posterior ridge in the Minnesota species. The surface markings also are coarser, and the mesial sulcus deeper in the former.

*Formation and locality.*—Middle Galena near Wykoff and Pleasant Grove, Minnesota.

### Cuneamya oblonga, *n. sp.*

PLATE XXXVI, FIGS. 40–41.

This species is very much like *C. truncatula*, differing from it chiefly in the following respects: The anterior end is more rounded, the lunule shorter and smaller, and the posterior end a trifle narrower and much less oblique, being almost vertical; the hinge line is longer, terminates posteriorly more abruptly and is nearly parallel with the basal margin. The posterior umbonal ridge is less narrowly rounded, the mesial sulcus about the same or slightly deeper, while the part of the shell in front of this sulcus, is practically without the anterior sulcus which is such a characteristic feature of *C. truncatula* and *C. coriformis*. This sulcus however is indicated by a slight flattening of the anterior slope. Finally, the surface corrugations are a grade finer. *C. miamiensis* H. and W., is similarly marked but has a different outline and much less distinct mesial sulcus. In the matter of outline *C. scapha* H. and W., another Ohio species, agrees more nearly, but in that species the lunule and escutcheon are both wider and longer, and the surface markings quite different from those of *C. oblonga.*

*Formation and locality.*—Galena limestone, Dixon, Illinois.

## Genus SPHENOLIUM, S. A. Miller.

*Sphenolium*, S. A. Miller, 1889. North Amer. Geol. and Pal. p. 513.

Shell of medium size and larger, thin, strongly ventricose, very inequilateral, elongate, occasionally with subparallel dorsal and ventral margins, but usually much the highest posteriorly. Beaks incurved; umbones prominent, large and full; umbonal ridge strongly rounded or subangular. No mesial depression or sulcus. Lunule present, usually small and sometimes not sharply defined; escutcheon practically wanting. Surface concentrically lined; occasionally also with radiating striæ. Ligament probably both internal and external. Hinge apparently edentulous; muscular scars very faint, not determined with certainty.

Type: *S. (Orthodesma) cuneiforme* S. A. Miller.

Too little is known of this genus to determine its affinities with any thing like certainty. So far as the known characters admit of judgment they indicate relations with the *Grammysiidæ* and the *Pholadellidæ.* Dr. Miller places the genus near *Orthodesma,* but in this he is undoubtedly in error.

The two Trenton species following are perhaps not strictly referable to *Sphenolium,* being too narrow posteriorly. In all other respects, however, they agree well enough with the more typical species of the Cincinnati rocks. Besides, I believe I have evidence to show that this disproportionate development of the posterior end was a gradual process, an undescribed species from the Utica horizon at Cincinnati being intermediate in this respect between the Trenton forms and those occurring in the middle and upper beds of the Cincinnati group.

### SPHENOLIUM PARALLELUM, *n. sp.*

PLATE XXXVI, FIGS. 42 and 43.

Shell elongate subovate, rather strongly convex, the thickness, hight and length respectively as one is to one and two and one-fourth. Dorsal margin straight, nearly parallel with the ventral, terminating posteriorly in an obtuse angle where it joins the obliquely rounded posterior margin; anterior end short, apparently narrowly rounded; basal line very gently convex; posterior end rather abruptly rounded in the lower half. Beaks prominent, full, incurved; umbonal ridge strongly convex, somewhat emphasized by a slight furrow immediately above it in the cardinal slope; another obscure furrow borders the dorsal edge. A small but well marked lunule in front of the beaks, and a narrow and rather illy defined channel behind them. Central and anterior parts of valves rather strongly convex. Surface marked concentrically with very fine striæ and a few more or less obscure undulations. The latter are more distinct and regular on the umbonal ridge than elsewhere.

The subparallel margins distinguish this species from the more typical forms of the species described by Miller from the Cincinnati rocks.

*Formation and locality.*—"Lower Blue" beds of the Trenton formation, Mineral Point, Wisconsin.

*Mus. Reg.* No. 8346.

### SPHENOLIUM STRIATUM, *n. sp.*

PLATE XXXVI, FIGS. 44 and 45.

The shape and general expression of this shell is almost exactly the same as in the preceding, *S. parallelum*, yet when critically compared certain differences are observed which render a separation necessary. The specimens are not very perfect casts of the interior and exterior, still they preserve traces of very fine radiating lines on the umbonal ridge and a few coarser ones on the cardinal slope which, if such had been present on *S. parallelum*, would undoubtedly show on the excellently preserved cast upon which that species is founded. The Galena specimens again present a number of small, regular and short concentric folds on the anterior end, but they are wanting on the sides and posterior end where the folds are rather distinct in the Lower Trenton species. In comparing the outlines a slight difference is to be detected in the postero-cardinal region where, instead of being subangular the margin is rounded in *S. striatum.* The four or five Cincinnati species known to me are all much higher posteriorly.

*Formation and locality.*—Middle Galena. Goodhue county, Minnesota. The exact locality is about thirteen miles south of Cannon Falls.

## Genus SAFFORDIA, n. gen.

Shell rather small, transversely subovate, moderately convex, equivalve, very inequilateral; back arcuate, beaks anterior, not large, curving obliquely inward and forward; umbonal ridge moderate; between the ridge and the dorsal edge a more or less distinct sulcus. A sharply defined lunule beneath the approximate beaks, while posterior to them there extends to the extremity of the hinge an equally distinct escutcheon. Hinge plate thin, arcuate, with one horizontal wedge-shaped cardinal tooth in the left valve which entered into a corresponding cavity in the under side of the hinge plate of the right valve immediately behind the beak. Posterior half of hinge consisting of a slender lateral tooth in the left valve and a corresponding furrow in the right. Anterior to the center an elongate depression for the reception of an internal ligament. Anterior muscular scar distinct, deep, subcircular, situated beneath the lunule; pallial line simple, submarginal, posterior scar undetermined. Test rather thick in the anterior part.

Type: *S. ventralis,* n. sp.

Beside the type, the Hudson River strata of Fillmore county, Minnesota, contain another species having the characters ascribed to this genus. This I published recently as a new species of *Cuneamya,* giving it the specific name *sulcodorsata.* It is a more elongate shell but otherwise closely related to *S. ventralis.* A third species, this one from the Galena, I described from casts of the interior as *Cypricardites ? modestus.*

The position of *Saffordia* seems to be near the Devonian *Grammysia,* the hinge being similar in the two genera, though not by any means identical. In *Grammysia* namely, as is shown in Hall's work on the Devonian Lamellibranchiata (Pal. New York, vol. v, part i, plate LVIII, fig. 6), there is no cardinal tooth in the left valve as in *Saffordia,* nor are the slender posterior lateral teeth represented. Another distinguishing feature of the latter, and one that is common to many Lower Silurian shells, is found in the greater depth of the anterior muscular scar. In the genus *Cuneamya* the hinge, aside from the escutcheon, is quite different, the test is very thin, and the muscular impressions exceedingly faint, while the back, instead of being arcuate, is concave behind the beaks, the latter being also tumid and much more prominent.

Named as a small compliment to the veteran geologist, Prof. J. M. Safford, State Geologist of Tennessee. Science is indebted to him for several most valuable works on the geology of his state, while personally I am under great obligations to him for assistance in the way of specimens and advice.

### SAFFORDIA VENTRALIS, *n. sp.*

PLATE XLI, FIGS. 34—41.

Shell transversely subovate, the hight and length very nearly as four is to five; beaks small, declining, situated at the anterior extremity of the distinctly arcuate dorsum, and projecting forward as far as the margin of the shell beneath it. Anterior margin distinctly concave in the middle, the lower part narrowly rounded; ventral margin rather strongly convex, posterior margin subtruncate, a little oblique, the upper half straight or slightly sinuate, the lower rounded. Surface of valves moderately convex, with a very inconspicuous umbonal ridge between which and the dorsal edge there is a shallow sulcus. Escutcheon well defined, extending the full length of the hinge, in a dorsal view very narrow between the beaks, wide at the middle, and narrowing again posteriorly. Lunule sharply defined, very deep, nearly twice as long as wide. Surface marked by subimbricating concentric growth lines. These are rather small but sharp and of nearly equal size for a short distance beneath the cardinal edge, and only a few of them seem to cross the umbonal ridge. Internal characters of hinge as shown in figures 37 and 41. Anterior muscular scar of medium size, subcircular, deep, showing very prominently on casts of the interior; pallial line and posterior muscular impression very faint.

This species is distinguished from *S. sulcodorsata* by its shorter form, terminal beaks, and more rounded ventral margin.

*Formation and locality.*—Upper beds of the Hudson River group near Spring Valley, Minnesota, and Iron Ridge, Wisconsin.

### SAFFORDIA SULCODORSATA *Ulrich.*

PLATE XLI, FIGS. 32 and 33.

*Cuneamya sulcodorsata* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 248.

Shell small, moderately convex, oblong-subquadrate, with the dorsal and ventral margins subparallel and gently convex, the posterior end truncate, very slightly produced and sharply rounded at the base, anterior end very short (long for the genus), narrowly rounded. Beaks subterminal, declining forward, strongly incurved, projecting forward rather than upward; umbonal ridge moderately prominent, not angular. Dorsal slope with a distinct expanding sulcus; ventral and anterior slopes gently and uniformly convex. Hinge line, posterior to the beaks, long, the edge inflected so as to form a well marked escutcheon. In front of and beneath the beaks a deep lunule. Surface marked with regular, concentric folds, obsolete on the cardinal slopes, and by two or three times more numerous fine striæ, which seem to, have extended over all parts of the surface.

This neat shell was at first described as a *Cuneamya*; but with the discovery of the closely allied *S. ventralis* it became evident at once that the species had been misplaced. Compared with the type species it is found to differ in its form, the dorsal and ventral margins being much less curved and the outline decidedly oblong instead of rather broadly oval. The umbonal ridge also is somewhat better defined and the anterior end of the shell projects beyond the beaks which is not the case in *S. ventralis*.

*Formation and locality.*—At the top of the Hudson River group, Spring Valley, Minnesota.

### SAFFORDIA MODESTA *Ulrich*.

PLATE XLI, FIGS. 29–31.

*Cypricardites? modestus* ULRICH, 1892. Amer. Geol., vol. x, p. 100.

Shell small, moderately ventricose, obliquely ovate in outline, known from casts of the interior only. In these the anterior end is very small, sharply rounded, abruptly depressed beneath the beaks, projecting very little beyond them, and almost entirely occupied by a subcircular muscular scar. Beaks small, only slightly incurved, appearing prominent. Umbonal ridge scarcely distinguishable, the cardinal slope faintly concave between it and another low ridge-like swelling that forms the back of the cast. Along the hinge line there is a narrow impressed area. The lunule, like the escutcheon, is proportionally narrower than in the other species. Shell thin; hinge plate narrow, apparently with the characters (as shown by recently obtained material) required by the genus.

As near as can be determined from casts of the interior only, this species would appear to occupy an intermediate position between *S. ventralis* and *S. sulcodorsata*, being longer than the first and shorter than the second.

*Formation and locality.*—Lower half of the Galena at Oshkosh, Wisconsin, and several localities in Goodhue and Fillmore counties, Minnesota.

## *Errata for the Chapter on Lamellibranchiata.*

PAGE.

477, 6th line from bottom, for *Chænodomus* read *Cymatonota.*

479, 3d line from bottom, for *Clidoporus* read *Clidophorus.*

479, 10th line from bottom, for usually read unusually.

479, 12th line from bottom, the variety referred to is described in vol. vii, Geol. Sur. Ohio, p. 629, as *Byssonychia vera* Ulrich.

482. Supply omitted letters S–B to ends of bottom line of cut.

485, 14th line from bottom, for *Ectenoptera*, Ulrich read *Opisthoptera*, Meek.

486. The family LYRODESMIDÆ should be restricted to the typical genus, and *Allodesma*, Ulrich, referred to the family CYCLOCONCHIDÆ (next page) while *Technophorus*, Miller, and *Ischyrina*, Billings, should follow as a distinct family, TECHNOPHORIDÆ. (See p. 608.)

504, 17th line from bottom, refer *M. truncata* Hall, to *Modiolodon* instead of *Eurymya.*

512, 9th to 14th line from bottom, *dele* remarks on *Modiolopsis truncata* Hall.

513, 5th line from bottom, for ACTINOMYA read WHITEAVESIA. It was learned too late to make the corrections in their proper places that the name *Actinomya* had been preoccupied by Mayer for a Cretaceous or Tertiary genus of shells. A new name is therefore necessary for the Silurian genus, and it gives me much pleasure to propose *Whiteavesia*, after Prof. J. F. Whiteaves, the successful paleontologist to the Geological Survey of Canada. The reader will please substitute the new name for the other in the following places: Page 485, 4th line from bottom; p. 501, 12th line from top; p. 504, 14th line from bottom; p. 505, several instances in second and third paragraphs; p. 506, 1st line from top; p. 513, 5th line from bottom; p. 514, several instances in third and fourth paragraphs; p. 515, 1st and 6th lines from top, and 4th and 5th lines from bottom; p. 516, 5th and 7th lines from top; p. 517, 7th and 17th lines from top; p. 518, 16th line from top; p. 524, 8th and 10th lines from bottom; and p. 531, 5th line from top.

520, 1st line from top, after ORTHODESMA CANALICULATUM add *n. sp.*

563, 19th line from top, for 5100 read 8626.

592, 19th line from bottom, for CTENDONTA read CTENODONTA.

593, 9th line from bottom, for *C. leveta* read *C. levata.*

## PLATE XXXV.

| | | Page. |
|---|---|---|
| Figs. 1 and 2. | AMBONYCHIA BELLISTRIATA Hall | 492 |
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| 2. | Anterior view of same, with the right valve supplied according to our idea of the species. Middle Galena, near Wykoff, Minnesota. | |
| Figs. 3 and 4. | AMBONYCHIA PLANISTRIATA Hall | 491 |
| | Left side and anterior views of a specimen preserving the two valves partly opened. "Lower Blue" limestone, Mineral Point, Wisconsin. | |
| Figs. 5 to 7. | AMBONYCHIA AFFINIS, n. sp. | 492 |
| 5 and 6. | Lateral and anterior views of a well preserved fragment of the cast of a left valve, showing very obscure concentric undulations, fine radiating striæ and the sharply defined subrostral lobe. Galena, Carroll county, Illinois. | |
| 7. | An illy preserved cast of a right valve from the middle Galena at Weisbach's dam, near Spring Valley, Minnesota Survey Museum Reg. No. 8342. | |
| Figs. 8 and 9. | AMBONYCHIA AMYGDALINA Hall | 493 |
| 8. | The cast of an imperfect left valve. The specimen has suffered from pressure, reducing its diagonal diameter so that the anterior side curves too uniformly into the base. | |
| 9. | Profile view, the right valve ideal Lower Galena, Goodhue county, Minnesota. | |
| Figs. 10 to 14. | CLIONYCHIA LAMELLOSA Hall | 494 |
| 10. | A small, but unusually well preserved cast of a left valve showing the impressions of the posterior adductor and pedal muscles, pallial line and ligamental area. This specimen is precisely like those which Hall named *A. attenuata*, but its less quadrate shape is evidently the result of pressure. Trenton limestone, Minneapolis, Minnesota. | |
| 11. | A left valve of the usual form from the "Lower Blue" limestone at Mineral Point, Wisconsin. | |
| 12. | Imperfect cast of a left valve preserving the muscular scars and a portion of the wide ligamental area. | |
| 13. | Anterior view of same, showing the impressions of the upper part of the margin, the form of the beaks and the pallial line running down from it. | |
| 14. | Cardinal view of same, showing scars of two small muscles (? pedal) behind the beak. One or both of these scars are present in all the *Ambonychiidæ*. Lower Trenton limestone, Beloit, Wisconsin. | |
| Figs. 15 and 16. | CLIONYCHIA NITIDA, n. sp. | 495 |
| | Lateral and anterior views of a right valve, showing the form of the species and the comparatively fine and regular concentric lines. Trenton limestone, Minneapolis, Minnesota. Survey Museum Reg. No. 5099. | |
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| | Lateral and anterior view of a nearly perfect right valve. Trenton limestone, Minneapolis, Minnesota. | |
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| Figs. 23 to 26. | BYSSONYCHIA INTERMEDIA Meek and Worthen | 499 |
| 23 and 24. | Anterior and lateral views of one of the original types of this species. Galena limestone. | |
| 25 and 26. | Cardinal and lateral views of a small but typical example from the middle Galena horizon, near Wykoff, Minnesota. | |
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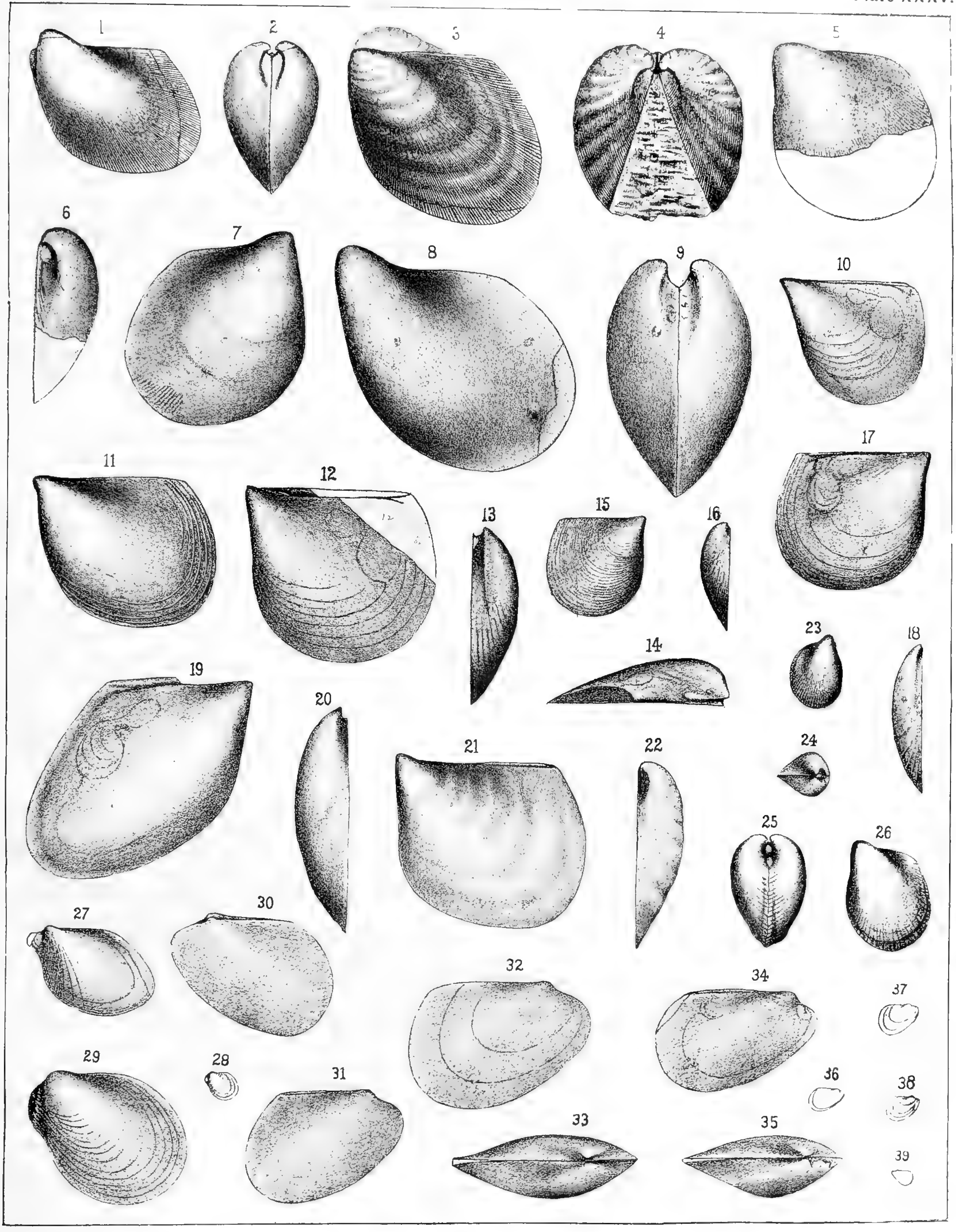
| Figs. 30 to 39. | ARISTERELLA NITIDULA, n. gen. et sp. | 524 |
| 30 and 31. | Left and right sides of an entire shell, × 4.5. | |
| 32 and 33. | Lateral and cardinal views of the largest specimen seen, × 4 5. | |
| 34 and 35. | Lateral and cardinal views of an internal cast, in which the hight is less and the inequality of the valves greater than usual, × 4.5. | |
| 36 to 38. | Natural size views of three shells. Middle third of the Trenton shales Chatfield, Minnesota. | |
| 39. | Outline view of a small left valve from the same horizon at St. Paul. In this shell the anterior end is unusually narrow. | |

{ Lamellibranchiata }

Plate XXXV.



## PLATE XXXVI.

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Figs. 1 and 2. MODIOLOPSIS SIMILIS Ulrich .................................................... 504

(See also plate XLII, fig. 19.)

Dorsal and anterior views of the original type of the species. Middle third of the Trenton shales, Minneapolis, Minnesota.

Figs. 3 to 6. MODIOLOPSIS ARGUTA, n. sp .................................................... 506

3 and 4. The right side and a dorsal view of a good cast of the interior. Middle third of the Trenton shales, near Fountain, Minnesota.

5 and 6. A smaller testiferous specimen, imperfect posteriorly, of the natural size and × 2. Chatfield, Minnesota.

Fig. 7. MODIOLOPSIS NANA, n. sp. .................................................... 507

Right side of a well preserved cast of the interior. Galena shales, Cannon Falls, Minnesota.

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Cast of a left valve. Middle Galena, near Wykoff, Minnesota.

Figs. 9 and 10. MODIOLOPSIS CHATFIELDENSIS, n. sp. .................................................... 508

Right side of a cast of the interior, of the natural size and × 2. Middle third of the Trenton shales, Chatfield, Minnesota.

Figs. 11 and 12. MODIOLOPSIS OBSOLETA, n. sp .................................................... 509

Testiferous left valve, of the natural size and × 2. Upper part of the middle third of the Trenton shales, Goodhue county, Minnesota.

Figs. 13 and 14. MODIOLOPSIS EXCELLENS, n. sp. .................................................... 511

13. Cast of the interior of a right valve. The specimen is a little imperfect in the anterior third. Geol. Survey Mus. Reg. No. 8374.

14. Well preserved fragment (anterior part) of a cast of the interior of a left valve. Survey Museum Reg. No. 8375. Hudson River group, Granger, Minnesota.

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15. The specimen described, a testiferous right valve, of the natural size.

16 and 16*a*. Lateral and dorsal views of same, × 2. Upper part of the middle third of the Trenton shales, Goodhue county, Minnesota.

Figs. 17 and 18. WHITEAVESIA SUBCARINATA, n. sp .................................................... 516

The right side and an antero-dorsal view of a cast of the interior, showing the form of the shell and obscure traces of radiating striæ on the posterior part. Middle Galena, Goodhue county, Minnesota.

Figs. 19 and 20. WHITEAVESIA MODIOLIFORMIS Meek and Worthen .................................................... 515

19. The left side of an internal cast, Beloit, Wisconsin. Survey Mus. Reg. No. 8341.

20. View of the original type of the species. In the drawing the base and the anterior end is restored and the right valve tilted, so as to give an exact dorsal profile. "Lower Blue" beds of the Trenton formation, Mineral Point, Wisconsin. Illinois State Museum.

Figs. 21 and 22. COLPOMYA DEMISSA, n. sp .................................................... 524

The nearly perfect shell upon which this species is founded; of the natural size and × 4.5. Middle third of the Trenton shales, Chatfield, Minnesota.

Figs. 23 and 24. ORTHODESMA SUBNASUTUM Meek and Worthen .................................................... 518

Lateral and dorsal views of an entire cast of this species. Galena limestone, Dixon, Illinois.

Figs. 25 and 26. ORTHODESMA SCHUCHERTI, n. sp .................................................... 518

Lateral and dorsal views of a cast of the interior, which is imperfect posteriorly, but in good condition otherwise. Middle Galena, Fillmore county, Minnesota. Survey Museum Reg. No. 8343.

Figs. 27 and 28. EURYMYA PLANA Hall, sp .................................................... 512

27. Interior of the left valve, as obtained in a gutta-percha impression of a cast of the interior.

28. Hinge and anterior muscular scar of the left valve, magnified nearly two diameters. Trenton limestone, Minneapolis, Minnesota.

Figs. 29 and 30. MATHERIA RUGOSA Ulrich .................................................... 563

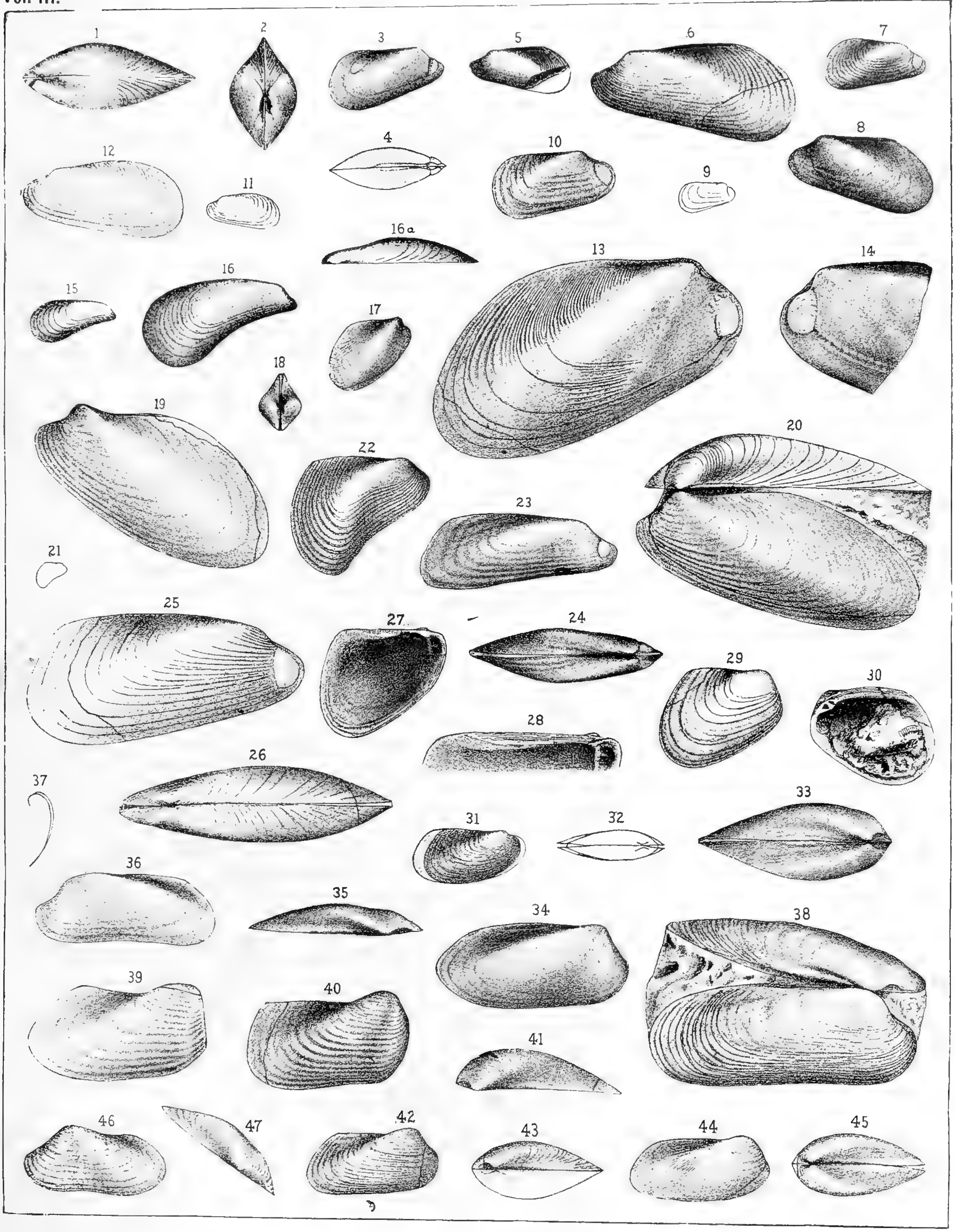
Views of the exterior and interior of a large right valve. Upper part of the middle third of the Trenton shales, Goodhue county, Minnesota.

[OVER.

## PLATE XXXVI.—*Continued.*

(Lamellibranchiata.)





## PLATE XXXVII.

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Figs. 1 and 2. ENDODESMA ORTHONOTUM Meek and Worthen, sp. .......... 527

Lateral and dorsal views of the original type of this species. The specimen is a good cast of the interior, in solid limestone, of a left valve. All of it is now exposed, the tough matrix, which covered a considerable portion of the ventral margin when it was used by Meek and Worthen, having been removed before it was redrawn for the present work. Lower Trenton limestone, Dunleith, Illinois.

Figs. 3 and 4. ENDODESMA GESNERI Billings, sp. .......... 528

Lateral and dorsal views of a good cast of the interior of a right valve. Trenton limestone, Ottawa, Canada. Introduced for comparison with the other species of this proposed genus.

Figs. 5 and 6. ENDODESMA POSTLATUM, n. sp .......... 527

Lateral and dorsal views of an internal cast. Upper Galena, Dubuque, Iowa. Geol. Survey Museum Reg. No. 8345.

Figs. 7 to 11. ORTHODESMA CANALICULATUM, n. sp. .......... 520

7 and 8. The right side and a dorsal view of a nearly entire cast. Waynesville, Ohio.

9. Well preserved but incomplete cast, showing the anterior end and obscure rays across the central half. Upper beds of the Cincinnati group, Waynesville, Ohio.

10. Posterior two-thirds of a cast from the Hudson River group near Spring Valley, Minnesota. The length of this specimen was reduced by pressure, and to this cause we must ascribe the more crowded arrangement of the radiating lines.

11. View of the broken end of same, showing the natural convexity of the valves and the cardinal depression.

Figs. 12 to 14. ORTHODESMA MINNESOTENSE Ulrich .......... 517

12. The left side of the type specimen.

13. Dorsal view of same.

14. Anterior part of a dorsal view, × 4. Middle third of the Trenton shales, Minneapolis, Minnesota.

Figs. 15 and 16. MODIOLOPSIS CONCENTRICA Hall and Whitfield .......... 510

15. Exterior of the shell as obtained from a gutta-percha impression of a natural mold.

16. Finely preserved cast of the interior. In offering these figures I wish it to be understood that the specimens selected are strictly normal for the species as it occurs in Ohio. Further, that the species is very constant, and that all marked deviations in contour which may be observed in a series of specimens are the result of distortion through pressure.

Figs. 17 to 19. VANUXEMIA SARDESONI Ulrich .......... 555

(See also plate XXXVIII, fig. 45.)

Lateral, anterior and cardinal views of the best cast seen. Trenton limestone, Minneapolis, Minnesota.

Figs. 20 to 24. MODIOLODON PATULUS, n. sp. .......... 521

20 to 22. The left side and anterior and dorsal views of a cast. Lower or middle Galena, Decorah, Iowa. Geol. Sur. Mus. Reg. No. 8363.

23. The left side of a cast of the interior from the Trenton at Danville, Kentucky.

24. A small specimen from the middle Galena of Goodhue county, Minnesota.

Figs. 25 to 28. CTENODONTA PLANODORSATA Ulrich .......... 589

(See also plate XLII, figs. 38 to 40.)

25. Posterior view of the original type.

26. Right valve of same, with a small part of the surface magnified.

27. Profile in a postero-basal view.

28. Cardinal view of same. Upper part of middle third of Trenton shales, Goodhue county, Minnesota.

Fig. 29. CTENODONTA COMPRESSA Ulrich .......... 600

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The original type of the species, × 1.3. Upper part of the middle third of the Trenton shales, Goodhue county, Minnesota.

Figs. 30 and 31. CTENODONTA LONGA Ulrich .......... 590

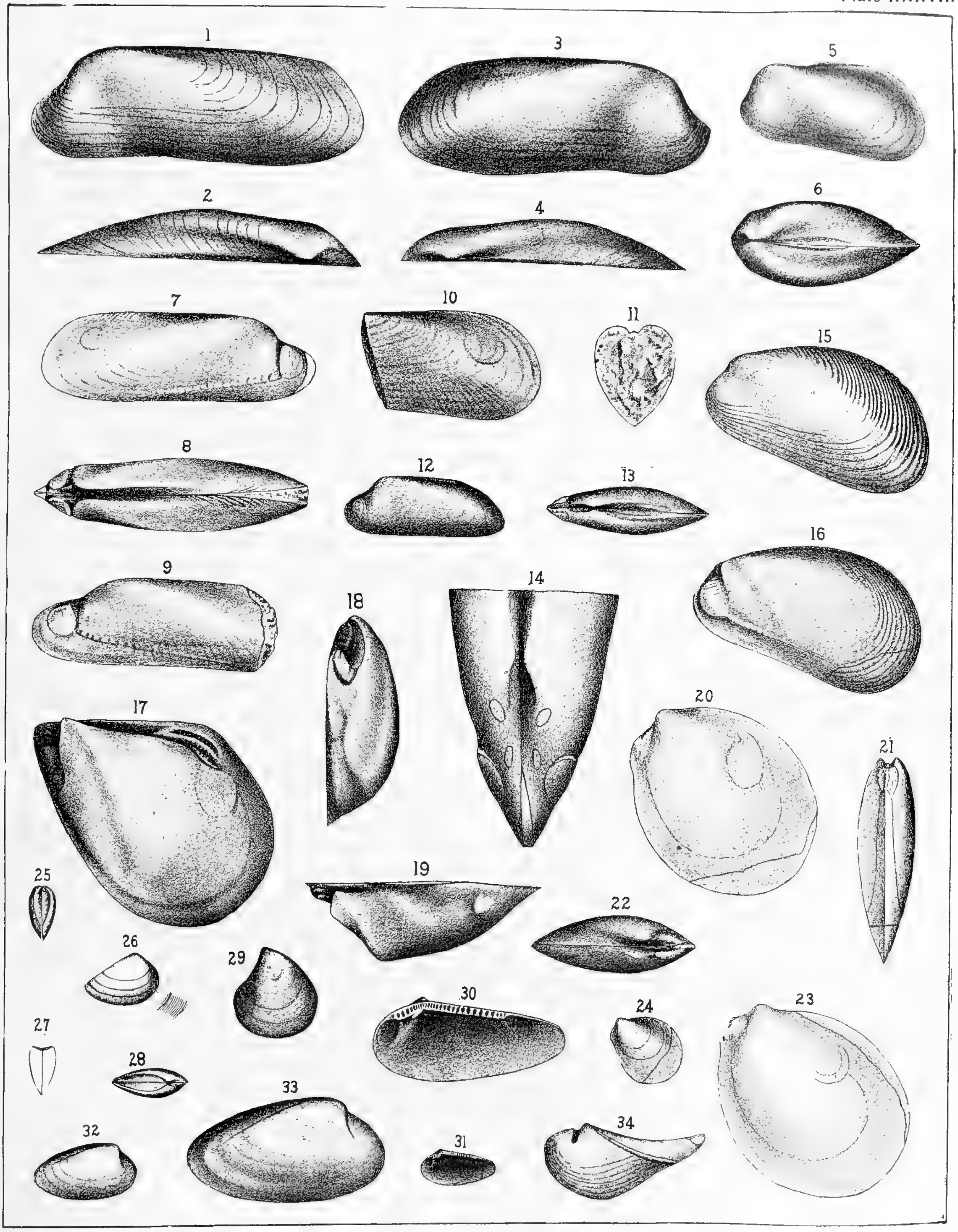
Interior of the right valve upon which this species was founded, magnified twice and of the natural size. Middle third of the Trenton shales, Goodhue county, Minnesota.

Figs. 32 and 33. CLIDOPHORUS ? CONSUETUS Ulrich .......... 606

The type specimen of the natural size and magnified twice. Middle Galena near Wykoff, Minnesota.

Fig. 34. TECHNOPHORUS EXTENUATUS Ulrich .......... 614

View of the left side of the cast of the interior upon which the species was founded. Middle third of the Trenton shales, Minneapolis, Minnesota.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# PLATE XXXVIII.

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Figs. 1 to 5. VANUXEMIA DIXONENSIS Meek and Worthen .................................. 550

1 to 3. Lateral, anterior and cardinal views of a large cast of the interior. In many specimens the anterior sulcus is deeper than in this one.

4. View of the interior of a right valve, as shown in a gutta-percha impression.

5. A small left valve which preserves a portion of the shell. Lower limestone of the Trenton formation, Minneapolis, Minnesota.

Figs. 6 and 7. VANUXEMIA DIXONENSIS, var. INSUETA, n. var .................................. 551

Anterior and lateral views of a perfect cast of the left valve. Trenton limestone, Minneapolis, Minnesota.

Figs. 8 to 14. VANUXEMIA ROTUNDATA Hall, sp .................................. 552

8. Perfect impression of the inner side of a rather large right valve. Geol. Sur. Mus. Reg. No. 8319.

9 and 10. Lateral and antero-cardinal views of an entire cast of the interior.

11 to 14. Respectively, posterior, anterior, dorsal and side views of the cast of the interior of a right valve of a small variety, differing from the usual form of the species in the more evenly rounded surface of the casts and greater incurving of the beaks. "Lower Blue" beds of the Trenton formation, Janesville, Wisconsin.

Figs. 15 to 19. VANUXEMIA OBTUSIFRONS Ulrich .................................. 554

15 to 17. Side, anterior and dorsal views of a good cast of the interior. Lower Trenton limestone, Minneapolis, Minnesota.

18 and 19. The hinge and an external view of a specimen retaining a large part of the shell. Dixon, Illinois.

Figs. 20 to 22. VANUXEMIA SUBERECTA, n. sp .................................. 553

Three views, dorsal, side and anterior, of a good, though rather small, cast of the interior. Trenton limestone, Beloit, Wisconsin. Geol. Sur. Mus. Reg. No. 8328.

Figs. 23 to 26. VANUXEMIA MEDIA, n. sp .................................. 553

23. An internal cast of a right valve. Trenton limestone, Minneapolis, Minnesota.

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A sharply defined impression of the inner side of a left valve. Middle third of the Trenton shales, Minneapolis, Minnesota.

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Four views of right valve of this species. 28, anterior; 29, the hinge; 30, cardinal; and 31, lateral. Middle third of the Trenton shales, Minneapolis, Minnesota.

Fig. 32. VANUXEMIA HAYNIANA Safford, sp .................................. 557

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A cast of the interior of a small right valve. Galena shales, Kenyon, Minnesota.

Figs. 33 and 34. VANUXEMIA TERMINALIS Ulrich .................................. 556

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34. Casts of left and right valves of this species. The former was found in the Trenton limestone at Minneapolis, and belongs to the collection of the Geological Survey, in which it bears the Mus. Reg. No. 5100. The latter is from the same horizon at Cannon Falls.

Fig. 35. VANUXEMIA NIOTA (? Hall) Whitfield, sp .................................. 560

The left side of an entire cast of a rather small example. The anterior margin seems to be more oblique than usual for this species. Trenton limestone (? "Upper Buff" beds), Rockton, Illinois. Geol. Sur. Mus. Reg. No. 8325.

Figs. 36 to 38. VANUXEMIA SUBROTUNDA, n. sp .................................. 559

36. The interior of an imperfect right valve.

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42. Cast of a large left valve that has suffered slightly from pressure, causing slight differences in the outline and the anterior side to be less abrupt than usual.

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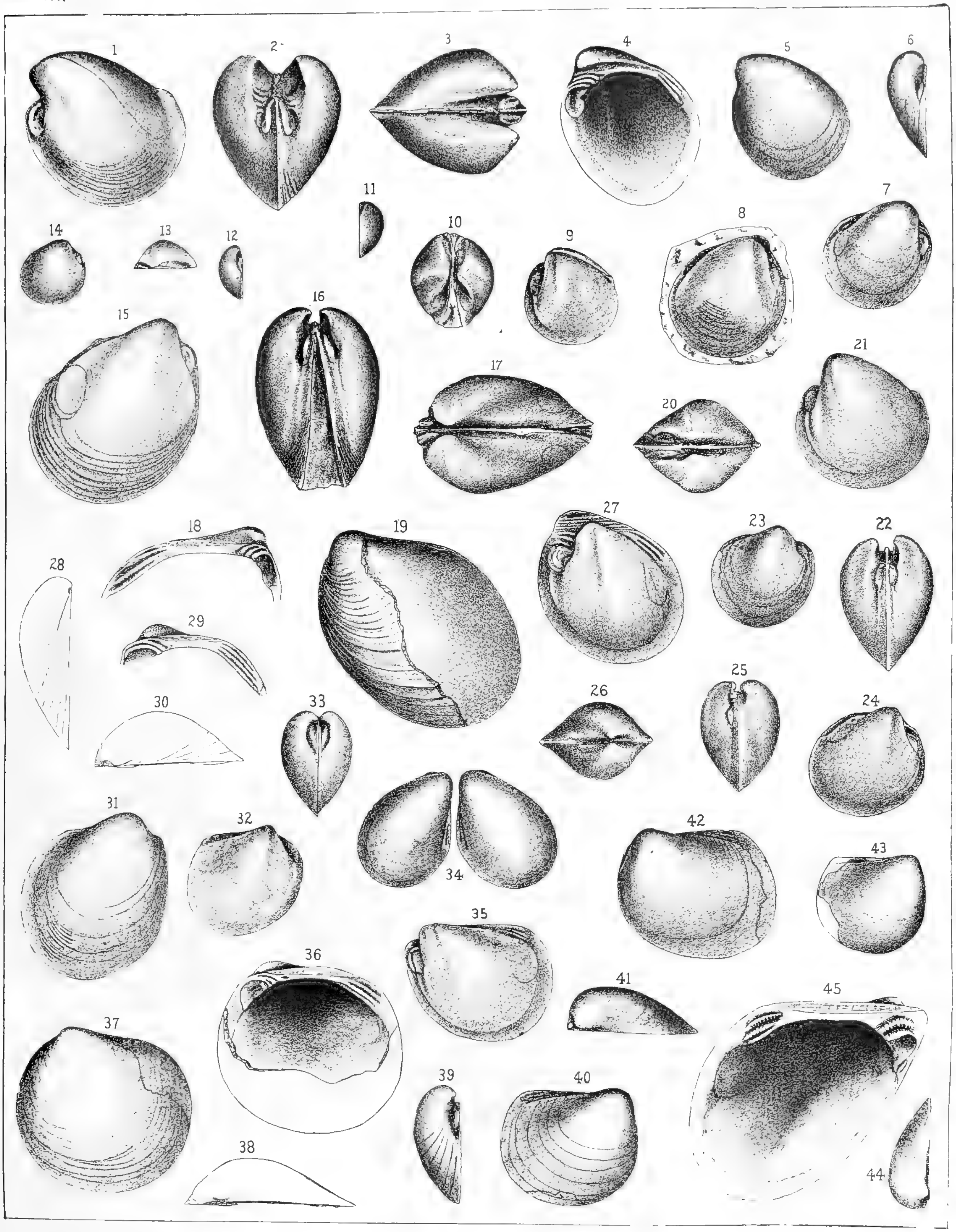
Fig. 45. VANUXEMIA SARDESONI Ulrich .................................. 555

(See also plate XXXVII, figs. 17—19.)

Interior of the left valve as brought out in a gutta-percha impression of the original type of the species.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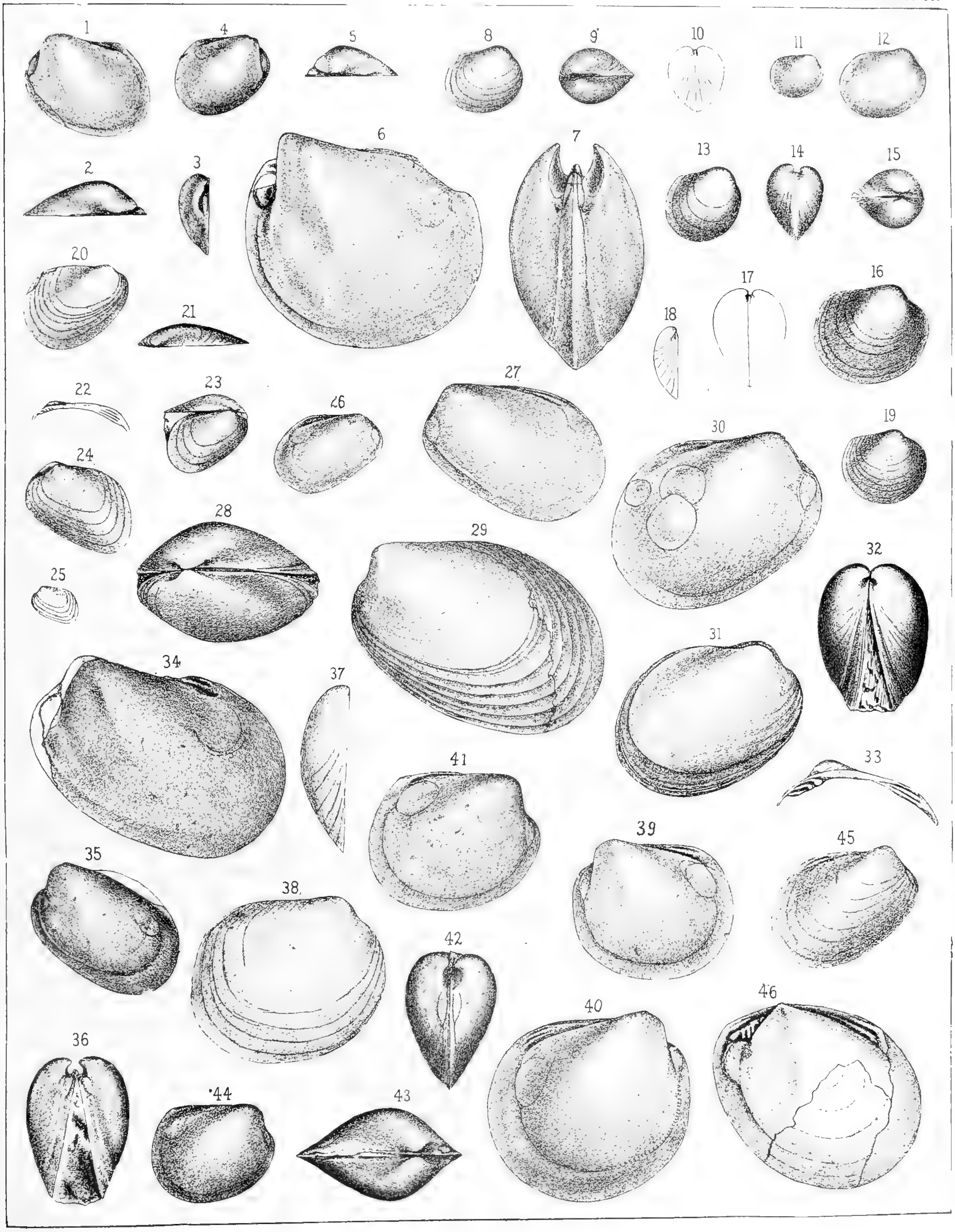
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(See also plate XXXIX, fig. 46.)
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Fgs. 2 to 6. CYRTODONTA BILLINGSI, n. sp .......... 538
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11. A small specimen (cast of a right valve) of the typical form. Middle Galena Wykoff, Minnesota.
12. Interior of the original type of *Cypricardites germanus* Ulrich. Upper Trenton near Danville, Kentucky.
13. Part of the interior of the var. *luculentus* Sardeson, as shown in a gutta-percha impression from a cast of the interior belonging to the Survey collection.
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Figs. 15 to 19. CRYRTODONTA TENELLA Ulrich .......... 546
15 and 16. Lateral and anterior views of a large right valve.
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18 and 19. Anterior and lateral views of another right valve, differing from the preceding in being more uniformly convex. Upper part of the middle third of the Trenton shales, Goodhue county, Minnesota.

Figs. 20 and 21. VANUXEMIA HAYNIANA Safford, sp. .......... 557
(See also plate XXXVIII, fig. 32, and text p. 479, fig, 36—IV.)
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Figs. 25 to 27. PLETHOCARDIA SUBERECTA Ulrich .......... 577
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31. A cast of a left valve from the upper beds of the Cincinnati group, near Blanchester, Ohio.
32. The interior of a left valve, showing the hinge with its cardinal teeth, escutcheon and posterior internal ligament supports, and faint muscular impressions. The outline is imperfect posteriorly, causing the shell to appear less oblique than it should be. Hudson River group, Spring Valley, Minnesota.

Figs. 33 and 34. TECHNOPHORUS SUBACUTUS Ulrich .......... 614
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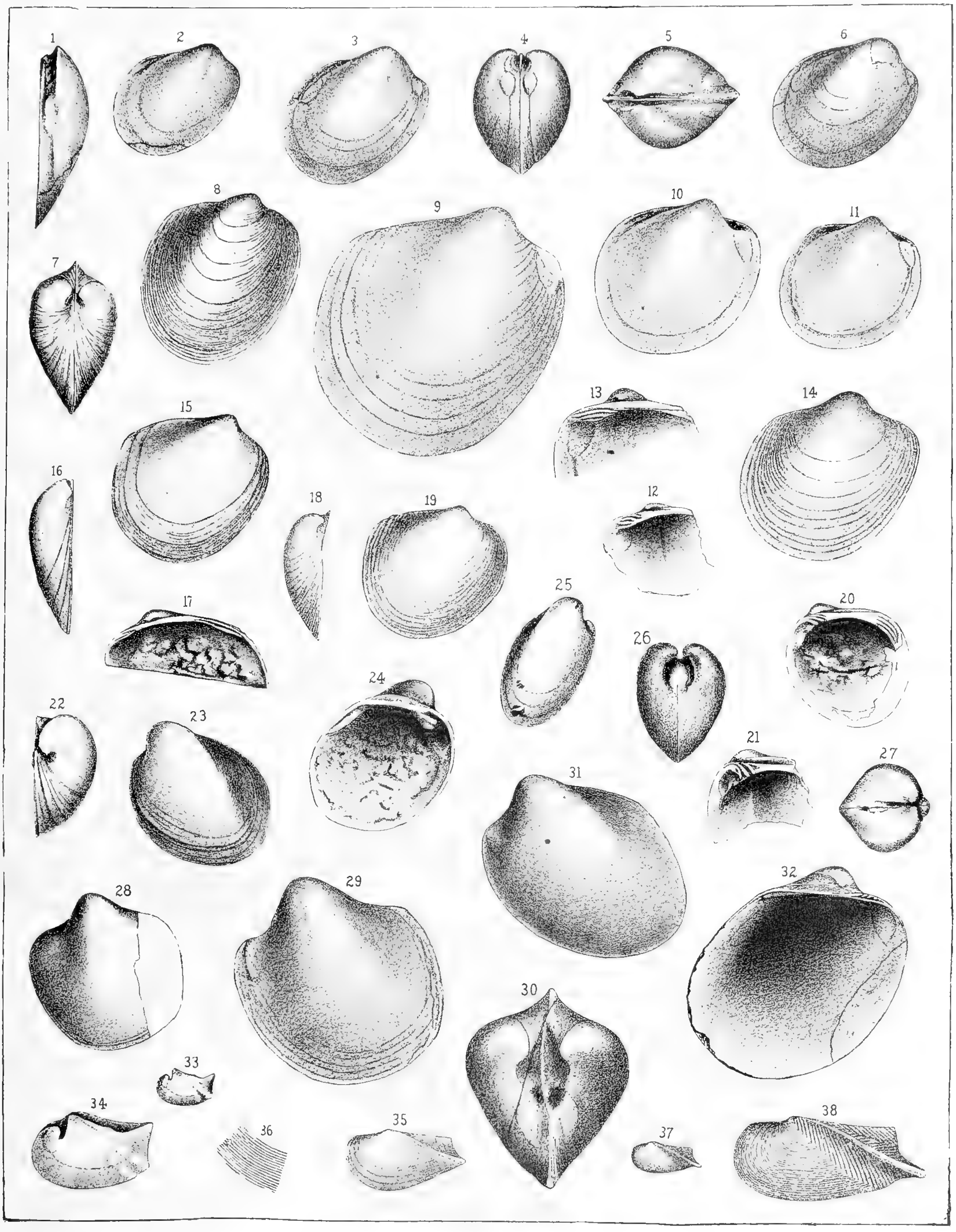
The type specimen, a perfect left valve, of the natural size and enlarged two and one-half times. Upper third of the Trenton shales, near Cannon Falls, Minnesota.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## PLATE XLI.

( Lamellibranchiata )

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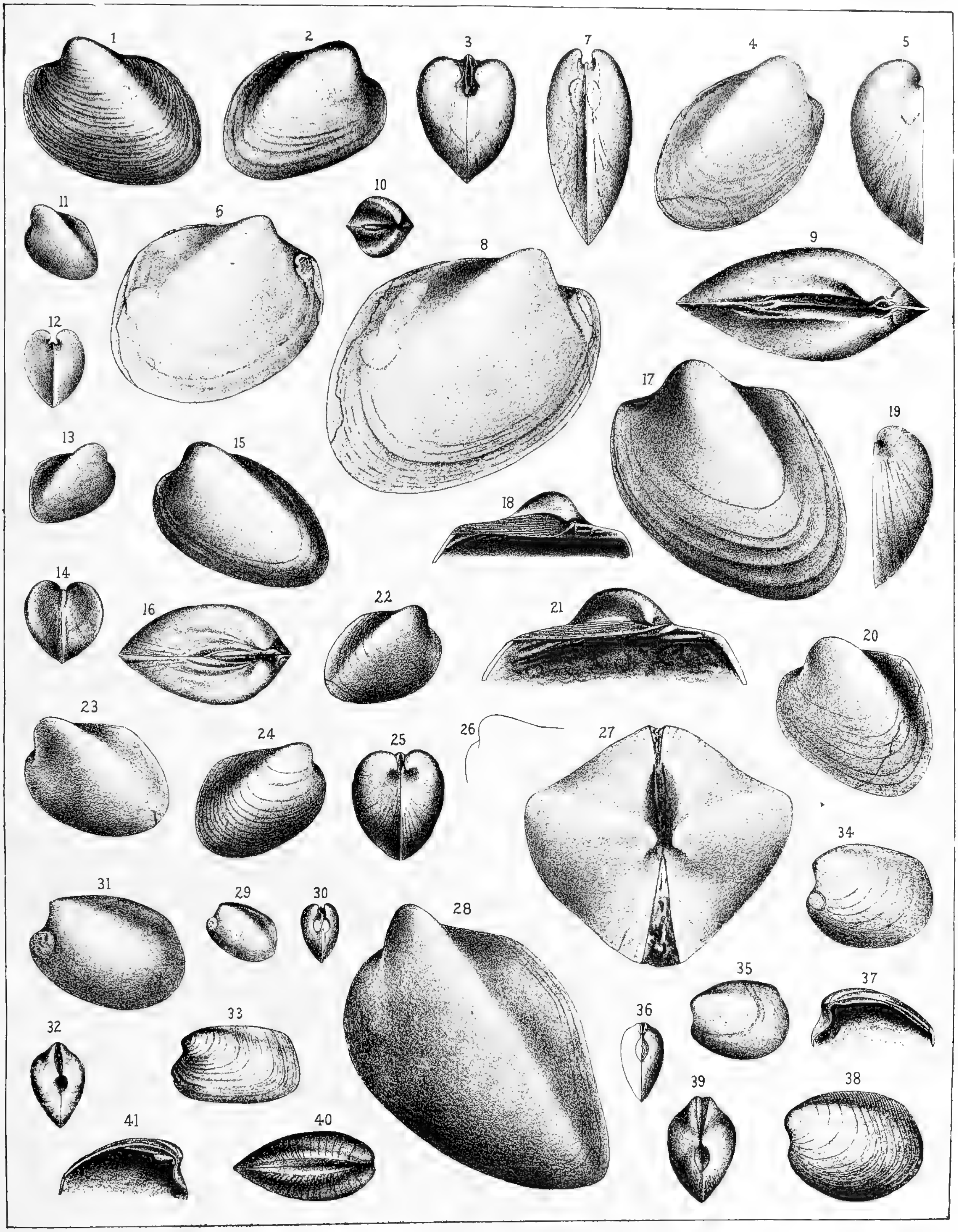
Plate XLI.



# PLATE XLII.

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Figs. 1 to 5. LYRODESMA ACUMINATUM, n. sp ........ 609
1 and 2. Lateral and cardinal views of a large right valve of the typical form.
3 and 4. Opposite views, the inner × 2, of a left valve of the var. *intermedia*
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Figs. 6 to 8. LYRODESMA CANNONENSE, n. sp ........ 910
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Figs. 15 and 16. MODIOLOPSIS OWENI, n. sp ........ 506
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Figs. 17 and 18. MODIOLOPSIS CONSIMILIS, n. sp ........ 505
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Fig. 19. MODIOLOPSIS SIMILIS Ulrich ........ 504
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Figs. 20 to 25. CLIDOPHORUS NEGLECTUS Hall ........ 607
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25. Very perfect cast of the interior of an unusually large right valve, showing, besides the usual characters, several obscure rays on the sides and a number of small umbonal scars. Minn. Geol. Sur. Mus. Reg. No. 7336.

Figs. 26 to 28. CTENODONTA LOGANI Salter ........ 591
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An excellent mold of the interior of a left valve.

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50. Silicified right valve of the species from the middle third of the Trenton shales.
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52. Cast of the interior from the Galena shales, provisionally referred to this species.

Figs. 53 to 58. CTENODONTA SCOFIELDI, n. sp ........ 593
53 to 56. The left side and posterior, anterior and dorsal views of a specimen preserving the shell and showing, among other characters of the species, the sharply angular umbonal ridge. Middle third of the Trenton shales, near Cannon Falls, Minnesota.
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58. The right side of a cast of the interior from the Galena shales, provisionally referred to this species. The anterior end is larger than in the typical form.

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Figs. 59 and 60. CTENODONTA SOCIALIS, n. sp. .......... 594
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Figs. 61 to 64. CTENODONTA CALVINI, n. sp. .......... 596
61. An excellent cast of the interior of a left valve, showing muscular scars and rays more plainly than usual. In this specimen the length also is a little greater than in the others.
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63 and 64. Lateral and cardinal views of a cast of a right valve, representing the usual characters of the species.

Figs. 65 and 66. CTENODONTA MADISONENSIS, n. sp. .......... 597
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Figs. 67 to 73. CTENODONTA FECUNDA Hall .......... 595
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Figs 91 and 92. CTENODONTA HAMBURGENSIS Walcott .......... 605
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Figs. 93 and 94. CTENODONTA ALTA Hall .......... 602
Lateral and posterior views of a cast of the interior.

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101. The greater part of a hinge of a left valve, × 2, showing the arrangement of the denticles, the sharply elevated outer margin and the ligamental area on the right side of the beak.

Figs. 102 to 106. CTENODONTA SIMILIS Ulrich .......... 604
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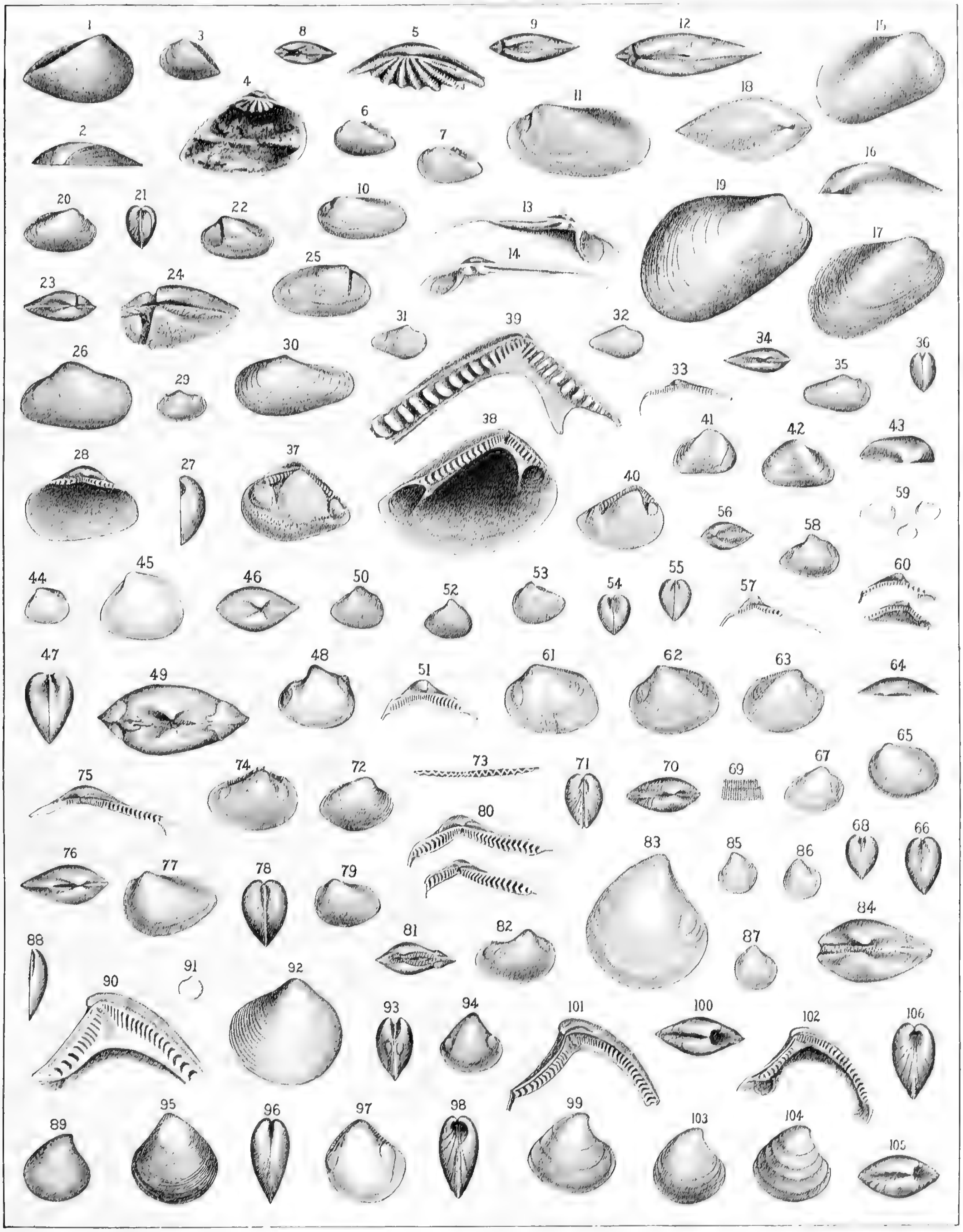
103. The left side of a specimen, showing the usual form of the species. Minn. Geol. Sur. Mus. Reg. No. 8368.
104 to 106. Lateral, cardinal and posterior views of a specimen having an outline very similar to that of *C. recurva*. But the absence of the anterior sulcus, the greater convexity of its valves and the less sharply defined lunettes are all characteristic of *C. similis* and prove its distinctness from *C. recurva*.

(Lamellibranchiata)





## PLATE XLIII.

Unless otherwise stated all the figures are magnified about twenty diameters.

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Figs. 1 to 3. LEPERDITELLA CANALIS, n. sp. .......... 637
Anterior lateral and ventral views of a left valve. Lower Trenton limestone, Minneapolis, Minnesota.

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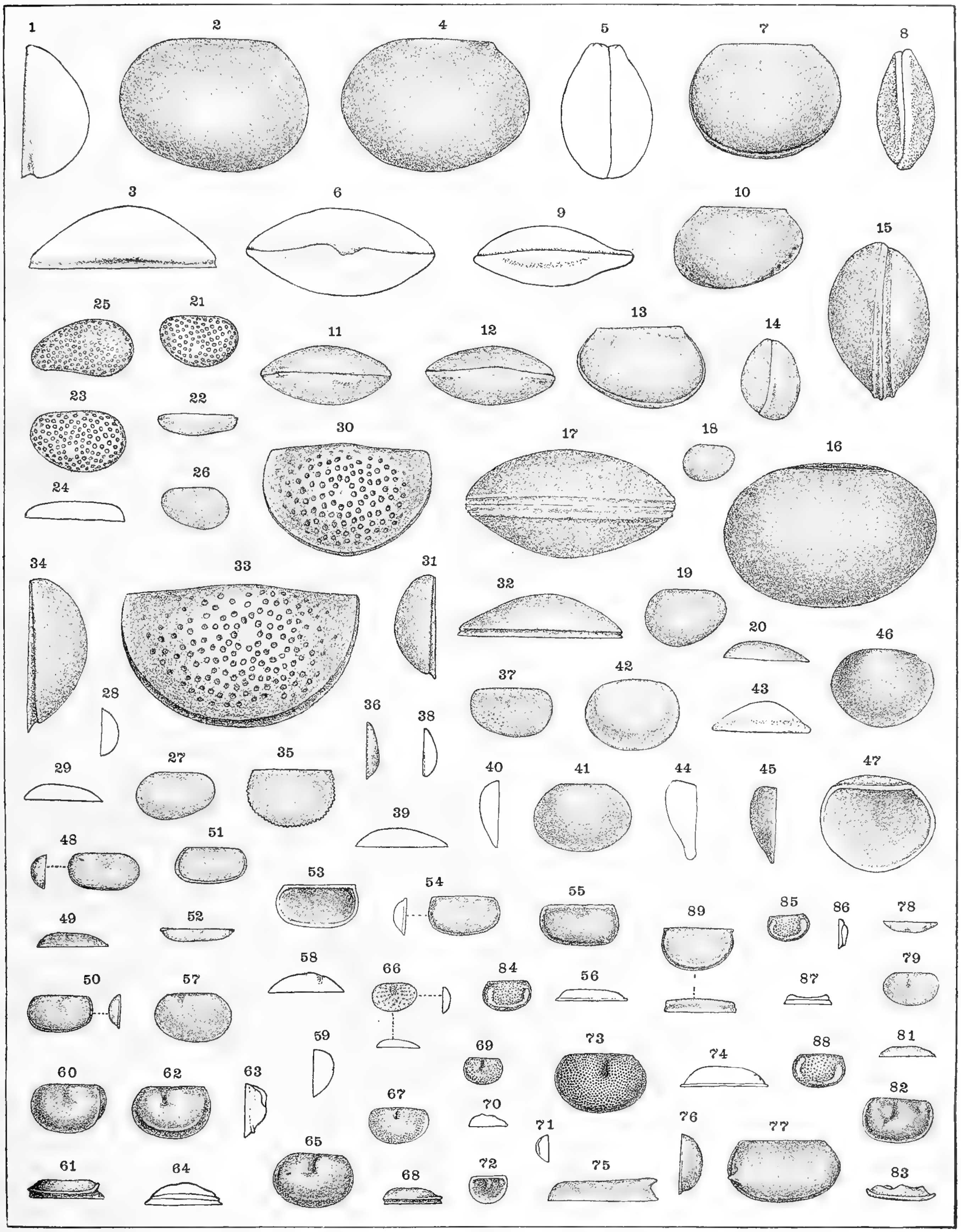
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All the figures on this plate are magnified about twenty diameters.

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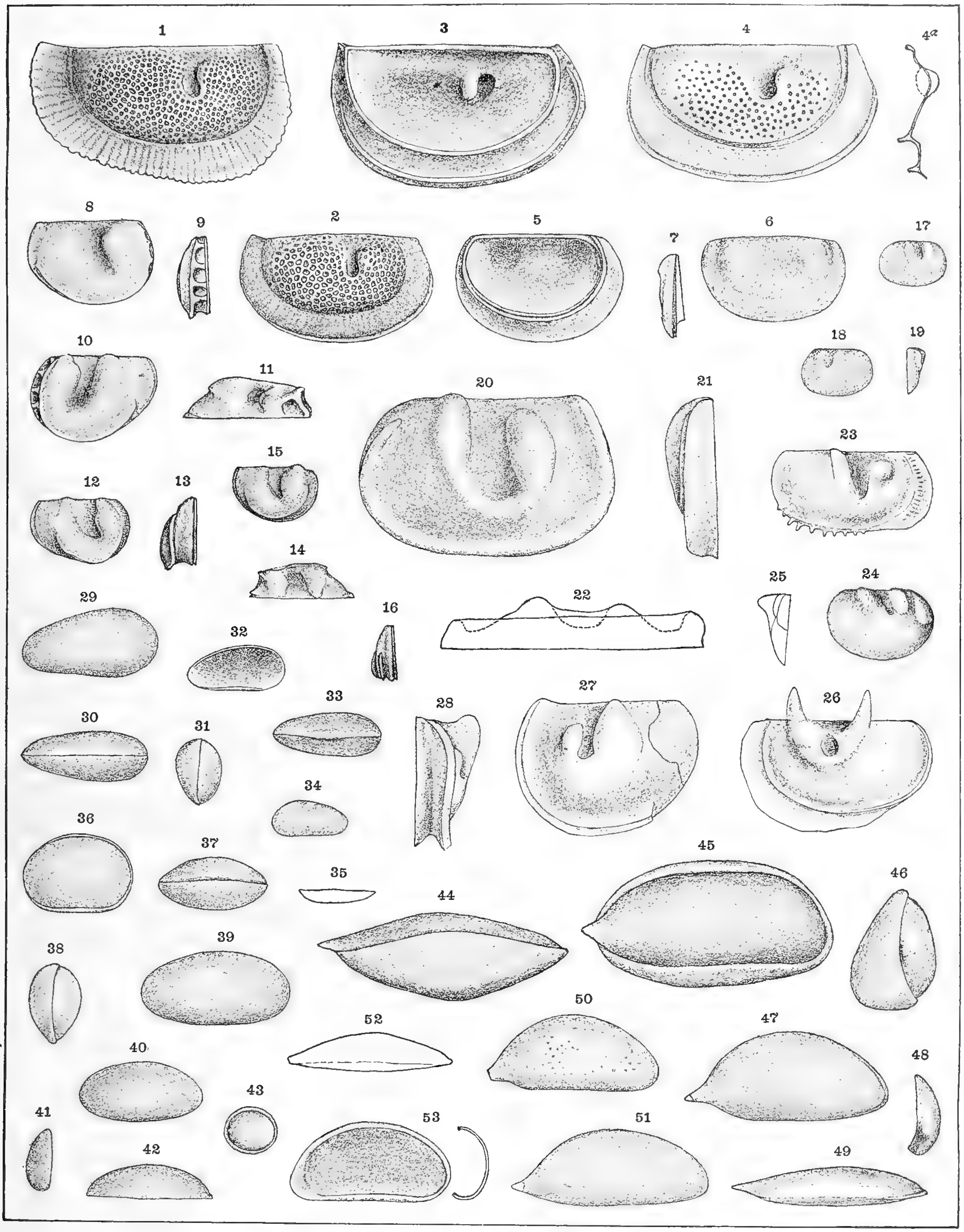
[Ostracoda]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## PLATE XLV.

Unless otherwise is stated, all the figures on this plate are magnified about twenty diameters.

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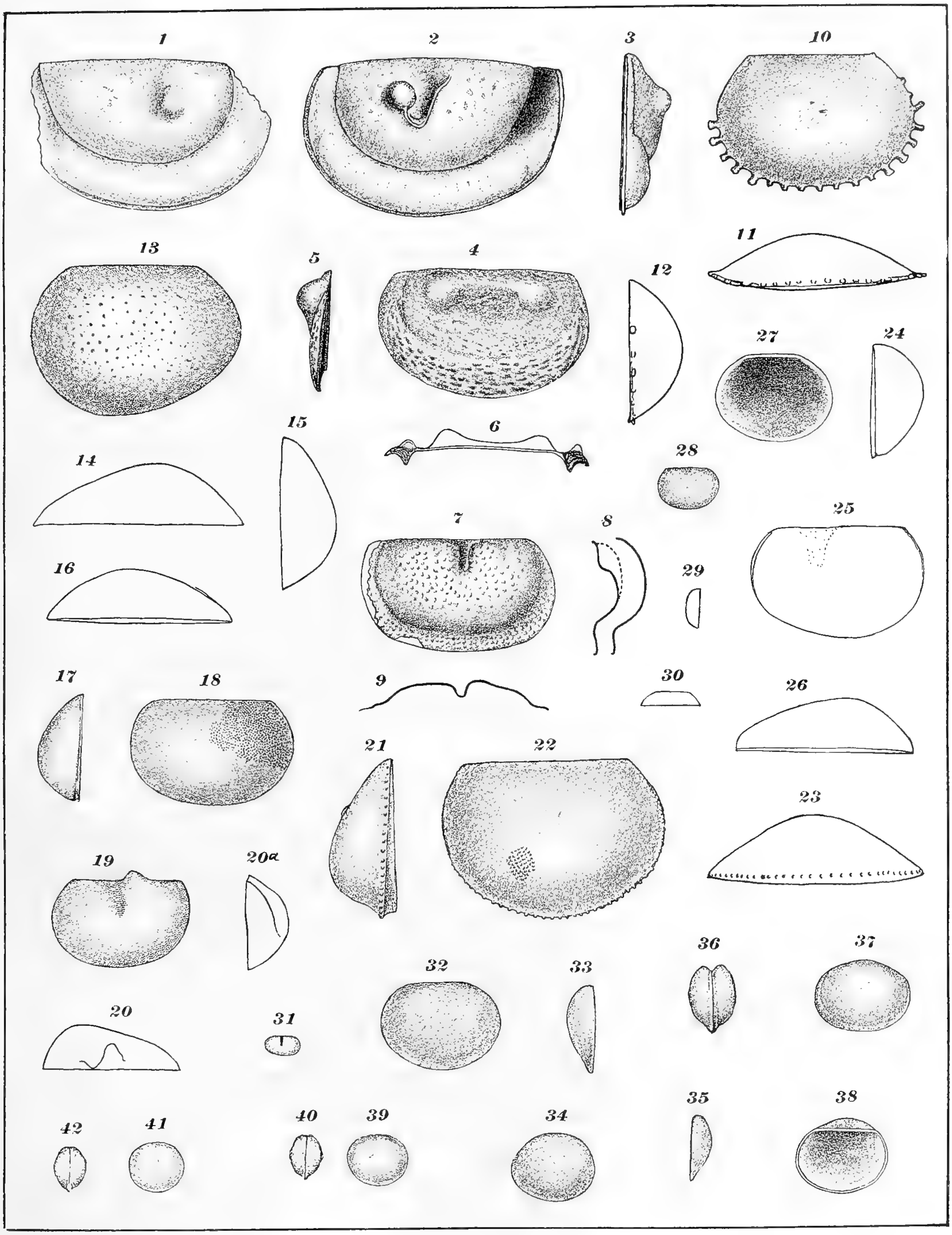
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# PLATE XLVI.

All the figures on this plate are magnified about twenty diameters.

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4. Another right valve. Birdseye limestone, High Bridge, Kentucky.

5. Inner side of a right valve. Minneapolis.

6 to 8. Three views of a left valve, differing from the usual form in unimportant particulars. Minneapolis.

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Figs. 15 and 16. MOOREA ANGULARIS, n. sp. .............................. 682

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Figs. 17 and 18. MOOREA (?) PERPLEXA, n. sp. .............................. 683

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29. Large and relatively high valve from the same position at Cannon Falls, Minn.

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Figs. 35 to 38. DREPANELLA BILATERALIS, n. sp. .............................. 671

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36 and 38. Ventral and posterior views of a left valve.

37. Interior of a right valve.

Upper third of the Trenton shales, St. Paul, Minnesota.

Figs. 39 and 40. DICRANELLA BICORNIS, n. gen. et. sp. .............................. 665

(See also plate XLIV, fig. 26.)

Side and posterior views of a nearly complete right valve. Middle third of the Trenton shales, Minneapolis, Minn.

Fig. 41. DICRANELLA SPINOSA, n. sp. .............................. 665

(See also plate XLIV, fig. 23.)

Posterior view of a left valve.

Fig. 42. DICRANELLA (?) SIMPLEX, n. sp. .............................. 666

Ventral view of the valve figured on plate XLIV, figs. 24 and 25.

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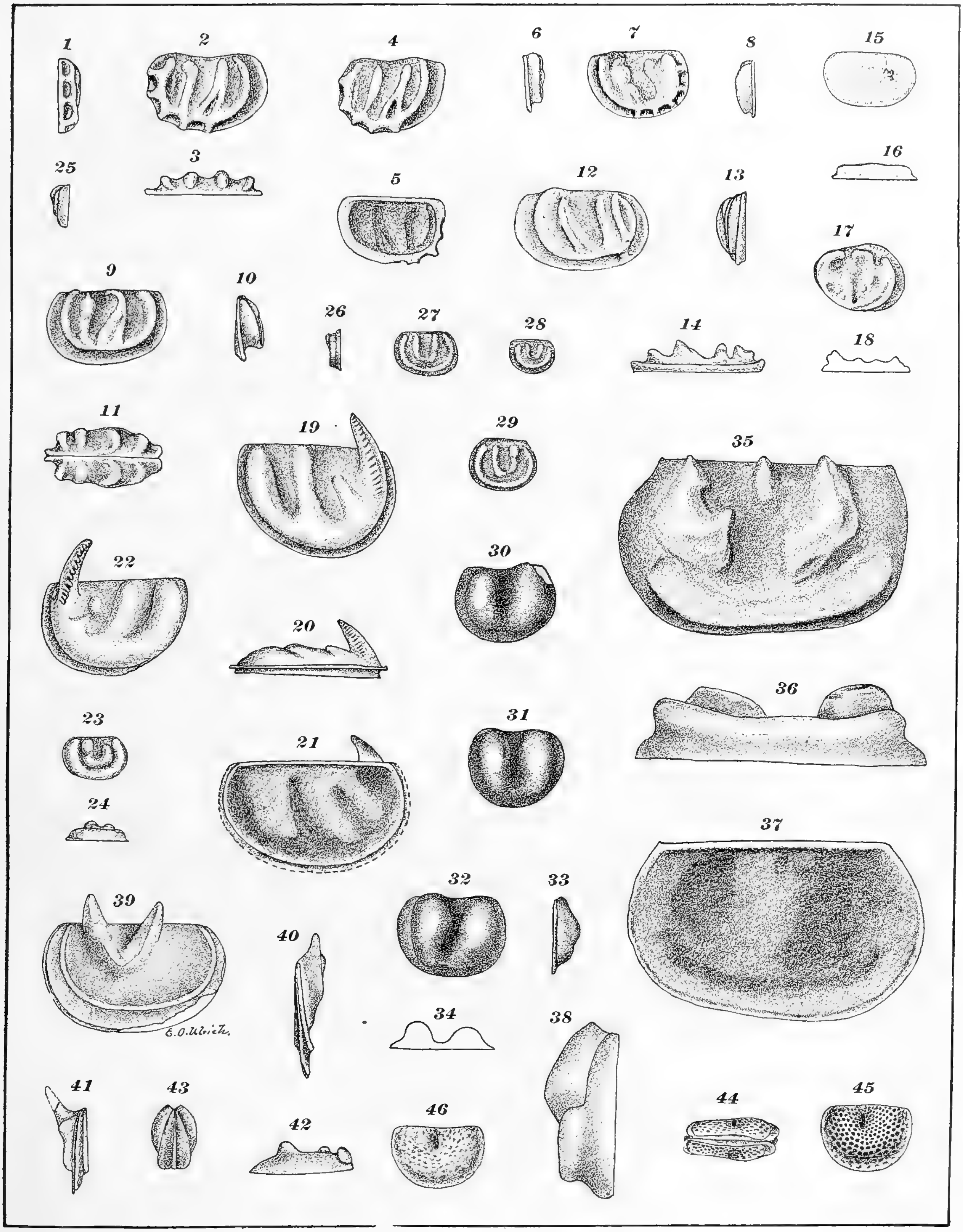
43 to 45. Anterior, dorsal, and left side views of an entire carapace. Galena shales near Cannon Falls, Minnesota.

46. Somewhat weathered and relatively longer left valve: from the same locality.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E.O. Ulrich.
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# CHAPTER VII.

# THE LOWER SILURIAN OSTRACODA OF MINNESOTA.

BY E. O. ULRICH.

This order of Crustacea comprises small, generally minute, animals having the entire body enclosed in a shell or carapace consisting of two more or less nearly equal calcareous or corneous valves, united along the back by a membrane, and capable of being opened at their ventral margins. The valves are closed by a sub-central adductor muscle, the attachment of which is marked on their inner sides by a tubercle, a pit or a number of small spots. The body is not segmented but has seven pairs of appendages, of which the first two are antennæ, while they, like the others, are also adapted for creeping and swimming. These appendages, together with the caudal extremity of the short abdomen, are protruded along the ventral margin of the carapace when the valves are opened.

Behind the first two pairs of appendages (antennules and antennæ), is a pair of mandibles, followed by a pair of maxillæ, while the third and fourth pairs may be either legs or jaws. Finally the last two pairs are leg-like and generally stronger than the preceding pairs. The extremity of the abdomen may be bifurcated or consist of a single spinous plate.

As a rule the eyes are well developed, with commonly a small median and two larger lateral ones present. The position of the latter is often indicated on the exterior of the valves by a small "eye tubercle." A distinct heart may be present or absent, but the alimentary and generative organs are well developed.

The Ostracoda, or "water-fleas" as they are often called, are represented by very numerous forms both in fresh water and in the sea. Of the families only the *Cypridæ* are chiefly fresh-water forms, while most of the other families are restricted to marine or brackish waters. Taken as a whole they are to be considered as shallow water inhabitants, and of social habits, being found in great numbers swimming near the surface of the water or creeping over the bottom. Remains of Ostracoda abound also in nearly all the geological formations, and in some cases so numerously that whole layers are almost composed of their shells. The fossil forms are furthermore of great variety, since, with perhaps a single exception, all the families which have been established for the recent forms have also been recognized in the fossil state, while many types occur in the paleozoic rocks that seemingly are now totally extinct.

With a single exception (*Palæocypris*), only the carapace valves are preserved in the fossil condition, and as these are often very similar in different genera and even families, it is evident that their study and classification is a matter of exceptional difficulty. To discriminate between these small fossils the paleontologist is obliged to rely on small differences in the shape, the relative size of the valves, the characters of the edges and of the hinge, the thickness of the valves, and the surface ornamentation. Among the paleozoic forms the valves are commonly lobed or sulcate and variations in these are usually counted important. A frequent difficulty is to distinguish between the anterior and posterior extremities. When not alike, the thickest end (it is generally also the highest) is considered as the posterior. It must be confessed, however, that this arbitrary determination can be accepted only as provisional. Some working rule like this is necessary until comparison of other details of structure will have furnished us with more reliable criteria upon which to base conclusions.

The carapace as stated consists of two calcareous or corneous valves of compact structure, commonly less than 4 mm. in length, though in a few cases the length exceeds 20 mm. The two valves may be equal (*Tetradella*, *Primitia*, etc.) or more or less unequal, with either the right or left overlapping the other at the ventral border only (*Leperditia*, *Leperditella*, etc.), or at the dorsal border as well (*Bythocypris* and *Krausella*), while in others the overlap is entire (*Cytherella*). The hinge or dorsal margin may be straight or arcuate, and, especially among the paleozoic types, is generally simple, though among more recent forms (*Cytheridæ*) hinge teeth and corresponding sockets are not uncommonly developed. The anterior and posterior margins may be broadly or narrowly rounded, pointed or drawn out beak-like; and when the back is straight the ends may join it angularly. The ventral margin is oftenest convex though it is not infrequently straight or gently concave. The sides of the valves in the majority of Ostracoda may be said to be approximately even in contour or convexity but in many cases, especially among paleozoic forms, they are indented and thrown into two or more tubercles, lobes or ridges. The surface of the valves may be smooth and polished or it may be granulose, pitted, reticulose, striated, hirsute or otherwise marked, the effect being in many instances quite ornamental. Finally many of the paleozoic Ostracoda of the family *Beyrichiidæ* have a wide, frill-like false border, which projects considerably beyond the true contact edges of the valves. The genus *Eurychilina* affords excellent examples of species with a "frill."

As regards the geological or time distribution of the Ostracoda, it is certain that they began in the upper divisions of the Taconic system, if indeed they are not to be reckoned among the earliest fossils known. In the Lower Silurian deposits already they occur in such great numbers and variety, that it is doubtful if the representations of the order at any subsequent time exceeded them in these respects. The predominant types, *Leperditiidæ* and *Beyrichiidæ,* moreover, while holding their own perhaps through the Upper Silurian, were greatly reduced during Devonian and Carboniferous times and are now totally extinct. Some recent families and genera on the other hand were sparingly represented, but taken as a whole the Silurian Ostracoda fauna is decidedly peculiar.*

In the Upper Silurian formations the *Leperditiidæ* and *Beyrichiidæ* still predominated, but the fauna here received decided accessions in the way of genera regarded as belonging to the family *Cypridæ.* The Devonian Ostracoda, though less numerous, are not very different from the Upper Silurian types, most of the old genera being more or less sparingly represented. Several genera (*e. g. Kyammodes,* Jones, and *Barychilina,* Ulrich) are so far to be considered as peculiar to this system of rocks. The Ostracoda fauna of the Carboniferous deposits, on the contrary, while retaining many small species of essentially Silurian genera like *Leperditia, Beyrichia* and *Primitia,* which occur associated with the related genera *Beyrichiella* and *Beyrichiopsis* and numerous forms of the previously established types of the *Cypridæ,* nevertheless assumed a distinctive aspect through the strong development of hitherto unknown types of *Cyprinidæ.*

In succeeding formations the Ostracoda are everywhere poorly represented in the Triassic and Jurassic. But in the Cretaceous and Tertiary strata of Europe certain genera, *Cythere* especially, develop an astounding variety and wealth of species. The forms are all small, and this may in part account for the fact that so few have been discovered in American deposits of these ages.

The recent genera having, or believed to have, paleozoic representatives, occur in the various formations as follows: *Cypridina, Bradycinetus* and *Philomedes,* in the Carboniferous; *Polycope,* Silurian and Carboniferous; *Cytherella* and *Cythere,* Silurian, Carboniferous and Permian; *Cythereis* and *Cytherideis,* Permian; *Bairdia,* Silurian, Devonian, Carboniferous and Permian; *Bythocypris,* Silurian, Devonian, Carboniferous; *Macrocypris,* Silurian and Carboniferous; *Pontocypris,* Silurian; and *Aglaia, Argillœcia* and *Candona,* in the Carboniferous.

*That the Silurian species which are now placed into recent genera actually belong there may well be questioned. In my opinion they do not, yet, as they cannot, with our limited opportunity for comparison, be distinguished, I am obliged to agree that the aims of classification are for the time being sufficiently satisfied.

## PROVISIONAL CLASSIFICATION OF THE PALEOZOIC OSTRACODA.

### Family LEPERDITIIDÆ.

GENERA: *Leperditia*, Rouault; *Leperditella*, Ulrich; *Isochilina*, Jones; *Aparchites*, Jones; *Schmidtella*, Ulrich; ? *Æchmina*, Jones.

### Family BEYRICHIIDÆ.

GENERA: *Beyrichia*, McCoy; *Beyrichiella*, Jones and Kirkby; *Beyrichiopsis*, Jones and Kirkby; *Klœdenia*, Jones and Holl; *Ulrichia*, Jones; *Primitia*, Jones and Holl; *Primitiopsis*, Jones; *Eurychilina*, Ulrich; *Dicranella*, Ulrich; *Halliella*, Ulrich; *Jonesella*, Ulrich; *Bollia*, Jones and Holl; *Ctenobolbina*, Ulrich; *Tetradella*, Ulrich; *Drepanella*, Ulrich; *Placentula*, Jones and Holl; *Kirkbya*, Jones; *Moorea*, Jones and Kirkby; *Strepula*, Jones and Holl; *Macronotella*, Ulrich; *Primitiella*, Ulrich; *Dilobella*, Ulrich.

### Family BARYCHILINIDÆ.

GENERA: *Barychilina*, Ulrich; *Kyammodes*, Jones.

### Family ENTOMIDÆ.

GENERA: *Entomis*, Jones; *Elpe*, Barrande; *Entomidella*, Jones; ? *Hippa*, Barrande.

### Family CYPRIDINIDÆ.

GENERA: *Cypridina*, Milne-Edwards; *Cypridinella*, Jones; *Cypridellina*, Jones; *Sulcuna*, Jones; *Cypridella*, DeKoninck; *Cyprella*, DeK.; *Bradycinetus*, Sars; *Philomedes*, Lilljeborg; *Rhombina*, J.; *Cyprosis* and *Cyprosina*, Jones.

### Family ENTOMOCONCHIDÆ.

GENERA: *Entomoconchus*, McCoy; *Offa*, Jones.

### Family POLYCOPIDÆ.

GENUS: *Polycope*, Sars.

### Family CYTHERELLIDÆ.

GENUS: *Cytherella*, Jones and Bosquet.

### Family CYTHERIDÆ.

GENERA: *Cythere*, Müller; *Bythocythere*, Sars; *Carbonia*, Jones; ? *Youngia*, Jones and Kirkby; *Xestoleberis*, Sars.

### Family THLIPSURIDÆ.

GENERA: *Thlipsura*, Jones and Holl; *Phreatura*, Jones and Kirkby; *Octonaria*, Jones.

### Family CYPRIDÆ.

GENERA: *Aglaia*, Brady; *Candona*, Baird; *Argillœcia*, Sars; *Macrocypris*, Brady; *Bythocypris* Brady; *Bairdia*, McCoy; *Pontocypris*, Sars; *Pachydomella*, Ulrich.

### Family BEECHERELLIDÆ.

GENERA: *Beecherella*, Ulrich; *Krausella*, Ulrich.

### Family DARWINULIDÆ.

GENUS: *Darwinula*, Jones (Brady and Robertson).

### NOT CLASSIFIED.

*Cytherellina*, Jones and Holl; *Bursulella* and *Bernix*, Jones; *Lepiditta*, *Lepidilla*, *Beyrichona* and *Hipponicharion*, Mathews; *Isoxys*, Walcott.

# Order OSTRACODA.

## Family LEPERDIITIDÆ.

### Genus LEPERDITIA, Ronault.

*Leperditia*, RONAULT, 1851, Bull. Soc. Geol., France, 2d Ser., vol. 8, p. 377; FR. SCHMIDT, 1873, Mem. Acad. Imp. Sci. St. Petersburg, vol. 21, No. 2; also 1883, *idem*, vol. 31, No. 5; JONES, 1881, Ann. Mag. Nat. Hist., 5th ser., vol. 8, p. 332; JONES and KIRKBY, 1887, Proc. Geol. Assoc., vol. 9, p. 503. Also JONES, 1856, 1858, 1884, 1890, 1891; KOLMODIN, 1869 and 1879; KRAUSE, 1877 and 1891; KIESOW, 1884; ZITTEL, 1885; MILLER, 1889; ULRICH, 1890 (not 1892). Previous to 1851 species were referred to *Cytherina*, *Cythere* and *Cypridina*.

Carapace more or less convex, often large, suboblong or semiovate in outline, with an oblique backward swing; dorsal edge straight, often angular at the extremities; ventral outline rounded, sometimes a little produced at the middle; greatest thickness in the ventral half, the lower edge usually being also blunt; valves unequal, the right the larger and overlapping the left; overlap chiefly ventral, simple, or the further entrance of the ventral edge of the left valve is prevented by two or more papillæ set within the overlapping edge of the right; hinge simple. Surface frequently horny in appearance, smooth in most cases, granulose or minutely punctate in others; a small tubercle or "eye-spot" is generally present on the antero-dorsal fourth, and a large, rounded subcentrally situated sunken muscle-spot is seen on the inner side of the valves and not infrequently distinguishable on the exterior also.

Type; *L. brittannica* Ronault.

An excellent account of this genus is given by Dr. Fr. Schmidt (*loc. cit.*) in his two papers on the "Russichen Silurichen Leperditien." According to that author and to Roemer, *L. grandis* Schrenck (*L. gigantea* Roemer) attained a length of 43 mm. This is the largest species of the genus and probably the largest known ostracode. In most of the species the length varies between 8 mm. and 25 mm., while in several other unquestionably congeneric forms the maximum length is less than 4 mm. Besides, a number of minute forms are referred here by Prof. Jones, myself and others, of which it is at least doubtful that they really belong to the genus. Because of their small size and chiefly perhaps because of the imperfection of the specimens, the ventral overlap of the right valve has not been established for them. Nor has the "eye-tubercle" and other peculiarities of the typical species been seen on them. For some at any rate *Aparchites* would offer a more natural reception. Finally, a number of comparatively small species (1.5 mm. to 3.0 mm.) which I have heretofore held as belonging to the genus, are now referred to a new genus on the ground that the free edges of their valves are different and the left instead of the right the larger.

Probably seventy-five good species of the genus are known, the greater number of which and all the larger forms, are restricted to the Lower and Upper Silurian deposits. The earliest forms occur in the Taconic, but it is not till we come to the Trenton that the species become numerous.* The Utica slate and Hudson River group species are nearly all small and of doubtful affinities. The same is true of the Devonian and Carboniferous forms, but in no wise of those which are inclosed in Upper Silurian strata, since in this age the genus seems to have attained its greatest development both in the way of size and species.

### LEPERDITIA FABULITES *Conrad.*

PLATE XLIII. FIGS. 10–14

*Cytherina fabulites* CONRAD, 1843, Proc. Acad. Nat. Sci. Phila., vol. i, p. 332.
*Leperditia fabulites* JONES, 1856, Ann. Mag. Nat. Hist., 2d ser., vol. xvii, p. 89; also 1881, *idem*, 5th ser., vol. viii, p. 342; also 1891, Contri. Can. Micro-Pal., pt. 3, p. 98; WHITFIELD, 1883, Rep. Geol. Sur. Wis., vol. i, p. 160; ULRICH, 1890, Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 173.
*Leperditia canadensis*, var. *josephiana* JONES, 1858, Ann. Mag. Nat. Hist., ser. 3, vol. i, p. 341; also 1858, Geol. Sur. Can., Dec. 3, p. 94.
*Leperditia fabulites* var. *josephiana* JONES, 1881, Ann. Mag. Nat. Hist., ser. 3, vol. viii, p 344.
*Leperditia josephiana* JONES, 1884, Ann. Mag. Nat. Hist., ser. 5, vol. xiv, p. 341.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SIZE.—1. | Beloit, Wis., | †(E. C.) | Length, | 12.4 mm.; | hight, | 7.9 mm.; | thickness, | 5.0 mm. |
| 2. | Minneapolis | (L. V.) | " | 14.0 " | " | 8.4 " | " | 3.0 " |
| 3. | " | (R. V.) | " | 11.7 " | " | 7.5 " | " | 3.0 " |
| 4. | " | (E. C.) | " | 11.5 " | " | 7.4 " | " | 5.0 " |
| 5. | Dixon, Ill. | (E. C.) | " | 12.2 " | " | 7.5 " | " | 5.5 " |
| 6. | Lavergne, Tenn. | (L. V.) | " | 13.2 " | " | 8.3 " | " | 3.1 " |
| 7. | Lebanon, Tenn. | (E. C.) | " | 10.0 " | " | 6.5 " | " | 4.7 " |
| 8. | " | (E. C.) | " | 7.5 " | " | 4.7 " | " | 3.2 " |
| 9. | " | (E. C.) | " | 8.2 " | " | 5.2 " | " | 3.8 " |
| 10. | " | (E. C.) | " | 7.0 " | " | 4.7 " | " | 3.3 " |
| 11. | " | (E. C.) | " | 8.0 " | " | 5.0 " | | |

Carapace of medium size, obliquely subovate, comparatively long, widest posteriorly; ventral curves moderate, strongest just behind the midlength; cardinal line straight, comparing with the length of the valve as 2 is to 3, the two extremities almost equally angular; hight of ends about as 3 is to 4, both obliqely truncate above, the anterior narrowly rounded in the middle; the posterior outline more broadly and evenly curved though having the usual backward swing. Ventral edge of carapace obtuse, scarcely flattened, with a slight furrow on each side near the edge of the

*Considering that the equivalent strata of Kentucky, Tennessee and Canada, contains no less than eleven species of *Leperditia*, it is a little remarkable that only one undoubted species of the genus has so far been discovered in the Trenton series of strata of the northwestern states.

†In giving the size of specimens, their condition is indicated by the abbreviations E. C., R. V., and L. V., signifying, respectively, entire carapace, right valve, and left valve. Where these initials are not used, it is to be understood that the dimensions are of an entire carapace.

right valve in which a row of minute punctæ is generally distinguishable; overlap extending all around the free edges, strongest ventrally; except in rare instances, neither valve has a flange or flattened border, and when present it is in all cases very narrow and undefined; dorsal edge somewhat thickened, especially upon the left side. Surface of valves smooth or very faintly pitted, rather evenly convex with the greatest thickness somewhat beneath the center; a low ridge-like thickening along the posterior half of the dorsal margin of the left valve is to be noticed. Eye tubercle just distinguishable in most cases, rarely so distinct as in the specimen figured, often not to be detected. On the inner surface however it is always marked by a distinct pit. Muscle spot not distinguishable externally except when the specimens are weathered, but on the inner side it is often well marked and surrounded by fine reticulating radial lines, short dorsally, longest post-ventrally. On the inner side of the ventral edge of the right valve there are two rows of small papillæ, three to five in each, the number seeming to increase with age. The purpose of these papillæ, one series of which occurs in the anterior third, the other in the posterior, evidently was to prevent undue overlapping of the valves by presenting an obstacle to the entering ventral edge of the left valve.

Of this species, I have before me no less than five hundred specimens, representing twelve localities in the states of Minnesota, Wisconsin, Illinois, Kentucky and Tennessee. Considering its wide geographical range and abundance, it is remarkably constant in all its characters. That it is so in its outer form is clearly enough shown by the above measurements, taken from representative examples. They show further that the northwestern specimens are on an average about one-third larger than those from Tennessee. In all other respects however they are all practically identical.

In 1890 (*loc. cit.*) I believed it probable that *L. josephiana* Jones, would prove distinct from *L. fabulites*, but it is now quite evident to me, as it also has become to Prof. Jones, that there is no ground whatever for any distinction between them. Compared with other species, the Upper Silurian *L. hisingeri* Schmidt, is not far removed, and the variety *fabulina* from Lake Winnipegosis very similar indeed. Still as pointed out by Prof. Jones there are a number of minor differences between them, and these will no doubt be added to when the later form is fully known. Another closely related form is the *L. wiluiensis* Schmidt, from the Upper Silurian of Russia. Its hinge line is shorter and the antero-ventral curve somewhat fuller, but in other respects, even to the rows of punctæ along the ventral margin, the two species are much alike. *L. linneyi* Ulrich from the Upper Trenton of Kentucky is more obliquely produced posteriorly and has a shorter hinge line, a flatter ventral edge, distinct flanges, and better developed tubercle and muscle spot.

*Formation and locality.*—Lower Trenton or Birdseye limestone, Minneapolis, St. Paul and Cannon Falls, Minnesota; Mineral Point, Janesville and Beloit, Wisconsin; Rockton and Dixon, Illinois; High Bridge and Frankfort, Kentucky; Lebanon, Lavergne and Murfreesboro, Tennessee; also St. Joseph Island, Lake Huron, and Murray Bay, Canada. It is said to occur in a similar position also in New York.

## Genus LEPERDITELLA, n. gen.

*Leperditia* (part.) ULRICH, 1892, Amer. Geol., vol. x, pp. 263–268.

Carapace leperditoid, ovate or oblong, with a straight back; surface of valves without eye tubercle or distinguishable muscle spot, but a more or less obscure broad depression is generally present in the central part of the dorsal half; left valve a little larger than the other, the free edges of the latter fitting into a groove. Length 1 to 3 mm.

Type: *Leperditia inflata* Ulrich (not *L. inflata* Murchison sp.).

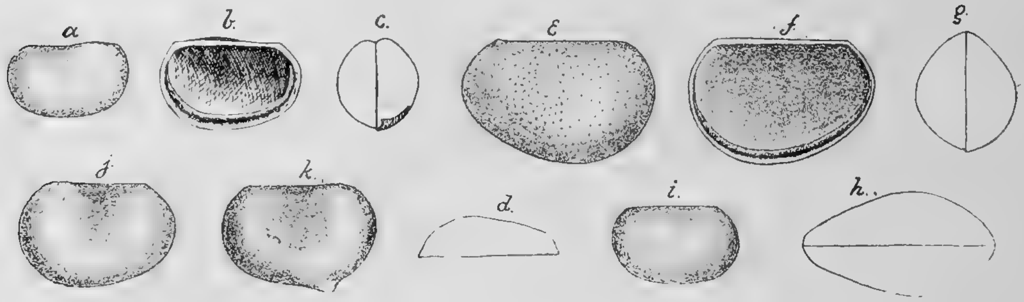


Fig. 46. *a*, small left valve of *Leperditella inflata* Ulrich; *b*, inner side of a larger valve of same, showing the marginal groove; *c*, vertical section in outline of entire carapace of same; *d*, dorsal outline of left valve of same; *e* and *f*, external and internal views of a left valve of *Leperditella mundula* Ulrich; *g* and *h*, outlines in anterior and ventral views of same; *i*, right side of an entire carapace of *Leperditella æquilatera* Ulrich; *j*, right valve of *Leperditella sulcata* Ulrich; *k*, left valve of *L. sulcata* var. *ventricornis* Ulrich. All the figures are magnified 10 diameters, and all the specimens from either the upper or the lower beds of the Birdseye limestone at High Bridge, Kentucky.

This genus is separated from typical Silurian *Leperditia* because the left instead of the right valve overlaps the other, and instead of a simple overlap the ventral edge of the right valve fits into a groove in the left. Furthermore, the eye tubercle and muscle spot of *Leperditia* are not distinguishable externally in *Leperditella.* In certain Carboniferous species of *Leperditia* (*L. carbonaria* Hall, *L. nicklesi* Ulrich and others) the overlap of the valves, though reversed, is very similar to that of the Lower Silurian species here brought together as *Leperditella.* Perhaps they also ought to be distinguished from *Leperditia.*

*Leperditella* embraces *L. tumida, L. mundula, L. æquilatera, L. inflata, L. germana, L. sulcata,* and var. *ventricornis* and *L. ? dorsicornis,* all described by me in the American Geologist for November, 1892, as species of *Leperditia.* To these I now add *L. canalis, L. persimilis* and *L. macra.* With the exception of *L. ? dorsicornis,* which is from the Hudson River group, all these species occur in strata equivalent to the Birdseye and Black River limestones of New York.

Prof. T. Rupert Jones recently described two species from Canada (Contri. Can. Micro-Pal., pt. 3, 1891), that may be congeneric with these species, viz.: *Leperditia ? obscura* and *Isochilina labellosa*, the latter appearing to be much like *L. tumida.*

### LEPERDITELLA CANALIS, *n. sp.*

PLATE XLIII. FIGS. 1—3.

SIZE.—Length, 1.78 mm.; hight, 1.22 mm.; thickness (L. V.) 0.59 mm.

Carapace ovate, widest posteriorly, tumid, the point of greatest thickness but little behind and beneath the center; anterior outline semicircular; dorsum straight, not angular in front, and quite obtuse behind, posterior margin somewhat obliquely rounded, scarcely truncated above; near the ventral edge of the left valve a distinct channel or groove, deepest centrally, has suggested the name. Surface smooth.

This species is closely related to *L. tumida* Ulrich, occupying a similar geological position in Kentucky and Tennessee, and of which a right valve is figured for comparison on plate 45, (figs. 13—15). The outline in that species however is not so regularly rounded in front, nor so full antero-ventrally, the greatest convexity is more posterior and scarcely so great, and the dorsal angles more distinct. But the feature particularly relied on in distinguishing the two species is the groove along the ventral border of the left valve in *L. canalis*, the Kentucky form being without this peculiarity.

*Formation and locality.*—Lower limestone of the Trenton formation, Minneapolis, Minnesota.

### LEPERDITELLA PERSIMILIS, *n. sp.*

PLATE XLIII. FIGS.4—6.

SIZE.—(E. C.) Length 1.75 mm.; hight 1.23 mm.; thickness 0.8 mm.

Carapace ovate, moderately convex, with the ends nearly equal; no dorsal angle behind but a well marked one in front; ventral overlap distinct; dorsal edge thick, shoulder like; greatest thickness central; suface smooth. The length varies between 1.5 mm. and 2.5 mm.

At first sight this species looks very much like *L. canalis*, but carefully compared they prove quite distinct. The outline is somewhat different being less wide (high) posteriorly, the dorsal angles are reversed, and the dorsal edges much thicker, while the thickness of the carapace is less and the ventral groove, which marks the left valve in that species, wanting. Similar differences distinguish it from *L. tumida. Aparchites ellipticus* holds about the same size and is not very different in outline. Still as its valves do not overlap ventrally and as it has no dorsal angles and really is a very distinct species, there is probably not much danger of confusion between them.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis, Minnesota.

### LEPERDITELLA MACRA, *n. sp.*

PLATE XLIII, FIGS. 7–9.

SIZE.—(E. C.) Length 1.4 mm., hight 1.08 mm.; thickness 0.55 mm.

Carapace short, scarcely oblique, subovate; dorsal margin straight, four-fifths of entire length of carapace, angles distinct; ends subequal, rounding almost uniformly into the basal outline; carapace moderately convex except in the anterior third, which is strongly compressed, giving a very unusual ventral and dorsal profile; anterior edges thickened, ventral overlap strong; surface smooth.

This species is remarkable for its compressed anterior part, and for its short form, in neither of which features it is equalled by any leperditoid ostracode known to me.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis, Minnesota.

### LEPERDITELLA GERMANA *Ulrich.*

PLATE XLV, FIGS. 24–26.

*Leperditia germana* ULRICH, 1892, American Geologist, vol. x, p. 266.

SIZE.—(L. V.) Length 2.17 mm.; hight 1.4 mm.; thickness 0.67 mm.

Carapace subovate, ends nearly equal, the posterior somewhat the wider; back straight for about four-fifths of the entire length, dorsal angles well marked; ventral outline somewhat oblique, most prominent just behind the center; edges rather blunt, with a narrow groove or rim along the free margins of the left and perhaps of both valves. Surface with the greatest convexity in the posterior half, and a broad, undefined depression in front of the center of the dorsal slope.

This form is closely related to *L. mundula* and *L. inflata*, two species from the lower division of the Birdseye limestone in Kentucky. From the first it differs in having the ends more equal, the edges blunter, and the surface more convex in the dorsal half. The narrow marginal rim is wanting in that species, and instead of a simple dorsal depression, that form has a low elevation in the lower part of it. The second differs chiefly in the greater inflation of the posterior half of its dorsal region.

*Formation and locality.*—This species has so far been met with only in the Lower Blue limestone of the Trenton at Mineral Point, Wisconsin, and Dixon, Illinois, but we know of no reason why it should not occur also at Minneapolis and other localities in the state.

### Leperditella ? dorsicornis *Ulrich.*

PLATE XLV, FIGS. 19, 20 and 20*a*.

*Leperditia ? (Primitia) dorsicornis* Ulrich, 1892. American Geologist, vol. x, p. 267.

Size.—(L. V.) Length 1.72 mm.; hight 1.1 mm.; thickness 0.54 mm.

Valves subelliptical, slightly oblique, the ends subequal, the back straight nearly to the posterior extremity; the latter is generally convex and almost vertical in the upper two-thirds, while in the lower third the outline merges rapidly into the uniformly convex basal margin; anterior end uniformly curved. Surface much the highest in the posterior half, with a part prolonged dorsally into a short and obtusely pointed prominence that bends down close to the hinge line and projects somewhat beyond it. This prominence gives definition to the posterior side of a distinct sulcus extending almost half across the valve from the central part of the dorsal edge, and forward along the latter.

Though having a sulcus, and therefore agreeing in a general way with *Primitia*, I have chosen to arrange this species with *Leperditella* because it seems to represent merely an extreme development from such typical species of the genus as *L. inflata*, *L. germana* and *L. sulcata*. Specifically the present form is readily enough distinguished by the concentration of the dorsal prominence, and greater definition of the sulcus. The form which I called *Primitia glabra*,* and which occurs in the upper beds of the Cincinnati group in Ohio and Indiana, has a similar outline, but it is somewhat smaller and without the dorsal prominence. Still, I would not be surprised to find that it has overlapping valves as in *Leperditella*.

*Formation and locality.*—The type was found in the Hudson River shales at Savannah, Illinois. As equivalent strata occur near Wykoff and Spring Valley, Minnesota, it is quite likely that the species occurs also in this state.

## Genus SCHMIDTELLA Ulrich.

*Schmidtella*, Ulrich, 1892. American Geologist, vol. x, p. 269.

Carapace small (2 mm. or less in length), short, rounded or subovate, moderately convex, more or less inflated in the dorsal region, this part being the thickest and appearing generally (in an end view), as projecting shoulder-like over and out from the straight hinge line; right valve slightly larger than the left and overlapping it along the ventral margin. No eye tubercle nor sulcus, but a faint central pit and elevation occasionally present.

Type; *S. crassimarginata*, Ulrich.

* Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 134; 1890.

The species which I propose to arrange under this genus might have been placed with *Aparchites*, Jones, were it not that they have overlapping valves. Even without that difference it may be questioned if such an arrangement would have been strictly proper, since no true *Aparchites* is strongly developed or gibbous in the dorsal region. As a rule *Aparchites* is thickest beneath the middle of the valves. The same is true of *Leperditia*, a genus that will, I think, be admitted by all to be distinct from *Schmidtella*. Though still somewhat in doubt respecting the systematic position of the new genus, it seems well to place it provisionally between *Leperditia* and *Aparchites*.

Besides the six Trenton species about to be described, *Schmidtella* will include *Aparchites? obsoletus* and *A. oblongus* of the Upper Silurian rocks of Europe. I refer to the specimens so designated and identified by Dr. Krause* with two British species described by Jones and Holl under *Primitia* in 1865, and more recently (1889) referred to *Aparchites* by Prof. Jones. While I am inclined to question the identity of the British and German specimens, I can scarcely doubt that the latter at least are truly referable to *Schmidtella*.

### SCHMIDTELLA CRASSIMARGINATA *Ulrich.*

PLATE XLIII, FIGS. 42–44.

*Schmidtella crassimarginata*, ULRICH, 1892, Amer. Geol., vol. x, p. 269.

SIZE.—(R. V.) Length 1.80 mm.; hight 1.45 mm.; thickness 0.60† mm.

Valves broadly suboval, very slightly oblique, the dorsal outline more gently arcuate than elsewhere, ends nearly equal though the posterior margin is more curved, especially above, than the anterior, the latter often forming an obtuse angle where it joins the dorsal line; ventral outline uniformly curved, semielliptical; back flattened, slightly convex in a side view, raising very abruptly from and projecting slightly above the nearly straight hinge-line; point of greatest thickness just behind the center of the upper half; a rather conspicuous yet not sharply defined broad furrow around the ends and ventral margin, least distinct posteriorly, produces the thick border that has suggested the specific name. Specimens vary in length from 1.6 mm. to 2.0 mm.

The border is more distinct and wider, and the back more flattened than in any of the other species referred to the genus.

*Formation and locality.*—Lower Trenton limestone, Mineral Point, Wisconsin, and Dixon, Illinois. Its occurrence in this limestone at Minneapolis is not yet established with certainty.

*Zeitschr. d. Deutsch. geolog. Gesellschaft, 1891, p. 492.

†The dimensions given in the original description are too small, the magnification of the valve measured having been supposed to be 15 diameters when it was only about 10 diameters.

## Schmidtella affinis, *n. sp.*

PLATE XLIII, FIGS. 45–47.

Size.—(R. V.) Length 0.97 mm.; hight 0.72 mm.; thickness 0.22 mm.

The largest valve seen has a length of 1.08 mm. and a hight of 0.9 mm.

This species is closely related to *S. crassimarginata*, and at first I was inclined to view it as a later variety of that species. But, considering the great constancy which prevails among the hundreds of valves of *S. crassimarginata* which I have seen, and the equal constancy exhibited by *S. affinis*, it has been thought best to hold them as distinct. Besides I found it difficult to decide to which of the two, *S. crassimarginata* or *S. umbonata*, the present form bore the greater resemblance. Compared with the first of these species, *S. affinis* is smaller, a trifle higher, the flat dorsum narrower, the ends less equal, with the posterior extremity more strongly curved and the basal outline more prominent in the middle. In an end view the profile is less triangular and the ventral edge thinner. The most prominent point of the surface also is more posterior, while the broad border, which is so conspicuous a feature for *S. crassimarginata*, is scarcely developed. For comparison with *S. umbonata* and *S. incompta*, see following descriptions.

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

## Schmidtella umbonata, *n. sp.*

PLATE XLV, FIGS. 36–38.

| | | | |
|---|---|---|---|
| Size.—(L. V.) | Length 0.8 mm.; | hight 0.59 mm.; | thickness 0.23 mm. |
| (R. V.) | " 0.8 " | " 0.65 " | " 0.23 " |

Valves ovate, slightly oblique, ends subequal, dorsum umbonate, projecting considerably above the straight hinge line; free margin with a border, narrower and less distinct on the left valve than on the right; greatest convexity near the middle of the valves, the point occasionally marked by a very faint depression or discolored spot.

This abundant species is relatively longer than *S. affinis*, has more nearly equal ends, narrower and better defined border, and more uniformly convex valves. From the much larger *S. crassimarginata* it differs too obviously to require comparison. *S. subrotunda* may be closely related but is much shorter and almost round.

*Formation and locality.*—Upper third of the Trenton shales, St. Paul and Cannon Falls, Minnesota. A variety, or more likely a closely related species, occurs in great numbers on slabs of Birdseye limestone collected at High Bridge, Kentucky.

### SCHMIDTELLA INCOMPTA, *n. sp.*

PLATE XLIII, FIGS. 39–41. PLATE XLV, FIGS. 27, 32 and 33.

SIZE.—(R. V.) Length 1.1 mm.; hight 0.8 mm.; thickness 0.28 mm.
" " 0.9 " " 0.65 " " 0.18 " var. *subæqualis*.

Valves moderately convex, dorsal margin straight, about half as long as the valve; ends nearly or quite equal, ventral outline regularly curved; surface highest a little above and behind the center, the dorsal slope convex but not projecting beyond the hinge line, the ventral slope long, gentle and straight or faintly concave, the wide border being almost obsolete.

Of this species we have two varieties, one occurring in the lower part of the Trenton shales, the other in the upper part of the Galena shales. The earlier or typical form (plate XLV, figs. 27, 32 and 33), is a trifle more convex and blunter at the dorsal edge, slightly shorter and less equilateral than the other. That the Galena variety constantly developed these minute peculiarities is shown by about fifty valves. Should a subordinate name be desirable, it might be called var. *subæqualis*.

The dorsum is less tumid in this species than in any of the preceding. On the whole it may be considered as marking an approach toward *Aparchites*. Still, the prominence of the surface in the post-dorsal third, though not strong, indicates a relation to *S. affinis*. A species occurs in the Birdseye at High Bridge, Kentucky, that seems to be intermediate between this species and *S. umbonata*.

*Formation and locality.*—Typical form, lower part of the Trenton shales, Fountain, Minnesota; var. *subæqualis*, upper part of the Galena shales near Cannon Falls, Minnesota.

### SCHMIDTELLA BREVIS, *n. sp.*

PLATE XLV, FIGS. 34 and 35.

SIZE.—(L. V.) Length 0.8 mm.; hight 0.65 mm.; thickness 0.2 mm.

Valves short, subovate, the oval being formed by drawing out the anterior end; dorsum short, gently arcuate, and projecting slightly above the straight hinge line; border inconspicuous.

In most respects this species is much like its associate, *S. incompta*, but the valves are much shorter, the dorsal outline is not straight, and the anterior margin is more narrowly rounded. *Polycope sublenticularis* Jones, from the Anticosti group, has a similar outline, but seems to be uniformly convex which is not the case with the species under consideration.

*Formation and locality.*—Rare in the lower part of the Trenton shales near Fountain, Minnesota.

### SCHMIDTELLA SUBROTUNDA, *n. sp.*

PLATE XLV, FIGS. 39—42.

SIZE.—Length 0.5 mm.; hight 0.43 mm.; thickness 0.3 mm.

Valves small, short, rounded-ovate, rather uniformly convex, with an obscurely defined, narrow border around the ends and ventral margin; near the center a faint depression, and immediately behind it a small elevation.

The generic position of this small species is uncertain. It is placed under *Schmidtella* chiefly because it seems to be related to *S. umbonata*, though much shorter. Its outline is almost exactly as in the *Cytherella ? subrotunda* of this report, which was also found associated with it. Possibly they belong to one species. Still, as the type of the *Cytherella* has neither a central pit nor a border, I am for the present obliged to regard them as distinct.

*Formation and locality*:—Lower third of the Trenton shales, Minneapolis, Minnesota.

## Genus APARCHITES, Jones.

*Aparchites*, JONES, 1889. Ann. and Mag. Nat. Hist., ser. 6, vol. iii, p. 385.

Carapace subovate, oblong, or somewhat rounded, with a straight hinge of variable length; valves subequal; edges thickened, never overlapping, often beveled or chaneled, in other cases simple, and rarely with a narrow flattened border. Surface more or less convex, usually smooth, without sulcus, tubercles or lobes.

Type: *A. whiteavesii* Jones.

The above definition embraces a number of species that had formerly been placed under *Primitia*, *Isochilina* and *Leperditia*. From the first they are distinguished by the absence of a sulcus, from the second by the absence of the eye-tubercle and certain shallow depressions behind it, and from the third by the absence of the eye-tubercle and the equality of their valves, there being no ventral overlap. From *Leperditella* they are separated by their equal valves, the left overlapping the right in that new genus. Finally, the new genus *Primitiella* includes some very similar carapaces, but these may be distinguished, in most cases very easily, by a broad though quite undefined depression or sulcus in the centro-dorsal region.

The species of *Aparchites* are all small, the average length being between 1.0 mm. and 1.5 mm., while the largest known does not exceed 3.0 mm. The total number of those known, including several undescribed species from Ohio, probably exceeds twenty. These are distributed almost equally between the Lower and Upper Silurian rocks, though in America they are known chiefly from the Trenton and Cincinnati formations.

## APARCHITES ELLIPTICUS, *n. sp.*

PLATE XLIII, FIGS. 15–17.

SIZE.—(E. C.) Length 1.97 mm.; hight 1.35 mm.; thickness 0.95 mm. In the largest specimen the length is 2.5 mm.

Carapace rather large for the genus, almost regularly elliptical in outline, the dorsal margin of the left valve more arcuate and projecting above that of the right; edges beveled all around but in the lower part the bevel is turned into a groove by the thickening of the contact edges; surface of valves smooth and rather uniformly convex.

This form, though the hinge is shorter than usual, must still be considered as a typical species of the genus. The general expression of the carapace is much as in the associated *Leperditella persimilis*, but it is somewhat longer, has no dorsal angle, and its valves do not overlap. I know of no American species of *Aparchites* with which it need be compared, the elliptical outline being distinctive, but there are several in the Upper Silurian deposits of Europe that are not far removed. Particularly is this true of the *A. simplex*, from Gothland, described by Prof. Jones in the Ann. and Mag. Nat. Hist., ser. 6, vol. iv, p. 272. That species, however, is smaller (0.9 mm. in length), relatively shorter, and apparently without bevelled edges. Some of the varieties referred to *A.* (*Primitia*) *maccoyii* Jones and Holl, are very near, if not identical. But I am not willing to admit the latter without a direct comparison of specimens.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis, Minnesota. An imperfect left valve from the Galena shales near Cannon Falls, may belong to this species, but it appears to have been relatively longer and somewhat narrower anteriorly.

## APARCHITES GRANILABIATUS *Ulrich.*

PLATE XLV, FIGS. 21–23.

*Leperditia granilabiata* ULRICH, 1892. American Geologist, vol. x, p. 267.

SIZE.—(L. V.) Length 2.1 mm.; hight 1.5 mm.; thickness 0.6 mm.

Valves high, very little oblique, ventricose in the lower half, somewhat flattened in the upper; outline almost semicircular in the lower two-thirds, the ventral curve being unusually convex; dorsal margin straight, about three-fourths as long as the valve, with angular extremities; border scarcely defined, set with small but prominent papillæ; free edges bevelled strongly inward. Surface covered with minute, regularly arranged granules; near the center a small raised spot.*

Recent comparisons have demonstrated the necessity of excluding species of this type from *Leperditia*. They have shown further that the typical species of *Aparchites*

* In the original description the surface is incorrectly described as punctate.

is really much nearer to the forms now referred to the genus than I was inclined to believe two years ago.

I have eight valves of a closely related species or variety from the lower third of the Trenton shales, at Minneapolis, and another, slightly longer than the rest, from the upper third near Cannon Falls. These specimens are less high than the type of *A. granilabiatus*, the ventral margin being less convex. The anterior end also is a trifle narrower, and the convexity of the valves somewhat less, while none of them show anything of the granulose surface ornament nor of the marginal papillæ. These specimens may provisionally be known as var. NEGLECTUS.

The straight back and dorsal angles will at once distinguish both the species and variety from *A. ellipticus*.

*Formation and locality.*—Upper third of the Trenton shales, St. Paul, Minnesota. Var. *neglectus* occurs in the lower third of the shales at Minneapolis.

### APARCHITES MILLEPUNCTATUS *Ulrich.*

PLATE XLV, FIGS. 16–18.

*Leperditia millepunctata* ULRICH, 1892. Amer. Geol., vol. x, p. 268.

SIZE.—(R. V.) Length 1.57 mm.; hight 1.0 mm.; thickness 0.42 mm.

Valves subelliptical, dorsal margin long, straight; ends rounded from the dorsal angles, equal; ventral edges bevelled inward; point of greatest convexity a little behind and beneath the middle; surface very finely punctate.

This species is smaller than *A. granilabiatus*, but relatively longer, and more uniformly convex. In its outline it is similar to *Leperditella æquilatera* Ulrich, from the Birdseye limestone of Kentucky (see fig. 46, p. 636), but it is a little higher, has beveled and not overlapping edges, and a punctate surface which is wanting in that species.

*Formation and locality.*—Lower or middle third of the Trenton shales, near Fountain, Minnesota.

### APARCHITES FIMBRIATUS *Ulrich.*

PLATE XLV, FIGS. 10–12.

*Leperditia fimbriata* ULRICH, 1892. American Geologist, vol. x, p. 268.

SIZE.—(R.V.) Length 1.88 mm.; hight 1.23 mm.; thickness 0.44 mm.

Valves suboval, moderately and almost uniformly convex; back straight, nearly two-thirds as long as the valve; dorsal angles sharp, a slight swelling of the surface immediately beneath them causing them to appear somewhat prominent; ends nearly equally rounded, the posterior a little the wider. The entire ventral border and the ends, excepting the upper third on each side, with a fringe consisting of long, almost paliform, processes, separated by intervals of 0.1 mm. or less.

The peculiar fringe distinguishes this species from all the Lower Silurian Ostracoda know to me.

*Formation and locality.*—Hudson River group, near Spring Valley, Minnesota.

APARCHITES ARRECTUS, *n. sp.*

PLATE XLIII. FIGS. 35 and 36.

SIZE.—(R. V.) Length 0.81 mm,; hight 0.53 mm.; thickness 0.11 mm.

Valves compressed-convex, scarcely if at all oblique, semiovate, the ends almost vertical in the upper half, the dorsal edge straight and very long; greatest convexity in the lower part of the valves, a large portion of the central part of the surface appearing flattened; free margins minutely toothed; bevel very narrow.

The dentate margin reminds of *A. granilabiatus*, but as the present form is much smaller and not nearly so convex, and as it has a longer hinge line and is much more elongated, it is quite evident that we are dealing with a distinct species. Its smaller size, erect ends and dentate margins distinguish it from *A. millepunctatus.*

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

APARCHITES CHATFIELDENSIS, *n. sp.*

PLATE XLIII. FIGS. 37 and 38.

SIZE.—(L. V.) Length 0.76 mm.; hight 0.46 mm.; thickness 0.12 mm.

Valves compressed-convex, somewhat elongate leperditoid in outline, being widest posteriorly; hinge line long, straight, dorsal angles rounded; posterior outline peculiar in swinging forward more than backward; ventral edge narrowly beveled inward; surface not well preserved but retaining some evidence of having been obscurely pitted.

The posterior outline is different and the thickness of the carapace less than in any other of the elongate species of the genus so far described.

*Formation and locality.*—Middle third of the Trenton shales, Chatfield, Minnesota.

APARCHITES MINUTISSIMUS *Hall*, var. TRENTONENSIS, *n. var.*

PLATE XLIII. FIGS. 18–20.

*Leperditia (Isochilina) minutissima* HALL, 1871, Desc. N. Sp. Foss. Hud. Riv. Gr., p. 7; also 1872, 24th Rep. N. Y. St. Mus. Nat. Hist., p. 231, pl. 8, fig. 13; HALL and WHITFIELD, 1875, Pal. Ohio, vol. ii, p. 102.
*Aparchites minutissimus* ULRICH, 1889, Contri. Can. Micro-Pal., pt. 2, p. 49.

SIZE.—(R. V.) Length 0.85 mm.; hight 0.54 mm.; thickness 0.16 mm.
(R. V.) " 0.49 " " 0.33 "

Two right valves of the Trenton variety of this species are figured on plate 43. The anterior part is narrower and the dorsal angles duller than in the typical Cincinnati specimens. The surface also is scarcely so convex, or rather it is not thrown up into a point near the center, but is comparatively uniform in curvature.

*Aparchites tyrrellii* Jones (Contri. Can. Micro-Pal., pt. iii, p. 62; 1891) from the Chazy at Lake Winnipeg, is a closely related, if not identical form. However, as figured by Prof. Jones, it appears to be less convex and the outline not so prominent in the post-ventral region.

*Formation and locality.*—The small specimen is from the middle third of the Trenton shales near Fountain, the larger from the top of the Galena shales near Cannon Falls, Minnesota.

## Family BEYRICHIIDÆ.

### Genus PRIMITIELLA, n. gen.

Carapace usually oblong, equivalved, moderately convex; surface smooth or finely punctate; in the dorsal slope a broad, shallow and quite undefined depression represents an undeveloped mesial sulcus.

Type: *P. constricta*, n. sp.

Besides the four new species about to be described, I propose to place in this genus *Leperditia unicornis* Ulrich (*Aparchites*, Ulrich, *Primitia*, Jones) and *Primitia whitfieldi* Jones, from the lower part of the Cincinnati group, *Primitia ulrichi* Jones, Utica slate, Canada, and probably the European species, *Primitia matutina* and *beyrichiana* Jones and Holl, *Primitia minuta* Eichwald (as figured by Jones) and *P. elongata*, var. *nuda*, Jones. I am inclined to think that *Isochilina? fabacea* Jones, from the Hamilton of New York, and *Aparchites inornatus* Ulrich also should be placed here. These species constitute a very natural group, distinguished from *Aparchites* by the dorsal depression. They are separated from *Primitia* because they give no adequate idea of that most prolific genus. To be a *Primitia* in my eyes the valves must be provided with a well marked subcentral pit or sulcus.

The Carboniferous genus *Youngia*, Jones and Kirkby, is closely simulated in all respects except the crenulated hinge by *Primitiella limbata*. Possibly that genus is not so far removed from *Primitiella* as we now believe to be the case.

### PRIMITIELLA CONSTRICTA, *n. sp.*

PLATE XLIII, FIGS. 48–52.

| | | | | |
|---|---|---|---|---|
| SIZE.—(E. C.) | Kentucky specimen: | Length 0.67 mm.; | hight 0.36 mm.; | thickness 0.24 mm. |
| | Minnesota " | " 0.60 " | " 0.35 " | " 0.21 " |
| | " " | " 0.68 " | " 0.33 " | " 0.22 " |

Carapace elongate, subelliptical or subquadrate, the length nearly twice the hight, convex; dorsal margin long, straight, with both extremities angular, or with the anterior one obtuse or rounded; ventral margin nearly parallel with the dorsal, gently convex, or almost straight in the middle; posterior margin somewhat oblique and subtruncate above; anterior outline always more curved than the posterior; free edges with a narrow border; surface with a broad, centro-dorsal depression.

The earliest known occurrence of this species is in the lower part of the Birdseye limestone of Kentucky. These specimens differ slightly from the later form in having the border much narrower, the ventral margin straighter and quite parallel with the dorsal, and the anterior outline more rounded. The valves seem also to be a little more convex.

*Primitiella elongata*, var. *nuda* Jones,* is similar but has straighter ends and sharper dorsal angles.

*Formation and locality.*—Lower and upper Birdseye limestone, High Bridge, Kentucky, and Lebanon and Lavergne, Tennessee; lower third of the Trenton shales, Minneapolis, St. Paul, and Goodhue county, Minnesota.

### PRIMITIELLA LIMBATA, *n. sp.*

PLATE XLIII, FIGS. 53–56.

SIZE.—(E. C.) Length 0.73 mm.; hight 0.38 mm.; thickness 0.20 mm.

The outline is almost as in *P. constricta*, only the ends are less rounded, the posterior one especially being nearly vertical, while the dorsal angles are sharper. The most important difference however lies in the fact that the border continues not only around the free edges but along the dorsal margin as well. The thickness of the carapace is somewhat less, and the surface rises more abruptly from the posterior border. Finally, the mesial depression is more obscure, and often scarcely distinguishable.

*Formation and locality.*—Lower third of the Trenton shales, Minneapolis, Minnesota.

### PRIMITIELLA SIMULANS, *n. sp.*

PLATE XLIII, FIGS. 26–28.

SIZE.—Length 0.73 mm.; hight 0.44 mm.; thickness 0.28 mm.

Valves rather strongly convex, leperditoid in outline, with the dorsal angles rounded; edges without border; a very faint, broad depression near the middle of the dorsal slope, and occasionally an obscure elevation at its base.

In the outline this species is very nearly like *P. minuta* Eichwald and *Aparchites subovatus* and *leperditoides* Jones. Still it is relatively higher than any of these, and the last two are without the dorsal depression. It resembles also *A. minutissimus* Hall, but may be distinguished by its proportionally greater length.

*Formation and locality.*—Lower part of the Trenton shales, near Fountain, Minnesota.

*Prof. Jones describes this form as a variety of *Primitia elongata* Krause, but since Dr. Krause has shown that his species possess a radially striated false border like that of *Eurychilina? subæquata* Ulrich, the form *nuda* should now be regarded as at least specifically and probably generically distinct from *P. elongata*.

## Primitiella fillmorensis, *n. sp.*

PLATE XLV, FIGS. 28–30.

Size.—Length 0.55 mm.; hight 0.38 mm.; thickness 0.23 mm.

A small, comparatively short form, with subequal, rounded ends, broadly curved ventral margin and a straight back, the extremities of which however are scarcely angular; mesial depression very shallow but wide, taking up a large portion of the centro-dorsal region; edges simple, or with an obscurely defined, narrow border. Though resembling several species of *Primitia*, from which it is distinguished by the width and shallowness of the mesial depression, I cannot find any described ostracode with which it is strictly identical.

*Formation and locality.*—Not uncommon in the lower part of the Trenton shales near Fountain, Minnesota.

## Primitiella unicornis *Ulrich.*

PLATE XLIII, FIGS. 75–77.

*Leperditia unicornis* Ulrich, 1879. Jour. Cin. Soc. Nat. Hist., vol. ii, p. 10, pl. vii, fig. 4.
?*Aparchites unicornis* Ulrich, 1889. Contri. Can. Micro-Pal., pt. 2, p. 50.
?*Primitia unicornis* Jones, 1890. Quart. Jour. Geol. Soc., vol. xlvi, p. 7.

Size.—Length 1.04.; hight 0.59 mm.; thickness 0.4 mm.

Carapace convex, scarcely oblique, oblong, with a long, straight hinge, and rather well-marked dorsal angles; ventral margin gently arcuate, nearly parallel with the back, the anterior hight of the valves being but little less than the posterior; posterior margin neatly rounded from the dorsal angle; anterior margin obliquely truncated in the upper half, sharply rounded at the middle; a narrow but well-defined border begins at this point and follows the outline to the post-dorsal angle; near the posterior extremity of each valve, usually somewhat beneath the mid-hight, a strong spine projects outwardly or posteriorly; in a dorsal or ventral profile the ends are blunt and the sides of the valves straight or just appreciably concave; in front of the middle of the dorsal slope there is a wide and very faint depression, and in the lower part of this a low swelling is almost invariably distinguishable. Specimens are usually about 1.0 mm. in length. A small variety occurs at Cincinnati, Ohio, averaging between 0.5 and 0.6 mm. in length.

All the American specimens of this species, excepting the valve figured by me from Manitoba *(op. cit.)* are remarkably constant in all their characters. Indeed, out of over fifty free carapaces and valves, I was unable to find one that differed enough from fig. 77 to make it worth the while to prepare drawings of it. Bearing this constancy in mind it is rather surprising to learn that Prof. Jones found considerable variability among the British specimens referred by him to the species. Comparing his drawings (*op. cit.*, pl. IV, figs. 8—13), with the figure here given on plate XLIII, it would appear that none of his specimens are strictly identical with the typical form of the species. They are all too narrow anteriorly, and three of the figured ones too long. The other three figures (8, 9 and 10) correspond fairly well with that of the Manitoba specimen already referred to, though the posterior spine in the last is stronger. Possibly some of the variability of the Bala specimens is due to crush, or perhaps their margins were covered by the shale. There remains to be added that in all these foreign specimens the border, as well as the slight elevation in the dorsal depression, seems to be wanting. Under the circumstances it would probably be advisable to separate them, if not specifically, at any rate as a variety, from the typical form of the species.

*Formation and locality.*—Doubtfully identified from a cast of the interior found in a thin bed of shale belonging near the base of the Hudson River group, three miles north of Spring Valley, Minnesota. The typical form occurs abundantly in the lower or Utica horizon of the Cincinnati group at a number of localities in the vicinity of Cincinnati, Ohio. The Manitoba variety is from beds equivalent to the upper divisions of the Cincinnati group at Stony Mountain, while the British specimens described by Prof. Jones are from Bala shales, near Welshpool, Montgomeryshire.

## Genus PRIMITIA, Jones and Holl.

*Primitia* (part.) JONES and HOLL, 1865. Ann. and Mag. Nat. Hist., ser. 3, vol. xvi, p. 415.

Carapace small, varying in outline, usually subovate, but the hinge is always straight; valves equal, never overlapping, generally provided with a narrow border; in, or to one or the other side of, the middle of the dorsal half, a well-marked pit or sulcus; the pit may be rounded and situated subcentrally, or it may be drawn out vertically so as to extend from the dorsal margin half across the valve; on one or both sides of the sulcus the surface may be raised into a low, rounded or ridge-shaped prominence. Surface of valves punctate, reticulate, or without ornament; in rare cases it seems to have been minutely granulose.

As typical species I will mention *P. mundula* Jones, *P. renulina* Jones and Holl, *P. variolata* J. and H., and *P. humilis* J. and H., Upper Silurian; *P. impressa* Ulrich, *P. sancti pauli* Ul., and *P. mammata* Ulr., Lower Silurian, the last two described in this work.

Prior to 1865, species of *Primitia* were referred to *Beyrichia*. For more than twenty years after that date, besides the type of structure to which the genus is now restricted, *Primitia* included (1) "non-sulcate" forms for which Jones in 1889, proposed the genus *Aparchites;* (2) so-called "passage forms" that I now propose to separate as *Primitiella;* (3) forms having the sides of the sulcus elevated into two strong tubercles, for which the genus *Ulrichia* has been established by Prof. Jones; and finally (4) some that may belong to *Eurychilina*, Ulrich, because they have the broad frill which projects greatly beyond the free contact edges of the valves in species of that genus. As usual, the original conception of *Primitia* was altogether too broad, and as, through the restless efforts of collectors, the species began to multiply, it became clear that they fell naturally into several groups, whose importance increased with time and study till their separation became, at first desirable, then necessary.

Still, *Primitia* retains a large number of species, the greater part of which are nearly equally divided between the Lower and Upper Silurian rocks. Two or three rather doubtful species have been described from primordial strata, but at least five good Devonian species have been discovered and as many more in the Lower Carboniferous, after which the genus seems to have become extinct. With a few exceptions all these species were described in papers by Jones, Jones and Holl, Krause, and Ulrich.

### PRIMITIA MINUTISSIMA, *n. sp.*

PLATE XLV, FIG. 31.

SIZE.—Length 0.33 mm.; hight 0.19 mm.

Carapace very small, rather elongate-elliptical in outline, without distinct dorsal angles, the ends rounded and nearly equal, the anterior slightly narrower than the other; valves rather strongly convex; sulcus narrow, sharply defined, extending nearly half across the valve; surface smooth.

This is the smallest *Primitia* known to me. It is evidently related to the British Wenloch species, *P. humilis* Jones and Holl, but is smaller, relatively more convex, with the ends more rounded, and the sulcus narrower. It is not very closely related to any of the known American species.

*Formation and locality.*—Lower part of the Trenton shales, near Fountain, and at Oxford Mills, Goodhue county, Minnesota.

### PRIMITIA UPHAMI, *n. sp.*

PLATE XLIII, FIG. 66.

SIZE.—Length 0.42 mm.; hight 0.27 mm.; thickness 0.15 mm.

Valves small, compressed-convex, slightly oblique, subovate, without distinct dorsal angles; posterior end wider and more broadly rounded than the anterior; ventral margin convex; edges thin, without border; sulcus represented by a rather large, though not very deep depression, situated about in the middle of the dorsal slope; surface marked by small punctæ, arranged in curved lines radiating from the sulcus; in certain lights each row appears as occupying the bottom of a narrow groove.

Though smaller and proportionally higher behind, this neat *Primitia* seems to be more closely related to *P. variolata* Jones and Holl, from the Wenloch of England, than to any American species. Still there is a regularity about the arrangement of the punctæ that is wanting in that species. In *P. trigonalis*, of the same authors and formation, the ornamentation is similar, but in other respects the species are quite different.

Named for Mr. Warren Upham, of the Geological Survey of Minnesota, whose published work has aided materially in advancing our knowledge of American geology.

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

PRIMITIA MAMMATA, *n. sp.*

PLATE XLIII. FIGS. 78–81.

SIZE.—Length 0.51 mm.; hight 0.30 mm ; thickness 0.18 mm.

Valves suboblong, the marginal portions somewhat depressed, while the central parts are slightly swollen beneath and on each side of the sulcus, the latter narrowing dorsally; back straight, dorsal angles rounded; posterior margin strongly rounded in the middle, ventral margin gently convex, subparallel with the hinge line; anterior outline most prominent in the upper part, the whole sweeping slightly backward; edges simple, surface without ornament.

The slight prominence of the surface about the sulcus gives this carapace an appearance that is not shared by any of the more simple forms of the genus. We are somewhat reminded of *P. tumidula* and *P. duplicata*,—indeed, I at first confounded it with the latter. The first is much more convex, shorter and larger, while perfect valves of the second will be distinguished at once by their double borders. *P. centralis* Ulrich, of the Utica horizon of the Cincinnati group, is similar in shape, but has a simply convex surface and the sulcus confined to a subcentral pit.

*Formation and locality.*—Lower third of the Trenton shales, Minneapolis, Minnesota.

PRIMITIA SANCTI PAULI, *n. sp.*

PLATE XLIII. FIGS. 73 and 74.

SIZE.—Length 0.86 mm.; hight 0.56 mm.; thickness 0.38 mm.

Valves strongly convex, thickest posteriorly, subovate in outline, with a straight back nearly three-fourths as long as the greatest length of the carapace, and rather distinct dorsal angles; ends rounded, subequal, the anterior sometimes a trifle narrower than the posterior; ventral margin broadly convex, free edges with a well-defined, narrow border; sulcus well developed, situated a little in front of the midlength, slightly oblique, deepest in its lower part, narrowing above by the development of a low swelling on each side, that on the anterior side more prominent than the other; a not very prominent, rounded tubercle near the lower part of the anterior border; excepting the sulcus and the flattened border, the entire surface is beautifully reticulated.

This fine species is probably more closely related to *P. milleri* Ulrich, from the upper beds of the Cincinnati group, than to any other known. The size of *P. milleri* is somewhat greater, its length being usually a little more than 1.0 mm. But the real differences between the two forms are (1) the proportionally greater length of the valves and of the hinge in the Minnesota species; (2) its longer and otherwise different sulcus, and (3) the possession of a rounded, antero-ventrally situated tubercle, which is wanting in the Ohio species.

*Formation and locality.*—Upper third of the Trenton shales, St. Paul and near Cannon Falls, Minnesota.

### PRIMITIA MICULA, *n. sp.*

PLATE XLIII, FIGS. 69–72.

SIZE.—Length 0.39 mm.; hight 0.25 mm.; thickness 0.23 mm.

This species, though much smaller, seems to be related to *P. sancti pauli.* It is however relatively shorter, with a longer hinge line and stronger dorsal angles. The valve is strongly convex, especially in the posterior half, and the prominences on each side of the curved sulcus are decidedly higher than in the larger species. Again, that species has a rounded tubercle in front which is wanting in *P. micula.* Finally, the surface is only obscurely punctate and not reticulate.

It is perhaps more closely related to *P. tumidula* of the Hudson River shales, but, aside from its much smaller size, it is at once distinguished by the absence of the narrow curved ridge, running a short distance within the ventral margin in that species.

*Formation and locality.*—Galena shales near Cannon Falls, Minnesota; associated with *P. uphami*, *Schmidtella affinis* and *Bythocypris cylindrica.*

### PRIMITIA CELATA, *n. sp.*

PLATE XLIII, FIGS. 67 and 68.

SIZE.—Length 0.57 mm.; hight 0.33 mm.; thickness 0.30 mm.

Valves with the back long, straight or gently arcuate, the dorsal angles distinct though not sharp, the ends about equally curved though the anterior is somewhat narrower than the posterior; ventral and anterior margins together following a semielliptic curve; free edges grooved, the true contact margins concealed by a projecting rim which however is not distinguishable in a side view from the regular slope of the surface except in front; sulcus sharply defined, simple, subcentral, extending less than one-third of the distance across the valve; surface minutely punctate.

The widely grooved edges distinguish this species from several otherwise similar forms occurring in the Upper Silurian of Europe. The projecting rim, which should not be mistaken for an ordinary border, is to be regarded as an undeveloped "frill" and precisely the same as the false border of *Ctenobolbina ciliata* and *Ceratopsis chambersi.* It is developed to a greater degree in the next species, but in *P. tumidula* it appears to have been in a large measure reabsorbed again.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis, Minnesota.

### Primitia duplicata, *n. sp.*

PLATE XLIII, FIGS. 60 and 61.

Size.—Length 0.70 mm.; hight 0.45 mm.; thickness 0.35 mm.

Valves rounded oblong-quadrate, with a long, straight back, rounded dorsal angles, and a distinctly elevated false border. This border projects slightly beyond and completely hides, in a side view, the anterior and ventral contact margins of the valve. Posteriorly however the true edge protrudes, the border here projecting outwardly much more than backward. Within the border the surface is moderately convex, the sulcus not deep yet distinct, and faintly traceable for about two-fifths the hight of the valve. In front of the lower part of the sulcus a small swelling is faintly indicated, while behind its upper two-thirds there is another but much larger low elevation. Surface without ornamentation so far as known.

This interesting species agrees with *P. celata* in having a false border, but as it is more elevated, especially in its posterior part, and as the two forms are quite different in the region of the sulcus, it is not at all likely that they will ever be confused by a careful observer. I know of no form now referred to *Primitia,* unless it be *P. tumidula,* which see, that is sufficiently near *P. duplicata* to require comparison. *Beyrichia initialis,* an associated species, looks considerably like it. It is of about the same size, and has a raised border. A critical examination of the latter however proves that it is not a false border, but the actual margin of the valve bent outward (compare figs. 61 and 83, plate XLIII). Of course the lobing of the valves, though certain similarities may be discovered, is still very different in the two forms. A comparison of their respective figures on plate XLIII will bring out the differences much better than I can define them.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis, Minnesota.

## Primitia tumidula, *n. sp.*

PLATE XLIII, FIGS. 62–65.

Size.—Length 0.73 mm.; hight 0.50 mm.; thickness 0.40 mm.

Valves strongly convex, subquadrate-ovate, back straight, rather long; posterior dorsal angle strong, the anterior more obtuse or rounded; ends nearly equal in hight, but the anterior margin is more curved than the posterior, the latter being somewhat truncated above; sulcus a little in front of, or quite in the middle of the dorsal half, deep, with a strong rounded swelling on each side; the posterior prominence larger and higher than the anterior one, but the latter usually somewhat better defined by a forward swing of the lower part of the sulcus; surface beneath the sulcus prominently convex, and sometimes bearing several small tubercles; a wide concave border, defined in the ventral part by a thin ridge, extending parallel with and some distance within the edge of the valves. This ridge I consider as the remnant of a false border, like the one which is so strongly developed in *P. duplicata.*

At first I thought this species might be the same as *P. cincinnatiensis* Miller sp., but a more careful examination proved it distinct, though perhaps closely related. In the first place its valves are higher, the ventral outline being much more curved. Next, the sulcus is relatively shorter, while the border is not narrow and flat. But the most important difference is the submarginal ridge which is distinguishable even on casts of the interior of *P. tumidula,* but of which not a sign is to be seen on Miller's species. In *P. duplicata* this ridge is much more strongly developed, forming a false border from one dorsal angle to the other. This fact causes the surface of the valves to appear much less convex than it really is, though the greatest thickness is a little less than in *P. tumidula.* But the sulcus in the latter is much deeper, and the tumidity of the surrounding parts greater than in the Trenton species.

*Formation and locality.*—In a thin bed of shale belonging to the lower part of the Hudson River group, three miles north of Spring Valley, Minnesota.

## Primitia gibbera, *n. sp.*

PLATE XLIII, FIGS. 57–59.

Size.—Length 0.81 mm.; hight 0.45 mm.; thickness 0.36 mm.

Valves somewhat leperditoid in outline, with a straight hinge line, the distance between the dorsal angles about five-ninths of the greatest length of the carapace; ends rounded; valves rather strongly convex, gibbous in the anterior half of the dorsal region; this prominent part is somewhat flattened on the back, and includes a short and rather shallow notch or sulcus. In the specimens at hand the surface slopes uniformly toward the edges and these seem to be simple and without a border;

but, as they are only casts of the interior, a narrow border may have existed on the exterior of the valves.

The gibbous character of the anterior part of the dorsal region, and the shortness as well as lateral position of the sulcus, are the principal peculiarities of the species. In other respects it resembles *P. mundula* and *P. simplex* Jones.

The affinities of this form are rather obscure. There is a suspicious resemblance to *Jonesella? obscura* (plate XLIV, figs. 17—19), but very little to *J. crepidiformis* the type of that genus. It may also be compared with *Placentula inornata* Ulrich, a Cincinnati species.

*Formation and locality.*—Associated with the preceding.

## Genus HALLIELLA, Ulrich.

*Halliella*, ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 184.

Similar to *Primitia*, but with a thicker shell, thick and bevelled edges, and usually a larger subcentral sulcus dividing the surface into two lobes. Surface of lobes coarsely sculptured or reticulate.

Types: *H. (Primitia?) sculptilis* and *H. retifera*, Ulrich.

The affinities of this genus are still obscure. Taking *H. labiosa*, we see Primitian characters coupled with those marking *Kirkbya*, and I am really quite undecided as to which are predominant. *H. sculptilis* Ulrich, from the Trenton of Kentucky, is farther removed from *Primitia*, but its long sulcus produces an effect more like *Ctenobolbina* than *Kirkbya*. The same is true, though in a lesser degree, of *H. (Primitia) seminulum* Jones. The Devonian *H. retifera*, though having something to remind of each, is not a *Primitia, Beyrichia, Ctenobolbina* nor a *Kirkbya*. It is these more or less obscure resemblances to a variety of generic types that makes it so difficult to point out the diagnostic characters of *Halliella*, and I find myself in the somewhat anomalous position of being much better able to say what they are *not* than what they *are*. I must admit also that I am not thoroughly satisfied that the four species now constituting *Halliella* are strictly congeneric. They may be so, but until their natural affinities are better understood, the genus is to be accepted as convenient rather than natural.

### HALLIELLA LABIOSA, *n. sp.*

PLATE XLVI, FIGS. 43–46.

SIZE.—Length 0.86 mm.; hight 0.62 mm.; thickness 0.40 mm.

Carapace semielliptical, the lower three-fourths semicircular, the hinge line nearly straight; dorsal edges somewhat thick and bevelled inward; free edges very thick, in a ventral view resembling lips; surface of valves gently convex within the wide concave border, the central part of the upper half depressed around a narrow pit; in front of the pit occasionally a slight rounded elevation. Surface beautifully marked with small pits closely arranged in concentric lines, usually less curved than the ventral outline of the valves.

This is one of the prettiest of the numerous Ostracoda occurring in the Trenton of Minnesota. It is also one of the most easily recognized, the thick, lip-like edges, and the concentric surface markings being unusually distinctive.

*Formation and locality.*—Near the top of the Galena shales, Goodhue county, Minnesota.

## Genus BEYRICHIA, McCoy.

*Beyrichia*, McCoy, 1846. Synop. Sil. Foss. Ireland, p. 57.

Carapace small, equivalved, oblong or semiovate, with a straight dorsal and convex ventral outline. Typically each valve has two sulci and three lobes, of which the central one is the smallest; the two larger lobes often coalesce ventrally. Surface usually marked with pittings, reticulation, papillæ or other ornament.

Type: *Beyrichia klœdeni* McCoy.

This genus, after *Leperditia*, is the most important of all the generic groups of Paleozoic Ostracoda. Many of the species also, those of the Upper Silurian rocks especially, are comparatively large, specimens over 3 mm. in length being not at all uncommon. The individuals, moreover, are generally abundant, layers of rock in many instances being crowded with, if indeed they are not largely made up of their separated valves.

In the restricted sense in which the genus is here defined, the oldest known species is the Minnesota form about to be described.* It is from the middle third of the Trenton shales (?Black River group). Of the Trenton proper, *B. bella* Walcott, may belong to the genus, and I have a doubtful species from the Utica horizon at Cincinnati, Ohio; but so far we know of no true *Beyrichia* from the Hudson River or Cincinnati group, those referred to the genus from this formation belonging to *Ctenobolbina*, *Drepanella*, *Bollia*, *Tetradella*, *Ceratella* and *Primitia*. In the Clinton, however, *B. lata* Hall (Vanuxem)† is a good species, and from here on to the close of the Carboniferous system the genus is more or less well represented in every group of strata.

* Prof. T. Rupert Jones has described *Beyrichia holli* from the Minævian flags of Great Britain (Geol. Mag., n. ser., Dec. 2, vol. 8, p. 343; 1881). but the affinities of the fossil seem to me as doubtful.

† Not *Bollia lata* Jones, 1890; Quart. Jour. Geol. Soc., vol. 46, p. 12, pl. 3, figs. 1, 2, 3. The specimens identified by Prof. Jones with *B. lata* are widely different from the typical Clinton form of this species, which is a true *Beyrichia*, but I cannot distinguish them from *Bollia symmetrica* Hall, sp.

## BEYRICHIA INITIALIS, *n. sp.*

PLATE XLIII, FIGS. 82 and 83.

SIZE.—Length 0.65 mm.; hight 0.41 mm.: thickness 0.30 mm.

Valves small, somewhat oblong, subquadrate; hinge line straight, nearly as long as the valve; dorsal angles distinct without being sharp; ventral margin but little convex, nearly parallel with the back; ends subequal, neither much curved; free margins with a distinct border or flange, turned outward. Middle lobe situated just above and a little in front of the center, rather low, rounded, not sharply separated from the anterior lobe; mesial sulcus deeper than the anterior, meeting beneath the small lobe; anterior lobe rather small, coalescing ventrally with the much larger posterior lobe, the junction faintly indicated. In the anterior part of the valve the surface is depressed, but in the upper corner a small tubercle is to be noticed.

In this species the isolation of the small lobe has progressed beyond the limits of *Primitia*, and the result is sufficiently close to *Beyrichia* to be included in this genus. An approach toward Beyrichian characters is faintly indicated in *Primitia duplicata* and *P. tumidula*, while the tendency to vary in this direction is much better expressed in certain varieties of *P. cincinnatiensis* Miller, and *P.? parallela* Ulrich.* The latter might be called a *Klœdenia*, Jones and Holl, a genus that, with slight peculiarities of its own, seems to be nothing more than a recognition of one of the more permanent transitional types between *Primitia* and *Beyrichia.*

Specifically, *B. initialis* is not likely to be confounded with any Lower Silurian ostracode known to me. Nor is there any pressing need of comparing it with its much larger Upper Silurian congeners.

*Formation and locality.*—Middle third of the Trenton shales, Minneapolis, Minnesota.

## Genus EURYCHILINA, Ulrich.

*Eurychilina*, ULRICH, 1889, Contri. to Can. Micro-Pal., pt. 2, p. 52; also 1890, Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 125.

Carapace with a long, straight hinge-line; semicircular, oblong-subquadrate, or somewhat rounded in outline; generally with a well-defined subcentral vertical sulcus and a more or less prominent node immediately behind it. Except at the dorsal side, the valves are surrounded by a wide marginal area, externally either flat or convex and usually marked in a radial manner; on the inner side deeply concave, an outer wall being raised almost to the level of the true or closing edge of the valve; area terminated in most cases by a narrow rim-like border. Hinge simple. Surface beautifully reticulated, pitted, granulose or smooth.

Type: *E. reticulata* Ulrich.

*Jour. Cin. Soc. Nat. Hist., vol. 13, pl. 10, figs. 5a and 15a; 1890

The principal peculiarity of *Eurychilina* is the hollow area surrounding, if not all, at any rate the greater part of the free margins of the valves. In *Primitiopsis*, Jones, a concave area occurs also, but only at the anterior end. This marginal area is not to be compared with the outwardly similar "frill" of *Beyrichiopsis*, Jones and Kirkby, nor to the "false border" of *Ceratella chambersi*, *Ctenobolbina ciliata* or *Primitia duplicata*, since a distinct structure (*i. e.* an outer wall), wanting in those species, is required to form it. Moreover, an equivalent of the "frill" is also present as a narrow terminal border in most of the true species of *Eurychilina*.

I say "true species of *Eurychilina*" because the genus as now understood includes some that are not strictly in accordance with the types. Regarding, of the species referred to the genus in 1890,* *E. reticulata*, *E. subradiata*, *E. longula*, *E. granosa*, *E. manitobensis* and probably *E. æqualis* is in every respect typical, we still have to account for *E. obesa* and *E. striatomarginata* (Miller). After careful examination I am ready to admit that these two species have not the required concave marginal area. In these namely the marginal expansion is nothing more than a simple border or "frill." Now, what is to be done with them? Can they justly be retained under *Eurychilina?* I think not.

In coming to this conclusion I have in mind the fact that a number of "frilled" primitian Ostracoda are known that seem to stand in close relationship with *E. obesa* and *E. striatomarginata*. One of these is here provisionally referred to *Eurychilina* (*E.? subæquata*) while two more are among my undescribed species from the Trenton of New York. In glancing over Dr. Aurel Krause's papers on the Ostracoda which he has found in the Silurian boulders contained in the drift of northern Germany, I notice no less than seven species that strike me as belonging in this connection, viz: *Primitia distans* Krause, *P. excavata* K., *P. elongata* K., *P. plana* K., *P.* (*Ulrichia*) *umbonata* K., *Entomis flabellifera* K., and *Beyrichia radians* K. Of course, if all or a good proportion of these species prove to be congeneric and are to be viewed as a group by themselves and as distinct from *Eurychilina*, a new genus will have to be established for them. I would have proposed a name in this work had I not been assured of soon receiving specimens of Dr. Krause's species. When these arrive I hope to enter upon a more thorough investigation of the *Beyrichiidæ* than I have yet been able to give them.

* Jour. Cin. Soc. Nat. Hist., vol. 13, pp. 125—130.

EURYCHILINA RETICULATA *Ulrich*, and var. INCURVA, *n. var.*

PLATE XLIV, FIGS. 1 and 2.

*Eurychilina reticulata* ULRICH, 1889. Contri. to Can. Micro-Pal., pt. 2, p. 52, pl. ix, figs. 9, 9*a*.
Not *Eurychilina reticulata* (Ulrich) JONES, 1890, Quart. Jour. Geol. Soc., vol. xlvi, p. 593, pl. xx, figs. 13*a*, 13*b*.

SIZE.—Without marginal area, length 1.83 mm.; hight 0.9 mm.; thickness 0.5 mm.
With " " " 2.40 " " 1.3 "

Valves, excluding the marginal area, nearly semicircular in outline, straight along the dorsal edge, moderately and almost uniformly convex; sulcus deep, extending half way across the body, not as wide as in the next species, its outline more sharply defined behind and below than on the anterior side; above the sulcus expands and becomes very shallow, while at the midlength it is constricted by a rounded prominence on the posterior side; surface, except along the dorsal edge, beautifully reticulate. Marginal area wide, narrowest posteriorly; on the outer side it is flattened or concave, and slopes inwardly, especially at the ends; ventrally the edge rises to form a narrow, wavy, free border; surface marked by radial lines, strongest ventrally, least distinct anteriorly; at its junction with the body of the valve, a more or less elevated, linear ridge is usually present. Internal characters of valves and marginal area almost exactly as in the next species (see plate XLIV, fig. 3.)

This fine species is perhaps the most beautiful of all the Paleozoic Ostracoda known to me, and when in a good state of preservation it is scarcely possible to confound it with any other. Yet, as cited above, Prof. Jones has referred a Devonian specimen from the Corniferous chert of New York to the same species. The characters of the valve figured by him are preserved in an empty mold, which in splitting the rock presented both an inner and an outer cast. Comparing these with the Minnesota species, I am obliged to differ wtih Prof. Jones' determination. Indeed, I doubt if they are even congeneric. The outline of the body of the valve is not semicircular in the Devonian species but has that oblique form which is commonly distinguished as "leperditoid." It is also proportionally a little higher, the reticulate ornament extends to the dorsal edge, the sulcus is shorter and much less defined, being merely a subcentral depression, and there is apparently no rounded prominence behind it. Further, the dimensions given by Prof. Jones show that his specimen is considerably larger than any Lower Silurian example of *E. reticulata* so far seen, the length in the latter rarely, if ever, exceeding 2.5 mm., while that of the Devonian form is stated to be 3.5 mm. These differences, if no others existed, would be sufficient to prove a distinct species.

But they are not all, since his fig. 13*b* shows that the border was convex exteriorly while it should be flat or concave; and in fig. 13*a*, representing an impression of the inner side of the valve, we see nothing of the outer wall of the marginal area. The last I regard as the most important difference, since, if the facts are correctly represented in Prof. Jones' figures it would remove his species from the typical section of *Eurychilina* to that distinct group of species which is defined on a preceding page in the remarks following the generic description.

Variety INCURVA, n. var. Plate XLIV, Fig. 2.

This subordinate name is proposed for a variety of this species that is rarely associated with more typical specimens in the upper third of the Trenton shales, the highest horizon in which this species is known to occur. The variety is a little smaller than full grown specimens of the typical form, and more rounded in the posterior outline. More striking differences however are seen in the marginal area. This, instead of being concave and curved outward, is convex and incurved, its width is less and more equal, the radii very indistinct and the terminal border more sharply defined. These differences produce a form closely resembling the Kentucky species *E. granosa*. We except of course the ornamentation, the two being very different in this respect.

*Formation and locality*—Ranges from the lower Trenton limestone to the upper third of the Trenton shales; Minneapolis, St. Paul, Cannon Falls, and near Fountain, Minnesota. The species is not abundant anywhere, only about twenty specimens in all having been seen. Variety *incurva* occurs as far as known only at St. Paul.

## EURYCHILINA SUBRADIATA *Ulrich.*

PLATE XLIV, FIGS. 3, 4, 4*a*.

*Eurychilina subradiata* ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 126.

SIZE.—Without marginal area, length 1.75 mm.; hight 0.9 mm.; thickness 0.50 mm.
With marginal area, length 2.32 mm.; hight 1.3 mm.

Body of valves almost exactly semicircular in outline, with the surface highest along an obtuse ridge-like prominence, running lengthwise across the central portion of the valve and from the summit of which the surface descends with a distinctly concave slope to the thickened dorsal edge; on the opposite or ventral side the slope is more gently concave or flat; anterior extremity compressed; sulcus deep and unusually wide, beginning a little within the dorsal margin and extending half way across the body, its lower and posterior margins thickened and sharply defined; just back of the sulcus a large round tubercle; surface appearing smooth in some specimens, but usually it is pitted as shown in fig. 4. Marginal area nearly flat, the inner edge rising abruptly and forming a low, sloping wall around the body, the outer edge formed by a sharply elevated narrow border; posterior and ventral portions of area holding about the same width, but at the anterior end it is usually much less; external surface of area with more or less obscure radial furrows. Inner side of marginal area strongly concave, the outer wall well developed and extending from near the post-dorsal angle around the ventral side and about half way up the anterior side. In perfect specimens the dorsal angles are prominent.

The pinched appearance of the central portion of the valves, pitted instead of reticulated surface, stronger tubercle, wider sulcus and more abruptly elevated marginal area, together with other differences readily distinguish this species from *E. reticulata*, *E. manitobensis* and *E. longula.*

The original types of the species occurred in a hard limestone, and appeared to be without pitting of the surface; but a re-examination proved that the shell is usually exfoliated in specimens obtained by splitting the limestone blocks. The Minnesota specimens are mostly preserved in soft shale and in many cases are very perfect.

*Formation and locality.*—"Lower Blue limestone" of the Trenton formation, Dixon, Illinois, and Mineral Point, Wisconsin; Birdseye or "Glade" limestone, Lebanon, Tennessee; rather abundant in the lower third of the Trenton shales (Stictoporella bed) at Minneapolis, St. Paul, Cannon Falls and Oxford Mills, Minnesota.

## Eurychilina ventrosa, *n. sp.*

PLATE XLV. FIGS. 1–3.

Size.—Without marginal area, length 1.82 mm.; hight 1.08 mm.; thickness 0.8 mm.
With marginal area, length 2.40 mm.; hight 1.5 mm.

This species is considerably like *E. subradiata* but the body of the valve is more convex and the outline much more oblique. It is also a little shorter. The marginal area has about the same width in the two species but it does not rise so abruptly and on the whole is convex in *E. ventrosa*, while the ends are not produced above into sharp angles. The border is peculiar also in front where it is bent so as to form an angle of about 45° with the plane of the valves. But the principal peculiarity of the border lies in a strong swelling which takes up its entire ventral part. Surface of valves with obscure traces of large shallow pits. Tubercle strongly developed.

The ventral swelling of the marginal area is a peculiar feature, and so far as I can see, normal. A similar though weaker and longer swelling occurs in four valves found associated with *E. subradiata* at Minneapolis. As these specimens however are typical of that species in all other respects, they probably represent a variety that subsequently changed to the form now called *E. ventrosa.*

*Formation and locality.*—Upper portion of the Galena shales (base of Fusispira bed) near Cannon Falls, Minnesota.

### EURYCHILINA ? SUBÆQUATA, *n. sp.*

PLATE XLV, FIGS. 7–9.

SIZE.—Without border, length 1.55 mm.; hight 0.85 mm.; thickness 0.58 mm.
With border, length 1.80 mm.; hight 1.05 mm.

Valves quadrate-subelliptical in outline, strongly convex, with the dorsal angles obtuse, the ends rounded, and the dorsal and ventral margins nearly parallel. Body of valve rather uniformly convex, with the anterior end a trifle more obliquely rounded than the posterior. Sulcus situated a little behind the center, deep, narrow, beginning at the straight dorsal border and terminating abruptly at a point less than one-third of the hight of the valve beneath it. On each side of the sulcus the surface rises into a low eminence, one, supposed to be the posterior, a little higher than the other. Central portion of surface exhibiting numerous, rather irregularly distributed pustules. Border not defined by an impressed suture line, flattened except at its extreme outer edge where it bends suddenly inward. Its surface presents more or less obscure radial series of minute granules, most distinct on the ventral portion where the border is also the widest.

As stated under the generic description, this is one of a number of species belonging to an undescribed genus. Of these forms *E. ? striatomarginata* Miller, from the uppermost beds of the Cincinnati formation, and *E. ? obesa* Ulrich, from the Birdseye limestone of Kentucky, are probably the nearest. The first is less convex, has a different sulcus and a wider border, marked with fine radiating lines instead of rows of granules. The latter agrees very well in most respects but may be distinguished at once by the absence of any well defined sulcus.

*Formation and locality.*—Upper third of the Trenton shales (Phylloporina bed), St. Paul, Minnesota.

### EURYCHILINA ? SYMMETRICA, *n. sp.*

PLATE XLIV, FIGS. 5–7. PLATE XLV, FIGS. 4–6..

SIZE.—Length 1.8 mm.; hight 1.1 mm.; thickness 0.4 mm.
Length 1.7 mm.; hight 1.08 mm.

Valves subelliptical or somewhat quadrate, equilateral, greatly compressed, 1.6—2.0 mm. in length. Dorsal margin straight or slightly convex, a little shorter than the valve; dorsal angles not very sharp; ventral margin semielliptical, curving neatly into the rounded ends. Body of valve flattened, but rising at two points near the hinge, each situated about midway between the dorsal angles and the center, into two, more or less prominent, large subequal rounded tubercles. These are connected by a thin ridge, the two bulbs and connecting bar resembling the old "bar shot." Surface broadly excavated centrally, and marked with obscure pits. Marginal area convex, about 0.3 mm. wide along the ventral edge, the width decreasing rapidly in nearing the dorsal angles; ventral two-thirds surmounted by a narrow, crescent-shaped thickening, depressed centrally, and marked with rather large elongated and concentrically arranged pits.

The affinities of this remarkable species are very uncertain, and it is only provisionally placed under *Eurychilina*. Perhaps it can go into the new genus with *E. ? subæquata* and the other species mentioned on p. 659. On the other hand, the two dorsal tubercles may indicate a remote relationship with *Ulrichia*. Whatever position it may ultimately occupy in classification, it is safe to say that it now stands quite alone.

*Formation and locality.*—Upper third of the Trenton shales (Phylloporina bed), St. Paul and near Cannon Falls, Minnesota.

## Genus DICRANELLA, n. gen.

Valves equal, similar to those of *Primitia*, excepting that they have "frilled" margins, while each side of the sulcus is raised into a more or less prominent horn-like process. These prominences are directed dorsally and may be subequal, or the posterior one may be much the smaller.

Type: *D. bicornis*, n. sp.

Though doubtlessly embracing a good generic type, it is as yet scarcely possible to give a satisfactory diagnosis of this new genus. Two of the following species, the type and *D. spinosa*, are certainly congeneric, and the third, *D. marginata*, probably also. But the fourth, *D. ? simplex*, is one of four species which, while closely related among themselves, are, to say the least, only doubtful members of this genus. Two of these four species Prof. T. Rupert Jones recently described as *Ulrichia nicholsoni* and *U. marrii* (Quart. Jour. Geol. Soc., vol. 49, p. 294; 1893) while the third, *Leperditia byrnesi* Miller, he refers (*op. cit.*, vol. 46, p. 12; 1890) to the genus *Æchmina*. According to my estimate of these species, they should not be referred to *Æchmina* because, instead of a single horn-like prominence rising from the center of the dorsal slope, they have two, one subcentral, the other behind it, while between them there is more or less of a notch or sulcus. In *Ulrichia* the two generic knobs are merely rounded prominences or tubercles on the surface of the valves, never horn-like, nor are their apices turned toward or beyond the dorsal margin. The probabilities are that the affinities of *Æchmina* and *Ulrichia* are widely different, and it would be good policy, for the present at least, to restrict their application to forms in which the generic features are sharply defined.

As to these four doubtful species, they are, it seems to me, clearly nearer *Dicranella* than the other genera to which they have been referred. The answer to the question, are they really congeneric with the typical species?, depends, I should say, entirely upon the significance we attach to the presence or absence of the marginal frill. Believing that further investigations are desirable, I shall not attempt to decide the question now. In the meantime the new species may be known as a doubtful *Dicranella,* while the others had best remain where Prof. Jones has placed them.

### Dicranella bicornis, *n. sp.*

PLATE XLIV, FIG. 26. PLATE XLVI, FIGS. 39–40.

Size.—Without border, length 1.5 mm.; hight 0.83 mm.; thickness 0.4 mm.
With border, length 1.8 mm.; hight 1.02 mm.

Valves oblong, straight dorsally, rounded ventrally and at the ends, the latter nearly equal. Two large, subequal, diverging, horn-like processes, angular in cross-section, arise behind the center of the dorsal half and project far beyond the dorsal edge; between their bases a suboval depression; lower half of posterior horn with a large rounded swelling. Outline of valves marked by a sharply defined, linear ridge; beyond this a wide but very thin, smooth border or frill, usually bending outward at the edge; border narrowest anteriorly, widest below.

This species is so easily recognized by its "horns," that comparisons are quite unnecessary.

*Formation and locality.*—Lower and middle thirds of the Trenton shales (Stictoporella and Rhinidictya beds), Minneapolis and St. Paul, Minnesota.

### Dicranella spinosa, *n. sp.*

PLATE XLIV, FIG. 23. PLATE XLVI, FIG. 41.

Size.—Length (including border) 1.5 mm.; hight 0.8 mm.; thickness 0.45 mm.

This species is similar to *D. bicornis* but the valves are a little longer, and the "horns" begin lower down on the valves and are not carinated, while the posterior one is shorter, and seems not to extend beyond the rounded swelling. The border also seems not to have been developed anteriorly, while along the ventral edge it is usually replaced by a series of spines. Posteriorly it has about the same width as in *D. bicornis,* but is ornamented with radial furrows instead of being plain.

*Formation and locality.*—Middle third of the Trenton shales (Rhinidictya bed), Minneapolis, Minn.

## Dicranella marginata, *n. sp.*

PLATE XLIV, FIGS. 27–28.

Size.—Length 1.7 mm.; hight 1.22 mm ; thickness 1.0 mm.

In this species the valves are much higher, especially in the posterior part, than in the two preceding species, the border, though wanting anteriorly, is much thicker and projects outward as much as downward or forward, while, instead of horn-like processes, we have two very unequal lobes, the posterior of which is comparatively very small, failing to reach the dorsal edge by a distance almost equalling its length, the anterior one (centrally situated) large, swollen in the middle, high and obtusely pointed above, the extremity reaching the dorsal edge or projecting slightly beyond it. The whole carapace also is thicker and has a more robust appearance. The peculiarities are strongly marked and conspicuous, and it does not seem likely that collectors will experience any trouble in recognizing the species.

*Formation and locality.*—Lower part of the Trenton shales (Rhinidictya bed), near Fountain, Minnesota.

## Dicranella ? simplex, *n. sp.*

PLATE XLIV, FIGS. 24–25. PLATE XLVI, FIG. 42.

Size.—Length 0.98 mm.; hight 0.67 mm.; thickness 0.35 mm.

Valves moderately convex, subelliptical; dorsal angles rounded, hinge line rather short; ends equal, rounded; ventral margin rather strongly convex; edges simple, without border. A strongly elevated, oblique, conical prominence just within and behind the center of the dorsal edge; another large tubercle, in this case rounded instead of conical and ovate in outline, near the center of the posterior half and like the other reaching the dorsal edge; between the two a rather deep sulcus. A third tubercle, of irregular form and nearly as large as the second, occurs just within the upper half of the posterior edge.

This species is evidently related to the Cincinnati form first called *Leperditia byrnesi* by Mr. Miller, and recently referred to *Æchmina* by Prof. Jones. That species however has only one posterior tubercle and a central oblique spine, while *D. ? simplex* has all three. The outline of the latter also is more convex ventrally. Of Minnesota Ostracoda, there is none sufficiently like it to require comparisons.

*Formation and locality.*—Lower part of the Trenton shales (Rhinidictya bed), near Fountain, Minn.

## Genus JONESELLA Ulrich.

*Jonesella* ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 121.

Carapace small, equivalved, moderately convex, oblong-subovate; hinge straight. Valves with a curved ridge on the posterior half or two-thirds. This ridge may be variously modified, but in the typical species it is thin and bent like a horseshoe, in another the anterior arm is horizontal instead of vertical, while in a third the two arms are divided. Edges simple or faintly bordered.

Type: *J. crepidiformis* Ulrich.

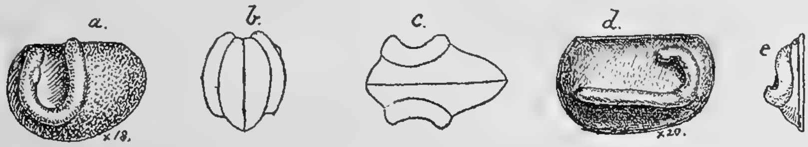


Fig. 47.—*a*, *b*, *c*, lateral, posterior, and ventral views of an entire carapace of *Jonesella crepidiformis* Ulrich; *d*, left valve of *J. pedigera* Ulrich; all about × 20. Both species are from the lower beds of the Cincinnati group at Covington, Kentucky.

The affinities of this genus, which includes so far as known only Lower Silurian species, appear to be with *Bollia*, Jones and Holl. But the horseshoe ridge in all true species of that genus is subcentral, while the edges of the valves are thickened into a more or less well-developed marginal ridge, no trace of which is apparent in *Jonesella*. The new species about to be described is peculiar in the faint development of the loop, and in the shortness of the horseshoe. In *J. crepidiformis*, as may be seen in the above cut, the ridge takes up the greater part of the posterior half. Still, a general agreement of parts between the two species is obvious, so that *J. obscura* may well be accepted as an incipient *Jonesella*. On the other hand, the prominent upper extremities of the bent ridge, remind considerably of certain species of *Ulrichia*, but as the whole carapace recalls *Bollia* quite as much, if not more, it is to be assumed that these resemblances indicate family relationship rather than generic. As usual with early types of life, the Lower Silurian Ostracoda are apt to be of a composite nature, and the determination of the really significant features of such forms, so far as generic and specific alliances are concerned, is never certain except through minute genealogical investigations. But this touches upon too large a subject for the present work.

In the original work on the genus I included a Minnesota species, under the name of *J. crassa*, that I shall now place elsewhere, because it seems to belong to another line of development, namely, it is closely related to *Ctenobolbina fulcrata*. For further remarks on this and related species see under *Ctenobolbina*.

### JONESELLA OBSCURA, *n. sp.*

PLATE XLIV, FIGS. 17—19.

SIZE.—Length 0.68 mm.; hight 0.43 mm.; thickness 0.3 mm.

Valves moderately convex, subovate, sometimes obscurely quadrate; hinge rather short, straight centrally, more or less rounded at the ends; ventral margin gently convex, nearly parallel with the dorsal. Horseshoe ridge comparatively small, almost entirely within the post-dorsal fourth, its arms terminating near the dorsal margin in two rounded elevations, the connecting loop but little elevated and in most cases obscure; beneath the loop another but very faint loop-like elevation of the surface may be noticed.

The horseshoe ridge is much smaller and the bent portion much less distinct than in *J. crepidiformis.*

*Formation and locality.*—Galena shales (Clitambonites bed), near Cannon Falls, Minnesota.

## Genus BOLLIA, Jones and Holl.

*Bollia*, JONES and HOLL, 1886. Ann. Mag. Nat. Hist., ser. 5, vol. xvii, p. 360

Valves subequal, oblong or somewhat rounded, with rounded and nearly equal ends and a straight hinge line; surface punctate or smooth, and bearing a large loop-like or more or less horseshoe-shaped ridge; from the edges the surface rises into a more or less well-developed, angular or rounded marginal ridge; the outer and inner ridge often come close together ventrally, but rarely, if ever, coalesce; horseshoe ridge of nearly equal strength throughout, or the ends may be bulbous and the connecting bent portion relatively very thin and low.

Type: *B. uniflexa* Jones and Holl.

This genus is easily recognized by the inner or horseshoe ridge, which always occupies a subcentral position with respect to the ends of the valves. The species are numerous and while they may be said to adhere rather strictly to the generic type, it is still true that they may be divided into three distinguishable groups. In the first or typical section, the outer rim or ridge is not strong, while the inner ridge has bulbous ends and is on the whole larger though the bent connecting portion is narrow. In the second section, of which *B. vinei* Jones and Holl, may be considered as typical, both the inner and outer ridges are relatively thin and small, even the ends of the horseshoe ridge being but little, when at all, thicker than the rest. The third section, of which *B. persulcata* Ulrich and *B. regularis* Emmons sp., are both, though in somewhat different ways, representative, includes species in which the inner ridge is thick without being bulbous at its ends, the marginal ridge swollen, sometimes thicker at one end than the other, and the depressions or sulci between the ridges relatively narrow. These species pass over into, and the section ought to include, some of the so-called quadri-jugate *Beyrichiæ*.* Their relations to *Tetradella* will be considered in the remarks under that genus.

## BOLLIA SUBÆQUATA, *n. sp.*

PLATE XLVI, FIGS. 26—29.

SIZE.—Length, 0.64 mm.; hight, 0.50 mm.; thickness 0.22 mm.
Length, 0.59 mm.; hight, 0.42 mm.; thickness, 0.20 mm.
Length, 0.40 mm.; hight, 0.32 mm.

Valves compressed, subovate in outline, straight above; length of hinge somewhat variable, shortest, apparently, in old examples; dorsal angles more or less distinct; edges of valves thick, forming a sharply-defined, thin marginal ridge; inner ridge thin, rather long, U-shaped, one of the arms with a slight swelling near or at its upper extremity; surface between the ridges flat and without ornament.

The small valves of this species remind somewhat of *Moorea punctata*, but as that form has no inner or horseshoe ridge they are distinguished very easily. *Tetradella quadrilirata* is a larger form and has the inner ridges joined below with the marginal ridge. The nearest allies occur in the Upper Silurian deposits of Europe, but it is distinct from them all.

*Formation and locality.*—Galena shales (Clitambonites bed), near Cannon Falls, Minnesota.

## BOLLIA UNGULOIDEA, *n. sp.*

PLATE XLVI, FIGS. 23—25.

SIZE.—Length 0.6 mm.; hight 0.4 mm.; thickness 0.35 mm.

Valves subovate, with equal rounded ends, a rather short, straight hinge, and illy defined dorsal angles; marginal ridge thick, rounded, a little wider at one end than at the other; inner ridge strong, one end swollen, the other small and failing to reach the dorsal edge; interspace between the two ridges very narrow.

* With the exception of several very doubtful species described by Krause, the known species fall into these sections, as follows:

| SECTION 1. | SECTION 2. | SECTION 3. |
|---|---|---|
| *B. pumila* Ulrich, L. Sil. | *B. subæquata* Ulrich, L. Sil. | *B. unguloidea* Ulrich, L. Sil. |
| *B. uniflexia* Jones and Holl, U. Sil. | *B. semilunata* Jones, Antic. | *B. regularis* Emmons sp., L. Sil. |
| *B. bicollina* J. and H., U. Sil. | *B. vinei*, Jones and Holl, U. Sil. | *B. persulcata* Ulrich, L. Sil. |
| ?*B. interrupta* Jones, U. Sil. | *B. vinei* var. *mitis* J. and H., U. Sil. | *B. duplex* Krause, U. Sil. |
| *B. bilobata* Jones, Dev. | *B. semicircularis* Krause, U. Sil. | *B. symmetrica* Hall sp., U. Sil. |
| *B. hindi* Jones, Dev. | *B. rotundata* Krause, U. Sil. | *Beyrichia clarki* Jones, U. Sil. |
| *B. obesa* Ulrich, Dev. | | *Beyrichia halli* Jones, U Sil. |
| *B. granifera* Ulrich, L. Carb. | | *B. ungula* Jones, Dev. |
| | | ?*Beyrichia devonica* Jones, Dev. |
| | | *Beyrichia subquadrata* Jones, Dev. |

This species, though smaller and distinct, resembles the Devonian *B. ungula* Jones, more closely than any other of the genus known. *B. persulcata* of the Cincinnati rocks is perhaps as near as any of the Silurian forms, but there are so many differences between them that it is unnecessary to enter into comparisons. In *B. subæquata*, which belongs to another section of the genus, both the inner and outer ridges are much thinner.

*Formation and locality.*—Associated with the preceding in the Galena shales, in Goodhue county, Minnesota.

## Genus DREPANELLA, Ulrich.

*Drepanella* (*Depranella* in error) Ulrich, 1890, Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 117.

Carapace equivalved, compressed-convex, somewhat oblong, the outline between subquadrate and subelliptical; dorsal border straight, ventral outline gently convex; ends subequal, the posterior somewhat truncated above, the anterior generally more rounded. Running nearly parallel with and close to the posterior and ventral edges, a sharply elevated, sickle-shaped ridge. Central and dorsal regions of valves with two principal, simple or divided, nodes or ridges. Surface smooth or reticulate. Size of carapace usually about 2.5 mm. long by 1.5 mm. high.

Type: *D. crassinoda* Ulrich,

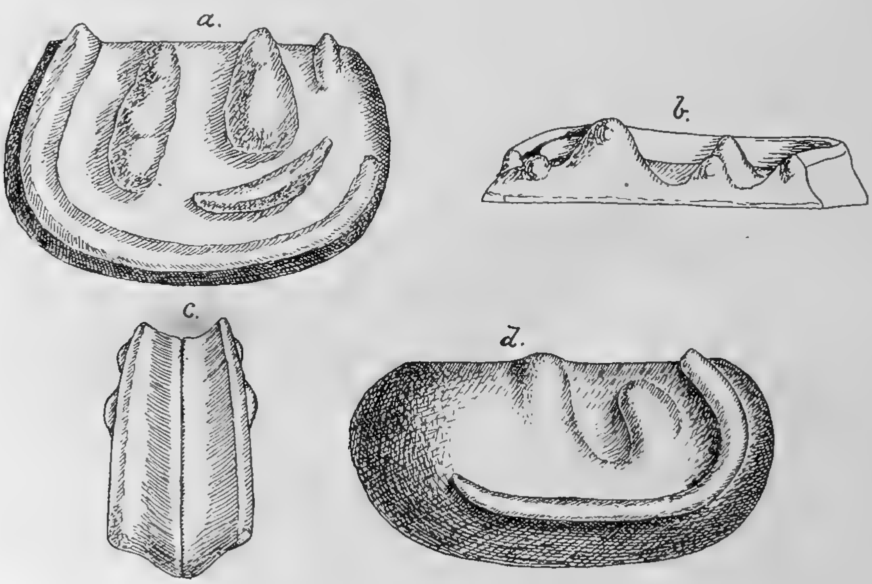


Fig. 48.—*a*, *b*, lateral and dorsal views of a right valve of *Drepanella crassinoda* Ulrich, from the Birdseye limestone at High Bridge, Kentucky; *c*, a left valve of *D. ampla*, var. *elongata* Ulrich, from the same formation and locality, introduced for comparison with *D. bigeneris*; *d*, right valve of *D. macra* Ulrich, from the same formation at Dixon, Illinois; all × 20. The last probably occurs also in Minnesota.

Of this genus only Lower Silurian species are known. Taking the six species and varieties upon which the genus was founded, we have a sharply defined generic group. With these we may include, without materially altering our conception of the genus, the new *D. bilateralis*, although in this species the characteristic sickle-shaped marginal ridge is wanting posteriorly. But the other Minnesota species, *D. bigeneris*, is certainly a remarkable form. In size and general appearance it agrees very well with *D. crassinoda* and *D. ampla* having the sickle-shaped ridge well developed, and two large centro-dorsal nodes, separated by a depression, as in the latter species. But the peculiar feature is that these nodes are prolonged below and united by a slender connection, giving us precisely the horseshoe ridge of a *Bollia*. The question arising at once is, why should the species not be viewed as a *Bollia*, rather than a *Drepanella*.

I have decided for *Drepanella* on what I believe to be good genealogical grounds. In the first place, aside from the ventral connection of the nodes, all the characters of the species are those of *Drepanella*. The marginal ridge, it is true, runs farther up on the anterior end than on any of the other species, yet its extremity is thin and the mere fact that it is a trifle longer than usual cannot be of much consequence. But the most important evidence on the question is furnished by *D. ampla* var. *elongate*, of which a copy of the original figure is given above. In this variety, namely, there is a well defined depression between the nodes precisely as in *D. bigeneris*, and all that is required to produce the loop of the latter, is a slight raising of the nodes, together with the lower border of the depression. This is not, I believe, supposing too much, for a ventral coalescence of the anterior and posterior lobes or nodes is not by any means restricted to *Bollia*. Indeed it occurred under one form or another, among many types of *Beyrichiidæ*. That this is true, a glance at plate XLIV may suffice to prove. One form is shown in fig. 4, another, and widely different, in fig. 6, while 8, 10, 12, 15, 17, 20, 23, 26, and 27 illustrate other types of the same condition.

### DREPANELLA BILATERALIS, *n. sp.*

PLATE XLVI, FIGS. 35–38.

SIZE.—Greatest length 2.7 mm.; length of hinge 2.15 mm.; greatest hight 1.64 mm.; greatest thickness, about 1.3 mm.; thickness, not including nodes and ridge, about 0.6 mm.

Valves suboval or oblong-subquadrate, compressed; dorsal margin straight; distinctly angular at the extremities; anterior end a trifle narrower, and the outline less convex than the posterior; ventral margin nearly straight centrally. Running parallel with and close to the ventral margin a strong ridge, somewhat thickened at each end, but not continuing up the posterior end as in the other species. Above this two irregularly triangular and very prominent large nodes extend to the dorsal edge, beyond which their pointed extremities occasionally project. The last is true also of a small central tubercle.

The form, prominence and bilaterally symmetrical disposition of the nodes and ridge give this species a very distinct and striking appearance, and among all the numerous Silurian Ostracoda not one is known with which it might be confused.

*Formation and locality.*—Upper third of the Trenton shales (Phylloporina bed), St. Paul and near Cannon Falls, Minnesota.

### Drepanella bigeneris, *n. sp.*

PLATE XLIV, FIGS. 20–22.

Size.—Length 2.3 mm.; hight 1.36 mm.; greatest thickness 0.95 mm.; average thickness, not including nodes and ridges, about 0.5 mm.; thickness of posterior and ventral edges about 0.6 mm.

Valves oblong-subquadrate, longest in the lower half, the ends nearly equal and converging slightly in the upper half; back straight, the posterior extremity subangular, the anterior rounded; ventral outline very gently convex; marginal or "sickle-shaped" ridge sharply defined, extending farther up on the anterior side than in any of the other species of the genus. Two thick nodes or lobes, the anterior one the longer and more prominent, are connected below by a narrow loop-like thickening of the lower border of the median depression or sulcus, the whole producing precisely the effect of the "horseshoe" ridge of *Bollia.*

My reasons for placing this fine species under *Drepanella* instead of *Bollia* are given in the remarks following the generic description. The specific characters are well marked and conspicuous, so that there is little difficulty in distinguishing the species from the rest of the Minnesota Ostracoda.

*Formation and locality.*—Lower limestone of the Trenton formation, Minneapolis and St. Paul, Minnesota.

## Genus DILOBELLA, n. gen.

Carapace small, equivalved, subovate or somewhat reniform in outline, the back straight or faintly concave; valves bilobed, the lobes subequal, very large, and almost completely separated by a deep subcentral vertical sulcus; edges thin, simple; surface smooth.

Type: *D. typa*, n. sp.

I find myself obliged to erect a new genus for this remarkable ostracode. A slight resemblance to certain forms of *Bollia* may be noticed, but the lobes are altogether too large for that genus. That it cannot belong to either *Entomis*, *Entomidella* nor *Ctenobolbina*, the only other genera with which it might be compared must be evident to anyone who has paid attention to this class of fossils. As to its affinities, they are obscure. Because of the slight basal connection between the lobes, it may be regarded provisionally as an extravagant development of the *Bollia* type of structure.

### Dilobella typa, *n. sp.*

PLATE XLVI, FIGS. 30—34.

Size.—Length 1.0 mm.; hight 0.8 mm.; greatest thickness 0.52 mm.
Length 0.9 mm.; hight 0.75 mm.

Valves varying somewhat in outline, some being obscurely quadrate or subovate, others short-reniform; dorsal outline more or less concave at the middle and rounded or subangular at the ends; ventral margin strongly convex, the lower half of the outline being in some cases almost semicircular. A deep, subcentral, vertical sulcus divides the valves into two large subequal lobes. These are very prominent, especially at their centers, and rise abruptly from the flattened borders. At the base an obscure connection between the lobes may be noticed.

When the valves are not perfectly cleared from the matrix, some difficulty may be experienced in distinguishing them from the associated *Ctenobolbina crassa*, which also has a deep sulcus. But in that species the sulcus is curved and does not divide the lobes ventrally, and the valves are longer and differently shaped. In fact the two species differ so greatly that I cannot conceive how good specimens might be confounded.

*Formation and locality.*—Upper third of the Trenton shales (Phylloporina bed), St. Paul, Minnesota.

## Genus CTENOBOLBINA, Ulrich.

*Ctenobolbina*, Ulrich, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 108.

Carapace small, elongate-suboval, strongly convex, the posterior two-fifths more or less decidedly bulbous or subglobular, and separated from the remainder by a deep, narrow and more or less oblique sulcus extending with a gentle curve from the dorsal margin more than half the distance across the valves toward the postero-ventral border. The anterior three-fifths often with another oblique but less impressed sulcus. Valves equal, the dorsal margin straight, hingement simple, the ventral edge thick, and the true contact margins generally concealed, in a lateral view, by a "frill" or flattened false border; surface granulose, smooth, or punctate.

Type: *C.* (*Beyrichia*) *ciliata* Emmons sp.

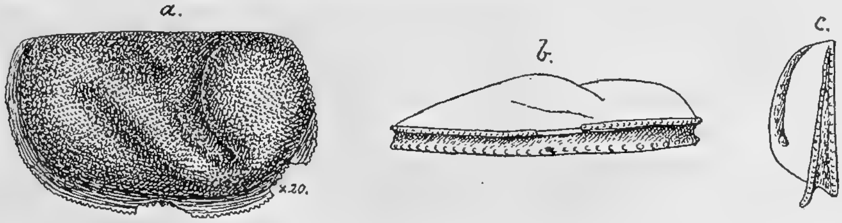


Fig. 49.—*a, b, c*, lateral, posterior, and ventral views of a left valve of *Ctenobolbina ciliata* var. *emaciata* Ulrich, × 20; shales of the Hudson River group, Savannah, Illinois. This species probably occurs also in the equivalent shales near Spring Valley, Minnesota.

This genus includes a well marked group of paleozoic Ostracoda, distinguished, in its typical development, from all the other genera of the family by the bulbous character of the posterior end. A small isolated middle lobe, which is the most persistent character of *Beyrichia* and *Klœdenia*, is, except in one case, never present, the central lobe or ridge, when one has been divided off from the anterior swelling of the surface, being united ventrally with the large posterior lobe. A small lobe is isolated in *C. tumida* Ulrich, but as the posterior half is decidedly bulbous in this species it may be advisable to leave it with this genus. Still, I have fully satisfied myself that it is a close ally, perhaps a progenitor of the Clinton *Beyrichia lata* Vanuxem, and that is not far from *B. klœdini* McCoy.

*Ctenobolbina* has its best development in the Cincinnati group, from which four or five good species and two varieties have been described. Two Trenton species, differing from the Cincinnati types in the lesser development of the posterior bulb, are found in Minnesota. *C. punctata* Ulrich, of the Niagara, retains the generic characters very well, as does also *C. papillosa* Ulrich, of the Devonian, while *C. informis* Ulrich, also Devonian, reminds of the Trenton *C. crassa*. *C. minima*, of the Hamilton, is much like *C. bispinosa* from Cincinnati, and both are almost primitian in their simplicity. Of European species I know of only one that has the characters of *Ctenobolbina* clearly developed. This is the *Beyrichia guillieri* Fromelin, as figured by Jones, in 1890, (Quart. Jour. Geol. Soc., vol 46, pl. 21, figs. 2*a, b, c*). It is closely related to *C. ciliata* and occurs in the Lower Silurian strata of France. Another, that is as much of a *Ctenobolbina* as *C. crassa, C. fulcrata* and *C. informis*, is the *Bollia? auricularis* Jones and Holl, from the Wenlock of England. Indeed, these four species are closely related and cannot justly be separated generically, so that I propose to refer the Wenlock species also to this genus. Prof. Jones concedes in a letter to me that the *auricularis* is not a *Bollia*, and a close comparison with the Minnesota species mentioned proves to me that my former opinion of the British species, when I thought that it might belong to *Halliella* (Jour. Cin. Soc. Nat. Hist., vol. 13, p. 185), is erroneous.

### CTENOBOLBINA FULCRATA, *n. sp.*

PLATE XLIV, FIGS. 8–11.

SIZE.—Length 1.2 mm.; hight 0.78 mm.; thickness 0.56 mm.
Length 1.2 mm.; hight 0.80 mm.; thickness 0.60 mm.

Valves obliquely subovate, highest posteriorly, with the back straight and the dorsal angles usually well defined. Posterior bulb comparatively narrow; sulcus deep, wide, oblique, curving backward below; anterior lobe undivided, larger than the posterior, in some specimens less oblique than in others; ventral and posterior sides of lobes terminating in a thin, flat or raised, border, supported in the hinder part by five, equidistant ribs or walls, thus forming as many small cavities in the posterior edge of each valve; surface smooth.

The small cavities in the posterior half of the edge remind of *Tetradella quadrilirata*, but here the resemblance ceases for they are widely different in all other respects. These cavities and the relative narrowness of the posterior bulb, together with other peculiarities, distinguish *C. fulcrata* from *C. duryi* Miller sp., a Cincinnati species that resembles fig. 8 more closely than does any other one of the genus. When however it comes to actual relationship, the next to be described is doubtless the nearest.

*Formation and locality.*—Upper third of the Trenton shales (Phylloporina beds), St. Paul and Cannon Falls, Minnesota.

### CTENOBOLBINA CRASSA *Ulrich.*

PLATE XLIV, FIGS. 12–16.

*Jonesella crassa* ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 123.

SIZE.—Length 0.94 mm.; hight 0.60 mm ; thickness 0.60 mm.
Length 0.80 mm.; hight 0.52 mm.; thickness 0.46 mm.

This species is closely related to *C. fulcrata*, and when the edges are obscured by the matrix, it is difficult to distinguish from one of the varieties of that species. But when the posterior edgê is visible the difficulties vanish, there being no supports nor cavities in the thick edge of *C. crassa* (compare figs. 13 and 16 with fig. 9, pl. 44.) Among other differences I may mention that in *C. crassa* the valves are constantly a little smaller, the sulcus wider, and the lobes more prominent, especially at the ventral edge. The lobes are also more compact and ridge-like, producing an effect that reminds so much of the "horseshoe" ridge of *Jonesella*, that I at first regarded the species as belonging to that genus. But that was before I knew of its close relationship with *C. fulcrata*.

*Formation and locality.*—Associated with the preceding in the upper third of the Trenton shales at St. Paul and Cannon Falls, Minnesota.

## Genus CERATOPSIS, n. gen.

*Tetradella* (part.) ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 112.
*Beyrichia* (part.) BARRANDE, HALL and WHITFELD, MILLER, JONES, and other authors.

Valves somewhat obliquely subovate, widest posteriorly, straight dorsally, with a thick rounded semicircular marginal ridge, and two submedium ridges extending obliquely upward from the marginal ridge, the anterior one reaching the dorsal edge, the other shorter and smaller; post-dorsal end of marginal ridge raised into a strong spine-like, or a mushroom-shaped process, beaded or fimbriated along one edge or around the flattened top. Free edges of carapace as in *Ctenobolbina*, being thick, and having "false borders."

Type: *Beyrichia chambersi* S. A. Miller.

This genus is related to *Ctenobolbina* on the one hand and *Tetradella* on the other, while it is distinguished from both, as well as from all known genera, by the remarkable post-dorsal process. The species of *Ceratopsis* are all Lower Silurian and, with the exception of *Beyrichia hastata* Barrande, a Bohemian species evidently of this genus, all American. *C. chambersi* is rarely met with in the middle third and rather commonly in the upper third of the Trenton shales in Minnesota. Recently I have also detected a few specimens in the upper part of the Trenton in Kentucky, but the most typical and abundant development of the species occurs in the lower two hundred feet of the Cincinnati group. Variety *robusta* applies to a reappearance of the species in the upper beds of this group in Ohio and Minnesota. *C. oculifera* (*Beyrichia*, Hall) though very abundant, seems to be restricted to the upper one hundred feet of strata exposed in the Cincinnati hills. In this form the elevated process took the shape of a thick-stemmed mushroom, the gently convex cap of which is beautifully fringed at the edge. A new species, which I propose to call *C. intermedia*, occurs at the base of the Cincinnati formation near Covington, Kentucky. In this the process forms a curved spine on which the fimbria is arranged in a semi-circular manner, the effect being very nearly intermediate between that exhibited in *C. chambersi* and *C. oculifera*. For further remarks on this genus see under *Tetradella*.

### CERATOPSIS CHAMBERSI *Miller*.

PLATE XLVI, FIGS. 19–22.

*Beyrichia chambersi* MILLER, 1874. Cin. Quar. Jour. Sci., vol. i, p. 234.
*Tetradella chambersi* ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 112.

SIZE.—Length 1.5 mm.; hight 1.03 mm.; thickness 0.6 mm.
Length 1.8 mm.; hight 1.10 mm.

The principal distinguishing feature of this abundant species is the spine-like form of the post-dorsal process. In the typical variety, of which fig. 19 is a fair example, the post-medium ridge is short and small. It is so in all the Trenton specimens and in the Lower Cincinnati group types of the species. Figure 22 is peculiar in having the upper end of this ridge separately developed as a small rounded node. It is the only case of the kind seen, and may be abnormal.

## Variety ROBUSTA, *n. var.*

*Beyrichia chambersi* HALL and WHITFIELD, Pal. Ohio, vol. ii, p. 104, pl. 4, figs. 11, 12, not strictly *B. chambersi* Miller.

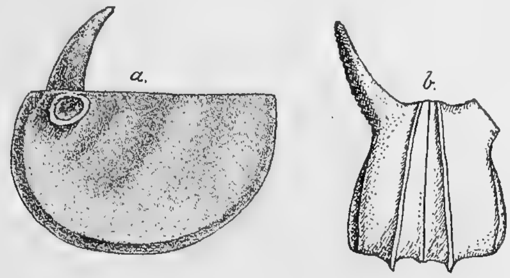


Fig. 50.—Lateral and posterior views of an entire carapace of this variety from the shales of the Hudson River group, near Spring Valley, Minnesota.

This designation is proposed for the variety which occurs in the upper beds of the Cincinnati group at numerous localities in Ohio, Indiana, and Kentucky, and in the equivalent Hudson River group strata of Minnesota. So far as known it is not to be found below the horizon of *Orthis subquadrata* Hall, and *Rhynchotreta capax* Conrad. It differs from the typical form of the species in having all the ridges somewhat thicker, and the post-median one much larger. In many cases the latter is nearly or quite equal to the anterior ridge, and extends like it entirely across the valve. The ventral portion of the carapace also is thicker, and the marginal ridge subangular where the contour turns abruptly inward to the false border.

*Formation and locality.*—The typical form of the species is rare in the middle and common in the upper third of the Trenton shales at Minneapolis, St. Paul and Cannon Falls. As yet, it has not been detected in any of the divisions of the Galena, but in the lower beds of the Cincinnati group it is a common fossil. The var. *robusta* was found in the upper part of the Hudson River shales near Spring Valley, Minnesota, and occurs abundantly in the upper beds of the Cincinnati group at Waynesville and Oxford, Ohio, Richmond and Versailles, Indiana, and many other localities in these states.

## Genus TETRADELLA Ulrich.

*Tetradella* (part.) ULRICH, 1890. Jour. Cin. Soc. Nat. Hist. vol. xiii, p. 112.
*Strepula*, ULRICH, 1889. Contri. to Can. Micro.-Pal., pt. 2, pp. 54, 56, not of Jones and Holl. "Trisulcate" and "quadrijugate" *Beyrichia* (part.) of authors.

Carapace somewhat oblong, often subquadrate, never tumid, with the hinge line straight. Surface depressed, with a semicircular marginal ridge; within the enclosed space, two, simple or slightly modified, equal or unequal, and more or less nearly vertical ridges unite below with the marginal ridge and extend upward from it, one in many cases failing to reach the dorsal margin. Free edges usually with a simple flattened border; in one case (*T. subquadrata*) thick and with the contact margins concealed by a "false border." Surface smooth or granulose.

Type: *T.* (*Beyrichia*) *quadrilirata* Hall and Whitfield.

In the original definition of this genus (*loc. cit.*) I included as a section the species that I now separate as *Ceratopsis*, under which name they have been distinguished in my private collection since 1881. I have been led to alter the opinion expressed in 1890, respecting the desirability of generically recognizing the distinguishing peculiarity of *Ceratopsis* by repeated comparison among the constantly increasing typical species of the genus. Of the fifteen good, and four somewhat doubtful species of *Tetradella* now known, not one shows the remotest sign of the "horns" of *Ceratopsis*. This horn-like process is a structural peculiarity, and while it may be analogous or even homologous with the central horn of *Æchmina* and the two horns of *Dicranella*, it is more highly organized, and surely deserves generic recognition when this rank is accorded to the more simple process in the two cases mentioned. In 1890 I thought it just possible that the feature might prove inconstant, if not abnormal, but that is now quite out of the question since it is as constant as any peculiarity can be, being repeated in thousands of examples of each of the three American species, during unusually long geological ranges, and with a persistency of specific marking that would be most extraordinary if the feature was not of structural importance.

The affinities of *Tetradella* seem to be with *Ctenobolbina* on the one hand and the "trisulcate" species of *Beyrichia*, which as I have shown on page 668, are generically distinct from *Beyrichia* and provisionally to be viewed as a section of *Bollia*, on the other. In the former, however, there are only two or three ridges instead of four, the space occupied by the two posterior ridges in *Tetradella* being representedby a single large bulb. The valves also are more convex, especially when, as is generally the case, the anterior sulcus is wanting or but feebly developed, and the free edges are thicker, while the "false border," which is almost unknown in the present genus, is generally well developed in *Ctenobolbina*.

The resemblance to the trisulcate *Beyrichia* is more marked and may prove troublesome to those who have not made a special study of the Ostracoda. Still, I remember no case now, in which one more or less well marked difference cannot be made out. Namely, in the "trisulcatæ" the arrangement of the sulci and ridges is approximately symmetrical and bilateral, the central sulcus being vertical, while the two lateral sulci curve outwardly. In *Tetradella*, however, this symmetrical arrangement is not evident since it is generally the case that *all* the sulci curve more or less posteriorly (*i. e.* starting from the dorsal margin).

But the principal reason for separating these forms from *Tetradella* is a genealogical one. The "trisulcate" or "quadrijugate" *Beyrichia*, namely, are regarded as a development from the third section of *Bollia* described on page 668, and which includes *B. unguloidea*, *B. persulcata*, *B. regularis*, etc. A good demonstration of this line of development may be established already from known species. Compare, for instance, *B. regularis* Emmons sp., Lower Silurian, and *Beyrichia clarki* Jones, *B. halli*, Jones, *B. hieroglyphica* Krause, *B. trisulcata* Hall, and *Klœdenia kiesowi* Krause, Upper Silurian, and it is clear that the change from the first to the last was nothing more than a gradual coalescence of the ventral curves of the inner and outer ridges and the consequent obsolescence of the sulci.

That *B. trisulcata* and similar forms could not have been developed from the typical trilobed (bisulcate) *Beyrichia*, nor from *Klœdenia* is perfectly clear to me, since it would be necessary to assume a division of the small or middle lobe of those genera, which I think I am safe in declaring, never took place.

*Tetradella* is essentially a Lower Silurian genus, nearly all the typical species being restricted to strata belonging to, or equivalent to the Trenton and Cincinnati formations. In America we have *T. quadrilirata* Hall and Whitfield, and var. *simplex* Ulrich, *T. lunatifera* and *T. subquadrata* Ulrich. Of European species doubtlessly belonging to *Tetradella* I may mention *Beyrichia complicata* Salter, *B. ribeiriana* Jones, *B. affinis* J., *B. bussacensis* J., *B. lacunata* J., *B. marchica* Krause, *B. erratica* K., *B. palmata* K., *T. signata* K., *T. carinata* K., and *T. harpa* K. As somewhat doubtful Upper Silurian representatives, we may regard four species figured by Dr. Krause, viz.: *Beyrichia digitata* K., *B. dissecta* K., *B. mamillosa* K., and *B. nodulosa* Boll. In the first the ridges do not appear to unite ventrally, and in the last the anterior pair are peculiarly twisted together, while in the second and third all the ridges are divided into nodes, two nodes taking the place of each ridge.

### TETRADELLA QUADRILIRATA *Hall* and *Whitfield*, and varieties.

PLATE XLVI, FIGS. 1–11.

*Beyrichia quadrilirata* H. and W., 1875. Pal. Ohio, vol. ii, p. 105.
*Beyrichia regularis* MILLER, 1875. Cin. Quart. Jour. Sci., vol. ii, p. 351. Not *B. regularis* Emmons
*Strepula quadrilirata* ULRICH, 1889. Contri, to Can. Micro. Pal., pt. ii, p. 54.
*Tetradella quadrilirata* ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 122.

SIZE.—Length 1.10 mm.; hight 0.75 mm.; thickness 0.42 mm.
Length 0.94 mm.; hight 0.62 mm.; thickness 0.38 mm.
Length 1.13 mm.; hight 0.70 mm.; thickness 0.55 mm.

Figures 1 to 3 are taken from a representative specimen of the species as it occurs in the Trenton shales of Minnesota. It is also very nearly identical with the typical form which is found so abundantly in the upper beds of the Cincinnati group in Ohio and Indiana. The original of fig. 4 is from the Birdseye limestone at High Bridge, Kentucky. This is somewhat shorter and more oblique than usual. Figure 7 represents a variety, not uncommon at Minneapolis, in which the antero-median ridge has a decided thickening above, and is less distinctly divided below. The two posterior ridges also are not entirely distinct. In the majority of these lower Trenton representatives of the species a delicate ridge or raised line is to be noticed just within the posterior portion of the marginal ridge. This is wanting, as far as observed, in the Ohio specimens, but in the related *T. lunatifera* this small ridge is represented by one that is quite as strong as the marginal ridge itself.

Figures 9 to 11 are taken from a variety of which several examples were collected at Fountain, Minnesota. These are thicker ventrally than usual (see the last of the series of measurements given above), longer, and have an unusually wide flattened border, turned outward at the edge. Some slight differences may also be noticed in the characters of the median ridges, but the most striking of all their peculiarities is the absence of the five marginal cavities. In some respects these specimens agree very well with the var. *simplex* described by the author from Hudson River shales in Manitoba, but as they are not identical another subordinate name might appropriately be applied to them.

*Formation and locality.*—Birdseye limestone, High Bridge, Kentucky; middle and upper third of the Trenton shales, Minneapolis, St. Paul, Cannon Falls, Fountain, and other localities in Minnesota; upper beds of the Cincinnati group at Clarksville, Blanchester, Waynesville and Oxford, in Ohio, Richmond and Versailles in Indiana.

### TETRADELLA LUNATIFERA *Ulrich.*

PLATE XLVI, FIGS. 12—14.

*Strepula lunatifera* ULRICH, 1889. Contri. to Can. Micro.-Pal., ii, p. 56.
*Tetradella lunatifera* ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 112.

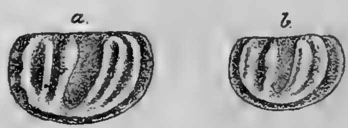


Fig. 51.—Two valves of *T. lunatifera* from the Galena shales near Cannon Falls, x22; showing differences in the ridges.

SIZE.—Length 1.28 mm.; hight 0.75 mm.; thickness 0.58 mm.

This species is in a general way much like *T. quadrilirata* but differs more or less obviously from that, as well as from all other species now referred to the genus, in having in all six ridges instead of the usual four. Two of this number however were produced by division of the posterior and antero-median ridges. All four of the inner ridges may be, as shown in the above cut, separate except at their lower ends where they unite with the marginal ridge. In others (see plate XLVI, fig. 12) the antero-median pair may be so near each other as to form practically but a single ridge. In others again this pair is united above and below but bent in such a manner that they enclose a crescent-shaped hollow space. Finally, in a few cases among Ohio and Manitoba specimens, the ventral connection between the inner and marginal ridges is obsolete.

The Minnesota specimens, although from a much lower horizon than the types, cannot be distinguished from them even as a good variety.

*Formation and locality.*—Galena shales (Nematopora beds), near Cannon Falls, Minnesota; upper beds of the Cincinnati or Hudson River formation at Oxford, Ohio, and Stony Mountain, Manitoba.

## Genus MOOREA, Jones and Kirkby.

*Moorea*, JONES and KIRKBY, 1867. Quart. Jour. Geol. Soc., vol. xxiii, p. 494; 1869, Ann. Mag. Nat. Hist., ser. 4, vol. iii, p. 225, and 1886, ser. 5, vol. xviii, p. 261; 1887, Proc. Geol. Assoc., vol. ix, p. 508.

Carapace very small, more or less oblong or ovate, with the valves compressed, rather thick shelled, smooth, punctate or granulose, and bounded by a raised marginal ridge; the ridge may be developed only at each end, or it may continue all around. Within the marginal ridge, the flat or gently convex surface shows no trace of a sulcus, pit, nor of lobes.

Types: *M. obesa* and *M. tenuis* Jones and Kirkby.

This genus is now for the first time recognized in Lower Silurian rocks, and two of the species to be described fairly illustrate the characters of the genus. The third, *M.? perplexa*, is of doubtful affinities. A fourth species, *M. smithii*, has been described by Prof. T. Rupert Jones from the Wenlock. This seems to be a questionable *Moorea*, the carapace being too convex and blunt at the ends, while the ridge, which should be submarginal, is here central and bifurcated posteriorly. A fifth species, *M. kirkbyi*, described from the Corniferous limestone of Ontario by the same author, is not far removed from *M. angularis*, while in the sixth *M. bicornuta* Ulrich, from the Hamilton, the anterior end bears two spines. *M. granosa* Ulrich, from the Chester group of Kentucky, is peculiar in having a granulose marginal ridge and a rounded subcentral spot outlined by a row of minute papillæ. The original types are from the Carboniferous rocks of southern England.

All these species are distinguished from *Kirkbya*, Jones, certain species of which they greatly resembly, by the absence of a central pit. Some also resemble *Placentula* Jones and Holl, and certain species of *Bollia*, but the first of these genera has a small dorsal loop and sulcus, while the latter always has a horseshoe-shaped ridge of which no trace is to be observed in *Moorea*. The valves in the new genus *Macronotella* are more convex and without the marginal ridge.

### MOOREA ANGULARIS, *n. sp.*

PLATE XLIII, FIG 89. PLATE XLVI, FIGS. 15–16.

SIZE.—Length 0.67 mm.; hight 0.40 mm.; thickness 0.23 mm.; length of hinge line 0.65 mm.

Valves compressed, suboblong, slightly leperditoid in outline, the posterior end a little wider than the anterior; hinge line straight, nearly or quite as long as the greatest length of the valve, with the dorsal angles acute; beneath them the outline is nearly semicircular; ridge thin, almost marginal, strongest ventrally, wanting or scarcely distinguishable dorsally; surface smooth, nearly flat.

Two specimens only have been seen of this species. Both are figured, the one from Minneapolis on plate XLIII, the other, from Fountain, on plate XLVI. The latter is the larger of the two and differs from the other, which is to be regarded as the type, in several respects. Possibly it is distinct, but as it has evidently suffered from weathering or maceration, the differences may not be normal, hence I perfer for the present to classify it as an *imperfect* valve of *M. angularis.*

The almost flat, though thick-edged valves of this species, cannot be mistaken, so that comparisons are quite unnecessary.

*Formation and locality.*—Middle third (Rhinidictya bed) of the Trenton shales, Minneapolis, and near Fountain, Minnesota.

### MOOREA PUNCTATA, *n: sp.*

PLATE XLIII, FIGS. 84–88.

SIZE.—Length 0.40 mm.; hight 0.24 mm.; thickness 0.18 mm.
Length 0.50 mm.; hight 0.32 mm.; thickness 0.22 mm.

Valves somewhat oblong-quadrate, the hinge nearly straight, about one-fifth shorter than the greatest length of the carapace; dorsal angles distinct; ends subequal; not strongly rounded, sometimes obliquely truncate above; marginal ridge developed along the anterior, ventral and posterior borders, thinnest and least prominent ventrally, thickest and somewhat club-shaped posteriorly, the ends terminating abruptly before reaching the dorsal angles; ridge usually continuous, but occasionally incomplete ventrally. Within the ridge the surface is flat and minutely punctate; above it descends abruptly to the hinge line.

A neat little species, reminding considerably of *Placentula excavata* Jones and Holl, and of species of *Bollia* like *B. vinei* J. and H., or *B. subæquata.* It is smaller than *Moorea angularis*, has less pronounced dorsal angles, a punctate surface, and different marginal ridge.

*Formation and locality.*—Upper third (Phylloporina bed) of the Trenton shales, St. Paul, Minnesota.

### MOOREA ? PERPLEXA, *n. sp.*

PLATE XLVI, FIGS. 17 and 18.

SIZE.—Length 0.85 mm.; hight 0.62 mm..

The figures present such a remarkable valve that I am quite unable to account for its peculiarities. Unfortunately the original of the drawings, which were made four years ago, has been mislaid or lost, so that I am obliged to publish them without a final verification of the characters shown. It may really be a *Moorea*, but I doubt it. Or it may be related to *Placentula*. With more material its affinities may become clear, and it is the hope that collectors will search for and perhaps succeed in rediscovering the species, that has induced me to retain it in my report.

*Formation and locality.*—Middle third (Rhinidictya bed) of the Trenton shales, near Fountain, Minnesota.

### Genus MACRONOTELLA, n. gen.

Carapace convex, semicircular or semiovate, with a long, nearly straight, hinge; valves equal, full centro-dorsally, without ridges or a sulcus, but exhibiting a smooth subcentral spot where the ornament is omitted; surface, in the only species known, coarsely punctate.

Type: *M. scofieldi*, n. sp.

I saw no way to escape the responsibility of erecting a new genus for the following species without forcing it into one of several that I am fully persuaded ought not to receive it. The long hinge, semicircular outline, and almost perfectly equal ends, rendering it difficult to distinguish one from the other, give it an expression peculiarly its own. *Kirkbya permiana* Jones, it is true, has a somewhat similar form, but like all the species of that genus, it has also a marginal ridge and a subcentral pit, neither of which are present in the species under consideration. Still, the smooth spot mentioned above probably represents the pit of *Kirkbya*, and it is with this genus that I think the affinities of *Macronotella* lie rather than with either *Aparchites* or *Isochilina*. The *Isochilina rectangularis* Ulrich (Jour. Cin. Soc. Nat. Hist., vol. 13, p. 182; 1890) from the Devonian at the falls of the Ohio, may be congeneric with *M. scofieldi*, there being some similarity in their outlines, but as the surface of the Devonian form is perfectly smooth and not inflated centro-dorsally, I hesitate to say it is.

### Macronotella scofieldi, *n. sp.*

PLATE XLIII, FIGS. 30—34.

SIZE.—Fig. 30. Length 1.57 mm.; hight 1.05 mm.; thickness 0.78 mm.
Fig. 33. Length 2.20 mm.; hight 1.33 mm.; thickness 1.05 mm.

Valves varying in length, semiovate or nearly semicircular, the dorsal outline not quite straight, being somewhat prominent centrally; free edges with a sharply impressed furrow, forming a beveled border; surface strongly convex, rather full in the centro-dorsal region, and marked, except on the ends and along the ventral border, by rather large and somewhat distant pits; a row of these pits, more closely arranged than usual, encircles a smooth subcentral spot.

Of the two specimens figured, the smaller is from Minnesota, the other from Kentucky. The latter, it will be observed, is not only larger, but also proportionally longer at the hinge line. The smooth spot, furthermore, is less centrally situated. I attach no importance to these differences, believing that they are quite within the ordinary limits of local, if not individual variation.

Named for Mr. W. H. Scofield, of Cannon Falls, Minnesota, to whom not only the author, but the Geological Survey of the state as a whole, is indebted for much valuable assistance. He has been particularly active in the development of the paleontology and stratigraphy of the Lower Silurian rocks of the state.

*Formation and locality.*—Lower Trenton limestone, near Cannon Falls, Minnesota; Birdseye limestone, High Bridge, Kentucky.

## Family CYTHERELLIDÆ.

### Genus CYTHERELLA, Jones and Bosquet.

*Cytherella* JONES, 1848, Subgenus of *Cythere;* Monog. Entom. Cret. Form., p. 28; BOSQUET, 1852, as a distinct genus; Desc. Entom. Foss. Terr. Tert., p. 10.
JONES and KIRKBY, 1867.
JONES, KIRKBY and BRADY, 1884. Monog. Carb. Etom., Pal. Soc. p. 70.

Carapace oblong or ovate, compressed, especially in front; smooth or pitted; valves thick and unequal, the right being much the larger and having its edge grooved or rabbeted all round on the inner side for the reception of the edge of the left valve; muscle-spot indicated by a roundish depression near the center of the valve externally, and by a corresponding thickening within. Length 0.5—1.4 mm.

Type: *Cytherella ovata* Rœmer sp.

This genus was founded upon Cretaceous, Tertiary and recent species, but no less than twenty Carboniferous forms, chiefly European, have been described as congeneric with the type by Jones, Kirkby, Brady and Ulrich. So far as their affinities may be determined from the carapace alone, the greater part if not all of these appear to be within the limits of the genus. Prof. Jones has also referred several Lower and Upper Silurian species to the genus, but here, it seems to me, the generic relations are in every case at least doubtful. The following two species at any rate, are almost certainly not *Cytherella*, yet they must be placed here because their known characters are more in accordance with this genus than with any of the others that have been established.

At present the principal diagnostic feature of *Cytherella*, that is, with the paleontologist, is the rabbeted edge of the right valve. This peculiarity, if my memory is not at fault, has not yet been shown to exist in any of the Silurian species hitherto referred to the genus. It does however exist, and very strongly developed too, in an undescribed species from the lower beds of the Cincinnati group. In this species, however, unless all the specimens seen (about twenty) are of one valve only, the edges of *both* valves are about equally grooved.

For remarks on *Cytherellina*, Jones and Holl, see under *Bythocypris* and *B. cylindrica*.

### CYTHERELLA ? SUBROTUNDA, *n. sp.*

PLATE XLIV, FIG. 43.

SIZE.—Length 0.5 mm.; hight 0.45 mm.

This species is founded upon a single carapace attached to the surface of a fragment of the zoarium of *Pachydictya foliata*. The smaller valve is exposed to view, and around it the overlapping edge of the larger, presumably the right valve, is distinctly defined. The outline is broad-oval, almost circular, and as near as can be determined, the surface of the smaller valve is moderately and quite uniformly convex, and exhibits neither a central depression, a tubercle, nor markings of any kind. The specimen was found in association with valves described on a preceding page as *Schmidtella ? subrotunda.* They are distinguished by a small, subcentral tubercle, but as they have the same rounded outline, it is possible that a better preserved series of specimens may show them all to belong to one species. That the synonomy may, in case the possibility is converted into a fact, be simplified, I have used the same specific name for both.

*Formation and locality.*—Lower third of the Trenton shales, Minneapolis, Minnesota.

### CYTHERELLA ? RUGOSA *Jones*, and var. ARCTA, *n. var.*

PLATE XLIII, FIGS. 21–25.

*Cytheropsis rugosa* JONES, 1858. Ann. Mag. Nat. Hist., ser. 3, vol. i, p. 254, pl. x, figs. 3 and 4; also 1858. Geol. Sur. Can., decade iii, p. 100.
*Cytherella? rugosa* JONES, 1891. Contri. Can. Micro.-Pal., pt. iii, p. 99.

SIZE.—Length 0.9 mm.; hight 0.58 mm.; thickness about 0.34 mm. Var. *arcta*, length 0.96 mm.; hight 0.53 mm. Prof. Jones' type specimen is said to be 0.83 mm. long, and 0.54 mm. high.

Carapace small, blunt at the ends; outline subreniform, rounded at both ends, the anterior one narrower than the other; of the upper and lower margins, one is nearly straight; the other strongly convex. Surface coarsely pitted, the pitting extending over all parts except a small spot situated, if we consider the straight margin as dorsal, beneath the center of the valves.

Fig. 25 represents a variety differing from the typical form in having the anterior end drawn out. It may be called variety *arcta*.

The generic position of this species is very doubtful. The typical form resembles *Aparchites minutissimus*, var. *trentonensis*, figured on the same plate, but the outline of var. *arcta* is much more like that of *Bythocypris cylindrica* Hall (see plate XLIV). It seems very doubtful to me that the species belongs to *Cytherella*, but as I am unable to suggest a better arrangement, I have adopted Prof. Jones' latest suggestion.

*Formation and locality.*—Top of the Galena shales (Nematopora bed), near Cannon Falls, Minnesota. Variety *arcta* is from the middle division of the Galena (Fusispira bed) near the same locality.

## Family CYPRIDÆ.

### Genus BYTHOCYPRIS, Brady.

*Bythocypris*, BRADY, 1880. Rept. Ostracoda, "Challenger," p. 45; JONES and KIRKBY, 1886, Ann. Mag. Nat. Hist., ser. 5, vol. xviii, p. 250; also 1887, Proc. Geologist Assoc., vol. ix, p. 510; JONES, 1887, Ann. Mag. Nat. Hist., ser. 5, vol. xix, p. 184; ULRICH, 1890, Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 196.

Carapace smooth, more or less reniform; left valve larger than the right, overlapping it on both the dorsal and ventral margins; dorsal margin strongly convex, ventral margin usually straight or slightly concave.

This is a recent genus into which a number of Paleozic Ostracoda have been placed by Prof. T. Rupert Jones and others. Whether this extension of the genus is justified or not, I am unprepared to say. It seems to me, however, that some of the species might with equal propriety be referred to other genera of the marine *Cypridæ*. But as I have not given the subject the thought and time which its great difficulty necessitates, my present judgment can have little value when opposed to that of Prof. Jones.

Respecting the species about to be described and those which I have in previous papers referred to *Bythocypris*, it is sufficient to say that in nearly every instance they agree closely with one or another of the species which Prof. Jones has placed under the genus.

It may be well to call attention to the fact that the Silurian genus *Cytherellina*, Jones and Holl,* is founded upon species very similar externally to some of the Silurian *Bythocyprides*. Whether any of the latter have the obscure internal thickenings of the test which are said to characterize *Cytherellina* is unknown, but considering the similarity of their external features, it seems a little strange that Prof. Jones has not remarked upon it in his more recent writings.

### Bythocypris cylindrica *Hall.*

PLATE XLIV, FIGS. 29–35.

*Leperditia (Isochilina) cylindrica* Hall, 1872, Twenty-fourth Rep. St. Cab. N. Y., p. 231, pl. VIII, fig. 12; Hall and Whitfield, 1875, Pal. Ohio, vol. ii, p. 101, pl. IV, fig. 5. (Figured in reversed position.)
*Isochilina cylindrica* Miller, 1875. Cin. Quart. Jour. Sci., vol ii, p. 351.
*Bythocypris cylindrica* Ulrich, 1889. Contri. Can. Micro.-Pal., p. 2, p. 48. (Not pl. IX, fig. 6.)
*Primitia minuta* (part.) (Eichwald) Jones, 1890. Quart. Jour. Geol. Soc., vol. xvi, p. 7, pl. III, figs. 18 and 19; not figs. 21—23.

Size.—Length 1.30 mm.; hight 0.65 mm.; thickness 0.5 mm.
Length 0.71 mm.; hight 0.32 mm.; thickness 0.23 mm.

As the characters of this species have been quite generally misinterpreted, I have taken the trouble to illustrate them as far as shown in three typical examples. Of the two series of measurements given above, the first may be regarded as a fair average for fully grown specimens, while the other is taken from one of the smallest seen. The length usually varies between 1.0 and 1.2 mm., and occasionally it reaches 1.5 mm. Figures 29, 32 and 34, though differing as much in their outlines as any in hundreds of valves, are but little unlike each other, and thus prove, in this respect at any rate, the constancy of the species. The greatest variability noticed is a slight one in the relative degree in which the central third of the ventral slope is flattened or hollowed out. It is never much, yet always distinguishable. The valves are slightly unequal, the left, being the larger, overlapping the right on both the dorsal and ventral margins.

On the inner side of the valves (fig. 32) a subcentral thickening of the test is noticeable. Though slight, it covers considerable space, especially in its vertical extent, and is of such a nature that it would cause a shallow vertical furrow on casts

* Ann. Mag. Nat. Hist., ser. 4, vol. iii, 1869. In this paper the authors redescribe the type species, *siliqua*, which Jones had in 1855 described from casts of the interior as a *Beyrichia*, and the new varieties *grandis*, *tersa* and *ovata*. The last is similar to *Bythocypris curta* of this report, but is not so equilateral, having the anterior end more produced; while the typical form of *C. siliqua* greatly resembles *B. cylindrica* Hall, sp.

of the interior. This internal thickening recalls *Cytherellina siliqua* Jones, which this species also resembles in its external characters, but the casts of that species are marked with two sulci instead of one. Still, I am not all satisfied that these two forms are not strictly congeneric. The sulcus in the casts of *B. cylindrica* being just behind the center, it corresponds with the posterior one of the two in the *Cytherellina.* As to the anterior one, would its absence be of any great consequence? While it does not seem to me now that it would be, it is deemed wisest to defer a decision on the point, since the verdict would necessarily involve many others of the paleozoic species now referred to *Bythocypris.* Of the latter, *B. testacella* Jones, from the Wenlock of England, differs chiefly in being more elongate and less broadly rounded posteriorly.

In the Canadian publication above cited, I referred a valve from the Hudson River group of Manitoba, to this species. That the identification was incorrect, I am now fully convinced. The figure, which was probably drawn in a reversed position, shows a left valve, agreeing very closely with the Wenlock species *B. concinna* Jones. Perhaps it should be referred to that species, but it would be well to await the discovery of more conclusive evidence before such a course is finally decided upon.

It is scarcely necessary to show why *B. cylindrica* is neither a *Primitia* nor a *Leperditia.* As to its identity with Eichwald's *Cypridina*, later *Leperditia minuta*, which Prof. Jones refers to *Primitia* (*loc. cit.*) and I to the new genus *Primitiella*, is a question that it seems to me can be answered only in the negative. The *minuta*, as figured by Prof. Jones from Russian examples of the species, has dorsal angles with a long straight back, giving it on the whole a decided primitian aspect, which certainly is not the case with the true *B. cylindrica.* In the same paper Prof. Jones figures two Cincinnati specimens, presumably of the latter species, to show their similarity or identity with the Russian *P. minuta.* He represents them as having a straight hinge and obtuse dorsal angles, the valves being figured, according to my interpretation, in a reversed position. As to these features I can only say that I have never seen any specimen in which they were present; and this can scarcely be because of a lack of material, for, of all the Cincinnati Ostracoda, *B. cylindrica* is by far the most abundant. Prof. Jones' figures being like Hall's figure of the species, is it not possible that the drawing of the former was biased by an examination of the latter?

*Formation and locality.*—Rare in the Galena shales near Cannon Falls, Minnesota. Very abundant in the lower beds of the Cincinnati group, at numerous points in the vicinity of Cincinnati, Ohio. Very large specimens, 2.0 mm. and more in length, occur in the upper beds of the same formation. These were referred to the species by Dr. S. A. Miller, but are not taken into account here because they are probably distinct.

## Bythocypris (?) curta, *n. sp.*

PLATE XLIV, FIGS. 36—38.

Size.—Length 1.03 mm.; hight 0.75 mm.; thickness 0.48 mm. A larger specimen has a length of about 1.5 mm.

This is an unusually short, subovate form, the ends being nearly equal and, with the dorsal margin, forming an almost regular elliptic curve; ventral outline straight centrally; surface smooth; valves moderately and uniformly convex, one larger and strongly overlapping the other above, below and at one end. The end having no overlap is slightly narrower than the other.

The subequality of the ends, especially as regards thickness, makes it difficult if not impossible to determine with certainty which is the right and which the left valve. As a *Bythocypris* the larger of the two must be on the left side, and if this is correct for the species, then the blunter of the two ends would be the anterior. In *Macrocypris*, a genus containing mostly elongate species, the right valve overlaps, but the carapace in the present species is too short for that genus. Of known species *B. ovata* Jones and Holl, a Wenlock form originally described as a variety of *Cytherellina siliqua*,* may be nearest, but differs like all other species of *Bythocypris* in being longer.

*Formation and locality.*—Middle third (Rhinidictya bed) of the Trenton shales, St. Paul, Minnesota.

## Bythocypris granti, *n. sp.*

PLATE XLIV, FIGS. 39—42.

Size.—Length 1.40 mm.; hight 0.68 mm.; thickness 0.7 mm.
Length 1.17 mm.; hight 0.57 mm.; thickness 0.6 mm.

Valves strongly convex, especially so ventrally, somewhat elongate elliptical in outline, the ventral margin convex but not so much as the dorsal, the ends subequally rounded but with the posterior one a little blunter than the anterior; surface smooth.

This species is readily distinguished from *B. cylindrica* Hall, by its more equal ends and convex basal outline. It seems to be closely related to *B. concinna* Jones, of the Wenlock shales of England, but the outline is a little different and the valves thicker in the ventral part. The left valves of *Kraüsella inæqualis* and *K. arcuata* are somewhat similar yet not enough so to render confusion between them at all likely.

The species is named for the promising geologist, Dr. Ulysses S. Grant, of the Geological Survey of Minnesota.

*Formation and locality.*—Middle third (Rhinidictya bed) of the Trenton shales, St. Paul and Minneapolis, Minnesota.

*Ann. Mag. Nat. Hist., ser. 4, vol. iii. pl. XIV, fig. 4; 1869.

BYTHOCYPRIS (?) ROBUSTA, *n. sp.*

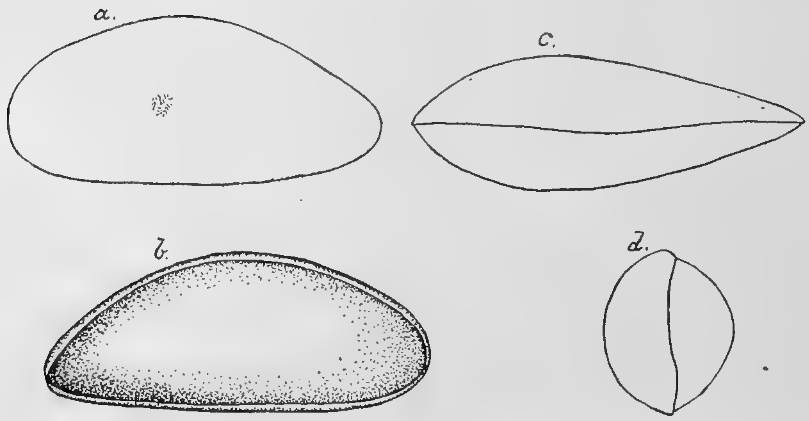


Fig. 52.—*a*, a left valve, with somewhat blunter ends than usual, showing position of subcentral spot; *b*, right side of entire carapace; c and *d*, ventral and posterior outline views of same; lower Trenton ("Lower Blue limestone"), Dixon, Illinois.

SIZE.—Length 2.5 mm.; hight 1.05 mm.; thickness 0.87 mm.

Carapace elongate, subelliptical or obscurely triangular, the outline convex dorsally and nearly straight or gently arcuate ventrally; anterior end strongly rounded and somewhat higher (blunter) than the posterior. In a ventral view the outline is wedge-shaped, the higher or anterior end being much more attenuate than the other. Valves rather strongly convex, unequal, the left overlapping the right all around except at the posterior extremity; dorsal edge of left valve somewhat thickened; posterior extremity of right (smaller) valve subacute; surface smooth; each valve occasionally showing a small discolored spot a short distance in front of the center.

The affinities of this fine species are doubtful. It is not a true *Bythocypris*, nor is it any more like either *Macrocypris* or *Pontocypris*. Perhaps it should be placed under *Bairdia* since it resembles certain species that have been referred to that genus by Jones and Holl. Yet, after a careful comparison with numerous Devonian and Carboniferous species of *Bairdia*, I have come to doubt the propriety of recognizing that genus in any of the known Lower Silurian species. The acuminate posterior extremity of the right valve reminds as much of the new genus *Krausella*, and it is an alliance with this genus that I would favor more than with *Bairdia*.

Specifically, *B.? robusta* will be distinguished at once from all known Lower Silurian *Cypridæ* by its large size.

*Formation and locality.*—Lower Trenton limestone, Dixon, Illinois, where it was found abundantly in association with *Krausella inæqualis* and *Schmidtella crassimarginata.*

## Family BEECHERELLIDÆ.

### Genus KRAUSELLA, n. gen.

Carapace small (1.5 to 2.5 mm. in length), somewhat elongate, subelliptical, obscurely triangular or semiovate in outline, the dorsal margin more convex than the ventral, the latter straight or but gently convex; with moderately thick and very unequal valves; right valve the smaller, drawn out posteriorly into a strong spine-like process; left valve overlapping the right all around.

Type: *Krausella inæqualis*, n. sp.

At present I am acquainted with only four species that should be placed in this genus, viz.: the two about to be described, *Bairdia anticostiensis* Jones (Quart. Jour. Geol. Soc., vol. xlvi, p. 548; 1890) from the Hudson River or Cincinnati formation of the island of Anticosti, and an undescribed form (near *K. arcuata*) which is rarely met with in the upper beds of the same formation in Ohio and Indiana. These species do not agree with *Bairdia* since the spine-like process is not formed by the tapering ends of *both* valves, but is restricted to the right valve, the left valve being rounded posteriorly and resembling the corresponding valve of a thick-shelled *Bythocypris*. We have therefore the difference that while the two valves of a *Bairdia* are similar in outline, they are quite different posteriorly in *Krausella*.

The spine-like process reminds of some of the species placed by the author under his genus *Beecherella*.* If there is any true relationship between *Krausella* and *Beecherella*, and I confess that I am strongly inclined to believe there is, then the *Beecherellas* were probably all described and figured in a reversed position. Another thing that has become more evident than formerly is that more than one generic type has been included under *Beecherella*. Considering the strongly marked peculiarities of the type species, *B. carinata*, it seems probable that we shall eventually find it desirable to restrict the genus to it.

Of *B. subtumida* we know only the right valve, and this is exceedingly like the same valve of *Krausella arcuata*. Still, I hesitate to say that it should be referred to the present genus since it may be shown that it, like *B. cristata*, has the posterior spine on the overlapping instead of the smaller valve. In the last species namely, the right valve seems to overlap the left, though the overlap is very slight and scarcely distinguishable. Should the relations of the valves (with respect to overlap) in these two species prove to be really the reverse of what we know to be the case in *Krausella*, a distinct generic grouping for them would probably be justifiable.

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* American Geologist, vol. viii, pp. 197-204, pl. 2, October, 1891. In this paper the author describes the new genus *Beecherella*, with six new species and one variety, all derived from the Lower Helderberg strata of New York.

*Beecherella ovata* is too imperfectly known to be referred to any genus definitely, but *B. navicula* and *B. angularis* are generically distinct from *B. carinata* as well as from *B. subtumida* and the species of *Krausella*. Leaving out *B. ovata.* we have then at least three and probably four, more or less closely related generic groups, which it seems to me may be justly referred to collectively as the *Beecherellidæ.*

### Krausella inæqualis, *n. sp.*

PLATE XLIV, FIGS. 44–46.

Size.—Length 2.3 mm.; hight 1.17 mm.; thickness 0.8 mm.

Carapace elongate-subelliptical, the ventral outline longer and straighter than the dorsal, the ends, excluding the posterior spine, subequal and most prominent in the lower half; outline in a ventral view elongate rhomboidal, in an end view subtriangular, the lower part being very thick. Valves thick, very unequal, the larger (left) strongly overlapping the other; basally the left valve turns inward abruptly, causing a decided flattening of the ventral edge; right valve moderately convex, with the dorsal and ventral margins subparallel, the dorsal edge being less curved than in the left valve; behind it is drawn out into a strong blunt spine-like process, the point of which extends a short distance beyond the edge of the opposite valve. Surface of valves without markings of any kind so far as observed.

This is a well marked species, distinguished chiefly by the great ventral thickness and relatively high position of the posterior spine. The latter may be a little lower and the dorsal outline somewhat more convex than in the specimen illustrated on plate XLIV. The inequality of the two valves is so great that, unless found in their natural position, they would scarcely be suspected of belonging together.

*Formation and locality.*—Lower Trenton limestone, Dixon, Illinois. (Stone's River group, Vanuxemia bed).

### Krausella arcuata, *n. sp.*

PLATE XLIV, FIGS. 47–53.

Size.—Length 1.9 mm.; hight 0.82 mm.; thickness about 0.58 mm.
Length 1.7 mm.; hight 0.70 mm.
Length 1.8 mm.; hight 0.70 mm.

In this species the outline is nearly semicircular or semielliptical, the basal line being straighter and the dorsal margin more arcuate than in *K. inæqualis.* The posterior spine also is more slender and situated lower, the point in some instances being almost on a line with the ventral edge of the right valve. Finally, the left valve is more uniformly convex, the upper half of the surface being fuller, while the ventral portion is much less prominent. Of all these differences the most striking and perhaps the only important one is the last.

*Bairdia*, or as it should now be called, *Krausella anticostiensis* Jones, sp., is represented as having a much blunter anterior outline, but in the Cincinnati formation of Ohio and Indiana we have a species that comes much nearer, the anterior end of the right valve being quite as narrow, only the most prominent point is higher.

*Formation and locality.*—Lower third of the Trenton shales, Minneapolis, Minnesota; lower Trenton limestone, Mineral Point, Wisconsin, and Dixon, Illinois; Birdseye limestone, High Bridge, Kentucky.

# COMMUNICATION.

PROFESSOR N. H. WINCHELL, *State Geologist.*

SIR:—At your request I have prepared the following discussion and illustration of the trilobites collected from the various faunas of the Lower Silurian in the state of Minnesota. In transmitting this paper for publication in your reports, permit me to record the obligation which I feel to you personally for the opportunity of studying and making notes upon this series of interesting fossils. At your instance only would the work have been possible.

My indebtedness to Mr. E. O. Ulrich, the paleontologist of your survey, is also great, as he has placed at my disposal his private collections, not alone of Minnesota trilobites, but of those from other Lower Silurian localities, and this material has contributed substantially to the fullness of these observations. He has also aided me with various timely and apt suggestions of which I have appreciatively availed myself.

Several gentlemen have, through you, kindly submitted specimens of these Crustacea for the purpose of this work: Mr. W. H. Scofield, of Cannon Falls, Dr. C. H. Robbins, of Wykoff, and Mr. R. H. Hasse, of Granger. By the favor of Prof. C. E. Beecher, some specimens collected by Mr. Charles Schuchert and now belonging to the Peabody Museum of Yale University, have been placed in my hands. To all these I beg to express here my appreciation of their consideration; to Mr. Schuchert especially for his friendly interest in the furtherance of the work.

I have the honor to remain, sir,

Very respectfully yours,

JOHN M. CLARKE.

*Albany, N. Y., January 2d, 1893.*

# CHAPTER VIII.

# THE LOWER SILURIAN TRILOBITES OF MINNESOTA.

BY JOHN M. CLARKE.

## INTRODUCTION.

The trilobites have long invited the attention of observers, the curiosity of the novice, and the most intelligent scrutiny of the student. Much of this interest lies in the frequent beauty of their preservation, their abundance, their complication of structure, and, no doubt, largely in the fact that the organic plan upon which they are constructed is long since extinct or only obscurely recognizable among their living descendants. It has been for the paleontologist to elucidate not only the various modifications of this plan of structure, but to demonstrate the anatomy both of their hard and soft parts, their alterations of form in the process of development from infancy to old age, the rise, progress and decline through time of subsidiary structural types. For this work science acknowledges its obligation to the pioneer investigations of Dalman, Brongniart, DeKay, Green, Pander, Emmrich and Burmeister; to those of McCoy, Salter and Woodward upon the species of Great Britain; of Beyrich, Corda, Barrande, Kayser, Novák upon those of Germany and Bohemia; of de Verneuil, Rouault, Barrois, Œhlert, Bergeron upon those of France; of Meneghini upon the Sicilian species; of Pander, Nieszkowski, Eichwald, Schmidt on the Russian species; Angelin, Holm in Scandinavia, and Hall, Ford, Walcott, Matthew and Beecher in North America; a list to which many names might be added.

The Trilobites have proved of first importance to the stratigraphical geologist as indices of geological age, and every new series of investigations emphasizes the importance of their various modifications to the student who busies himself primarily with the structure of the earth and the correlation of the early sedimentary deposits. To the names above given we should append those of investigators who have apprehended the trilobites mainly from this point of view; Conrad, Emmons, Murchison, F. and A. Roemer, Linnarsson, Dames, Billings, Whitfield.

## Terminology.

As a peculiar terminology of the parts of the trilobite has been generally adopted it will be useful to the student to recount in brief the signification of the terms employed in the following descriptions.

The trilobite derives its name from the longitudinal lobation of the test into three parallel divisions. The central division alone covers the vital and essential organs of the animal, the lateral portions being virtually protective integumentary expansions. Transversely the test is also composed of three parts, a head-plate, or

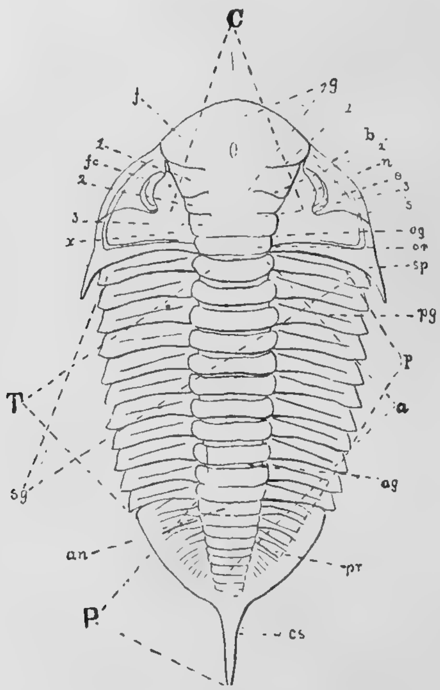


Fig. 1—*Diagrammatic figure of a trilobite.*

*C.* Cephalon.
*g.* glabella
*f.* frontal lobe.
*1, 2, 3.* 1st, 2d and 3d lateral lobes.
*1', 2', 3'.* 1st, 2d and 3d lateral furrows.
*x.* fixed cheeks.
*fc.* free cheeks.
*s.* facial suture.
*e.* eye.
*n.* palpebral lobe.
*og.* occipital groove.
*or.* occipital ring.
*b.* border.

*T.* Thorax.
*sg.* segment.
*ag.* articulating groove.
*pg.* pleural groove.

*P.* Pygidium.
*an.* annulation.
*pr.* pleural rib.
*cs.* caudal spine

*a.* axis.
*p.* pleuræ.

*cephalon, C,* which corresponds in a certain sense with the cephalo-thorax of the crab and lobster; a median segmented portion or *thorax, T,* and a tail-plate, or *pygidium, P.* Each of these parts is in articulation with that adjoining. The central longitudinal lobe of the body is called, in its extent over the cephalon, the *glabella, g;* on the thorax and pygidium, it is known as the *axis, a.* The lateral longitudinal lobes are, on the cephalon, known as the *cheeks, x*; on the thorax and pygidium as the *pleuræ, p.* The two longitudinal grooves dividing the entire test are the *dorsal furrows.* The glabella partakes of a segmentation similar to that of the thorax, but incomplete, the dividing grooves rarely extending across it. These grooves are the *lateral glabellar furrows* and are usually in three pairs (sometimes four, and sometimes wholly obscured) which are numbered by pairs from the anterior backward (*1′, 2′, 3′*). Of the lobes formed by these furrows the anterior, or *frontal lobe, l,* is large and unpaired; thence backward the *lateral lobes* are numbered to correspond with the furrows, each lobe lying behind the furrow with which it corresponds numerically, (*1, 2, 3*). The posterior end of the glabella is limited by a transverse furrow, the *occipital groove, og,* behind which lies a distinct segment or *occipital ring, or;* both of these extend on to the cheeks of the cephalon and form a coalesced segment.

The lateral expansions of the cephalon or the *cheeks* are usually divided into two parts by a *facial suture, s,* which extends from the posterior or lateral margin to the anterior margin. The test was readily separable along these lines after the sloughing of the integument or the decomposition of the lining tissue. The outer or separable portions are known as the *free cheeks, fc,* the inner portion between the sutures and the dorsal furrows, as the *fixed cheeks, x.* In a few genera the facial sutures are obscure or not developed, but where they exist the cephalon consists of three plates, two free cheeks and a central intrasutural plate to which the term *cranidium* is here applied. The cranidium consists of the glabella, fixed cheeks and a greater or less portion of the occipital ring. The outer lateral margin of the cephalon may be thickened into a *border, b,* which meets the occipital ring at the outer posterior angle of the cheek (*genal angle*). This angle may be obtuse, acute or produced into spines of greater or less length (*genal spines, sp*). The *eyes,* which are present in all but a few very early genera, are situated on the cheeks and are traversed by the facial sutures which leave the inner portion of the eye-node (*palpebral lobe, n*) on the fixed cheek, and the outer, visual portion (*e*), or that bearing the lenses, on the free cheek.

The *thorax, T,* is composed of a variable number of movable, separable parts or *segments, sg.* The axis of each bears an anterior ring which is overlapped by the outer ring of that preceding, and thus forms an articulation. The groove between the double axial ring of each segment is called the *articulating groove.* The pleuræ are frequently beveled on their anterior surface near their extremities, so that adjoining segments readily slipped over one another when the animal contracted or enrolled itself. The lateral parts of the segments are frequently divided transversely by a *pleural groove, pg.* The extremities of the segment may be acute or obtuse.

The *pygidium, P,* consists of a number of anchylosed segments, their parts on the axis being known as *annulations, an,* and on the pleuræ as *ribs, pr.* The ribs may terminate within the margin of the shield or be produced beyond it. The extremity of the pygidium may be obtuse, angular or continued into a *caudal spine, cs.*

The test of all the parts is continued beyond and beneath the margin, the enfolded portion or *doublure* extending but a short distance inward. This is trans-sected by the anterior limbs of the facial suture, or by a branch or branches from those limbs. That portion of the doublure lying beneath the anterior extremity of the head and sometimes isolated by the sutures is the *epistoma.* Below this lies a free subquadrate or subtriangular plate, the *hypostoma.* The doublure is more or less distinctly developed at the extremities of the thoracic segments and within the margin of the pygidium.

# Class ARTHROPODA.

## Subclass CRUSTACEA.

## Order TRILOBITA.

### Family CALYMMENIDÆ.

### Genus CALYMMENE, Brongniart, 1822.

#### CALYMMENE CALLICEPHALA *Green*, 1832.

*Calymmene callicephala* GREEN, 1832. Monogr. Trilobites N. Amer., p. 30, cast 2.
*Calymmene senaria* MEEK, 1873. Palæontology of Ohio, vol. i, p. 173; pl. 14, figs. 14*a f*.

There are a number of small and quite perfect individuals from the Galena horizon which agree in all essential features with Ohio fossil. While following Mr. S. A. Miller and later writers in employing Green's designation for this species, I feel that there is still a shadow over its accuracy, for the following reason: The specimen upon which the species was founded and which was very accurately reproduced in Green's cast No. 2, was an extended individual, showing the peculiarly broad axis of

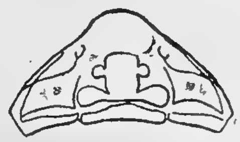

Fig. 2.—Outline of cephalon of *Calymmene callicephala* Green. From the cast of the original.

the Cincinnati specimens, but having a very short glabella. The latter had been somewhat abraded, giving it apparently abnormal width, and I have not seen another example in which the width at the base is so great compared with the length of the glabella, and at the same time the anterior edge of the glabella so remote from the frontal extremity of the cephalon. To indicate this structure I have introduced an outline figure of the cephalon taken from this cast. It is stated in the original description that this specimen was labeled in the collection of the Philadelphia Museum as from Hampshire, Virginia; the author, at the same time speaking of others from the Miami river and near Cincinnati. There is, thus, no doubt of his intention to include the well known Hudson River form under this name:

Conrad's *Calymmene senaria** and Green's *C. blumenbachi*† from Trenton Falls, N. Y., are distinct from *C. callicephala,* as shown by the accompanying figure of the cephalon of the latter, which indicates the decided genal spinules and the long shovel-shaped, not abruptly concave, anterior extension. The Cincinnati form may

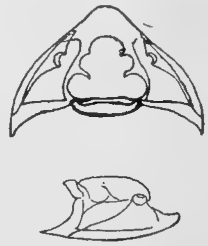

Fig. 3.—Outlines of cephalon of *Calymmene senaria* Conrad, Trenton Falls, N. Y.

also occur in the Trenton fauna of New York as it does in the Hudson River or Lorraine shales of that region, but the usual Trenton species must retain the name proposed for it by Conrad.

Among the Minnesota specimens is one to which my attention has been especially directed by Mr. Ulrich, from the Hudson River group near Spring Valley, bearing a cluster of coarse tubercles on each segment of the axis near the dorsal furrows. I am disposed to believe that the original size of these tubercles has been enlarged by a slight deposit of tufaceous matter upon them, but even if this supposition be correct the tubercles must have been larger than usual on this part of the test. The epidermal granulations are seldom well retained in the Ohio specimens but some of the Minnesota examples show them distinctly, while in the New York specimens they are clearly defined over the entire dorsal surface.

*Formation and locality.*—Galena shales, St. Paul, Cannon Falls; Hudson River group, near Spring Valley, Minnesota.

## Family ASAPHIDÆ.

### Genus ASAPHUS, Brongniart, 1822.

### Subgenus ISOTELUS, DeKay, 1824.

The original species of *Asaphus, A. expansus* Wahlenberg, is of a type which does not appear to be represented in the American faunas. Its lobate glabella, distinctly segmented pygidial axis, and narrow thoracic axis, are sufficiently distinctive to give the term a morphological value when thus restricted. DeKay's term *Isotelus,* very significant and proposed two years later, includes species with broad axis and obsolete segmentation at maturity. We therefore believe that an excellent purpose

*4th Ann. Rept. Pal. Dept.; N. Y. Geol. Survey, p. 49; 1841.
†*Op. cit.*, p. 28, cast 1.

is subserved in the retention of this name. For purposes of comparison a copy of Dalman's figure of *Asaphus expansus* is here introduced.

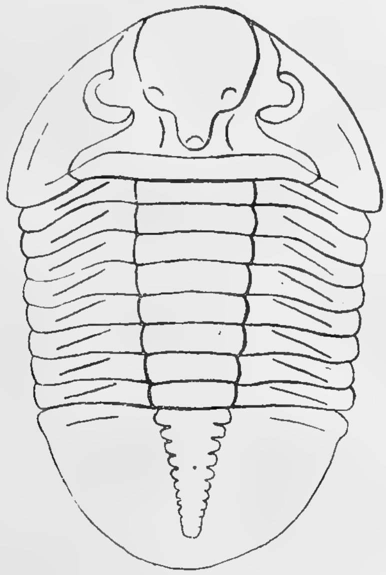

Fig. 4. Outline of *Asaphus expansus* Wahlenberg (after Dalman).

### Isotelus gigas *DeKay*, 1824.

*Isotelus gigas* DeKay, 1824. Annals Lyceum Nat. Hist. N. Y., vol. i, p. 174, pl. 12, fig. 1, pl. 13, fig. 1.
*Asaphus platycephalus* (Stokes) of most authors.

### Isotelus maximus *Locke*, 1838.

*Isotelus maximus* Locke, 1838. Second Ann. Rept., Geol. Surv. Ohio, p. 246, figs. 8, 9.
*Isotelus megistos* Locke, 1841. Trans. Amer. Assoc. Geol. and Nat. p. 221, pl. 6.
*Asaphus megistos* (Locke) of most authors.

In referring to these two widely known trilobites under the same caption, it is not the intention to assume their specific identity. It is, however, on many accounts convenient to consider them together, as careful study of a large series of both forms has elicited some important suggestion concerning their mutual relations.

The usual basis of distinction between these contemporaneous fossils is an exceedingly simple one. Constructed upon essentially the same specific type, the one, *I. gigas*, is devoid of cheek spines; the other, *I. maximus*, possesses them. It is hardly necessary here to enter into a detailed account of the characters of these fossils. They have been given at length by various authors, Hall,[1] Burmeister,[2] Meek,[3] Miller,[4] and others.

In the original specimens the conventional distinction between the species was clearly indicated. DeKay's figures, one of an enrolled example, one of an extended

(1). Palæontology of New York, vol. i, p. 231; plates 60, 61, 62, 63, 1847.
(2). Organization of the Trilobites (Ray Society's translation), p. 110, pl. 2, fig. 12, 1843.
(3). Palæontology of Ohio, vol. i, p. 159, pl. 14, fig. 13, 1873.
(4). Cincinnati Quart. Journ. Science, vol. i, pp. 137, 138, 1874.

individual, both show that the cephalon was without cheek spines. In Locke's figures (in part a restoration) of his *I. maximus* published in 1841, the cheek spines are given full importance as a differential character. Writers have found apparently distinctive differences in some other respects; a broader, more obtusely angular head and tail-shield and a relatively wider thoracic axis in *I. gigas.* Others, again, notably Locke and Miller, ascribe to *I. maximus* the broader, more crescentic shields.

My observations upon extensive series of these two forms from the New York Trenton have convinced me that specimens of each, preserved without casual distortion of the parts furnish positively no basis for a specific distinction in any of these respects, while it is easy to find grades of difference in these features varying with the degree of vertical compression of the test. Normally, in both the spinous and aspinous forms, the cephalon and pygidium are elongate subtriangular, the extremities being subacute, slightly flattened or extenuate. The facial sutures meet at an acute angle at, or just behind the frontal margin. The glabella is obscurely defined and more obscurely lobate, traces only of the lateral furrows being visible in an oblique light. The cheeks bear an intramarginal furrow, above which their general surface is elevated into a more or less conspicuous node, crowned by the eye. The occipital ring and furrow are quite obsolete. The axial furrows of the thorax are distinct, the axis itself broad, considerably more than one-third the width of the thorax. The lobation of the pygidium is very obscure. The dorsal furrows being hardly distinguishable, The axis is much narrower at its beginning on the pygidium than at its termination on the thorax, but in mature specimens its outline is scarcely discernible. Even a slight compression of the test, bringing the thinner or less resistant portions under strain gives an unnatural distinctness to the lobation of the cephalon and pygidium and likewise an abnormal width to the axis. The specimens of both of these forms from the schistose strata of Minnesota and Ohio more generally evince these effects of compression than those from the purer and more homogeneous limestone of Trenton Falls.

The specific type of these forms being in general the same, there are still to be considered the important points of difference at first mentioned. It is, in a general sense, true of the New York examples that the aspinous head shield occurs only in individuals of large size; that is to say, *I. gigas* is almost invariably a large asaph. I have not seen a well defined and clearly indubitable specimen of the aspinous head as small as the average spinous cephalon, nor a head of *I. maximus* as large as an average *I. gigas.* Among the fossils of this region *I. maximus* rarely exceeds a length of 60 mm., which would be small indeed for an *I. gigas,* of which individuals measuring 200 or 250 mm. in length are not at all uncommon. Among the Minnesota specimens the same fact holds; the largest, and indeed the only well defined specimen of *I. gigas* that I have seen has a length of 180 mm. The smaller specimens of the same type, so far as their preservation permits the determination, possess cheek spines.

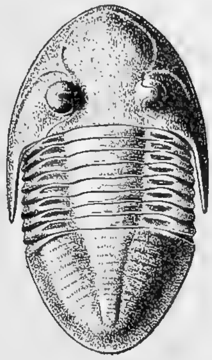

Fig. 5.—*Isotelus maximus* Locke. Hudson River group, Granger.

It would appear that among the specimens from the Hudson River group of Ohio, Indiana and Illinois, this is not always the case, as Locke's immense original and its specific name itself indicate.* Here, locally, the occurrence of large fragments of spiniferous heads is not altogether infrequent, perhaps even predominant with reference to the aspinous heads; but whether the rule or the exception in that locality, it need not modify the purport of our argument.

The morphological significance of the cheek spines in the trilobites has not been demonstrated, nor have they invited especial attention. Undoubtedly their significance varies in different groups. In this group with the evidence now at hand, we find a suggestion of their meaning. To present these points with the greater lucidity a few general remarks will be appropriate, bearing upon the developmental characters of the species under consideration, and upon the phylogeny of the asaphs.

In *Isotelus maximus*, advancing growth is accompanied by gradual obscuration of all lobation. In the average adult of the New York Trenton, as described above, this obsolescence of surface division is well advanced, but in immature individuals the degree of lobation (especially of the parts of the pygidium, viz.: the definition of the axis, its annulations and the ribs of the pleuræ), is proportioned inversely to the size of the animal. Young entire individuals, 15 mm. in length, and many young pygidia belonging to animals not much larger have the segmentation so clearly developed that both ribs and annulations may be distinctly counted, the normal convexity of the shield being, meanwhile, undisturbed. Sharp lobation of the test

*It might, I think, be a fair question whether the spines in this figure were not "drawn in" from some smaller example retaining them. Without impugning the acumen of this observer, one cannot but be impressed with the fact that this original, if correctly represented, excelled in size and perfection of details all that the rocks have since afforded.

is hence an immature condition in this species. In the development of the asaphoid stock, we find in the earlier Silurian *Ptychopyge* and *Niobe* this sharp lobation of the caudal plate a normal character of maturity.

Similar evidence is furnished by many genera of trilobites and may be expected from all. In *Homalonotus,* for example, external lobation of the parts at maturity regularly decreases from the appearance of the genus to its extinction. In the last representative in American faunas *(H. dekayi,* of the Hamilton group) segmentation of the terminal plates is almost wholly lost, but young and normally convex individuals of the species are distinctly segmented, like the mature examples of *H. major*, from the Oriskany, and *H. vanuxemi,* from the Lower Helderberg faunas. The genus *Phacops,* in its restricted meaning, is conveniently divisible into species having the pleural ribs of the pygidium grooved and those having them simple. The former precede the latter in time. All the American Silurian and early Devonian species belong to the former division, while *Ph. rana* of the middle and later Devonian is the only representative of the latter, as well as the last member of the genus. Very young individuals of *Ph. rana*, however, evince the duplication of the pygidial ribs. Instances of this kind might be multiplied.

Returning to the young of *Isotelus maximus,* we meet with a high development of the genal spines, which may extend as far as the sixth thoracic segment. In individuals which appear to be full grown, those in which the obsolescence of segmentation is well advanced, these spines rarely pass the second or third segment. This difference in size is, however, quite variable and somewhat irregularly so. In Owen's species *Isotelus iowensis,* another form constructed on the same specific type as those under consideration, the spines are represented in the restored figure given by this author* as extending to the caudal shield, though the medal-ruled engravings in the same work, taken from actual specimens do not indicate this length. Accepting the restored figure as correct it appears that these long spines are associated with a more distinct segmentation of the pygidium than is normal to either *I. gigas* or the adult *I. maximus;* and judging from this evidence alone (I have had no opportunity of examining authentic specimens of this form), this would seem to be the condition of normal maturity.

Among the Minnesota specimens is an enrolled individual conforming fully to the general specific type of *I. gigas-maximus* in its elongate subtriangular head and tail shields, and bearing a minute spinule at the genal angle, which could not have extended more than half way across the first thoracic segment. This individual is above the average size of the *I. maximus* of the Trenton limestone. In another

*Geological Survey of Wisconsin, Iowa and Minnesota, pl. 2, fig. 3. 1852.

specimen from the Trenton horizon of New York of about the same size as the foregoing there is no spine, but at the angle of the cheek there is a distinct puckering

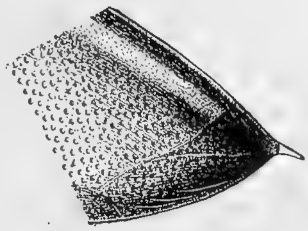

Fig. 6. Genal extremity of *Isotelus gigas maximus*, with minute spinule, × 3.

of the test, making a small, acute tubercle. This evidence goes to indicate that the cheek spine in these asaphids is a character of immaturity, diminishing in size as the adult condition is approached.

Fig. 7.—Genal extremity of *Isotelus gigas-maximus*, with puckered, but aspinous apex. Trenton limestone, N. Y.

In the earlier representatives of this generic type where segmentation of the pygidium is retained at maturity (*Ptychopyge*), the long cheek spines are also retained, *e. g. Asaphus romingeri* Walcott, of the Black River limestone; and, as observed above, the adult condition of such species is to be regarded as phylogenetically immature. The sporadic or restricted local appearance of genal spines in large individuals, an occurrence of rarity, is a natural exception to normal processes, the retention of infantile characters at maturity, or their resumption in the senile condition, occurring alike in individuals, species and races. The *Isotelus canalis* Whitfield, sp., is an early Trenton (Birdseye) or Calciferous form, very closely similar in all specific values to *I. gigas-maximus*, retaining, however, at maturity cheek spines, without the segmentation of the cephalon and pygidium. Our acquaintance with this form is essentially restricted to the single large, enrolled, distorted and otherwise imperfect specimen described by Mr. R. P. Whitfield. Toward the close of the Trenton epoch and during the predominance of the normal *Isotelus*-type and with the senile decline of the race, the highly segmented and spiniferous type reappears in the *Asaphus canadensis* Chapman and the *Gerasaphes ulrichana* gen. et. sp. nov., both from the horizon of the Utica slate, both recurrent *Ptychopyge* or a senile reappearance of the immature individual type.*

*Some years ago the writer had the opportunity of studying the structure and mode of development of the eye in a single highly facetted trilobite, *Phacops rana* (Journal of Morphology, vol. ii, p. 253, pl, 21. 1888), and demonstrated not only a gradual increase in the number of lenses from immaturity to adulthood, but also that, after maturity, senile growth was accompanied by a resorption or obscuration of the lenses, and in consequence, by a return of the visual area to its infantile condition. These conclusions were derived from the investigation of a vast number of selected specimens.

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The suggestions made here with reference to the morphological significance of the genal spines can be tested fully only when extensive series of specimens are brought under study. That in the subgenus *Isotelus,* they are infantile characters gradually eliminated in successive moultings of the test, appears to be true, not only of the individual, but of the race.

### ISOTELUS GIGAS *DeKay,* 1824.

Of late years the name introduced by Stokes, *Asaphus platycephalus,* for a trilobite from St. Joseph island, lake Huron, has become current for this species, on the ground of priority of description.* None of the figures given by Stokes show the structure of the genal angles, and it is therefore wholly a matter of presumption whether his specimens were of the same character as those afterwards fully described and illustrated by DeKay.†

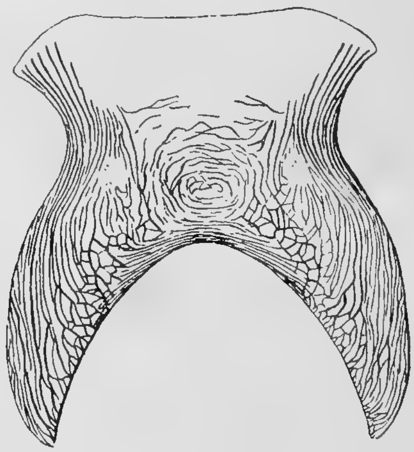


Fig. 8.—*Isotelus gigas* DeKay. Hypostoma of a large individual. Hudson River sandy shales (erratic), central New York.

*Formation and locality* of *Isotelus gigas* in the Minnesota formations. Hudson River group, Granger. There is a single nearly entire specimen which appears to have had a spineless cephalon, from the Galena limestone at Mantorville; and from the same locality a fragment of the glabella of an immense individual, which in its entire condition must have had a length of not less than 17 inches. This is the largest authentic specimen of an asaphid recorded, and I have here introduced an outline figure of the animal in its natural proportions.

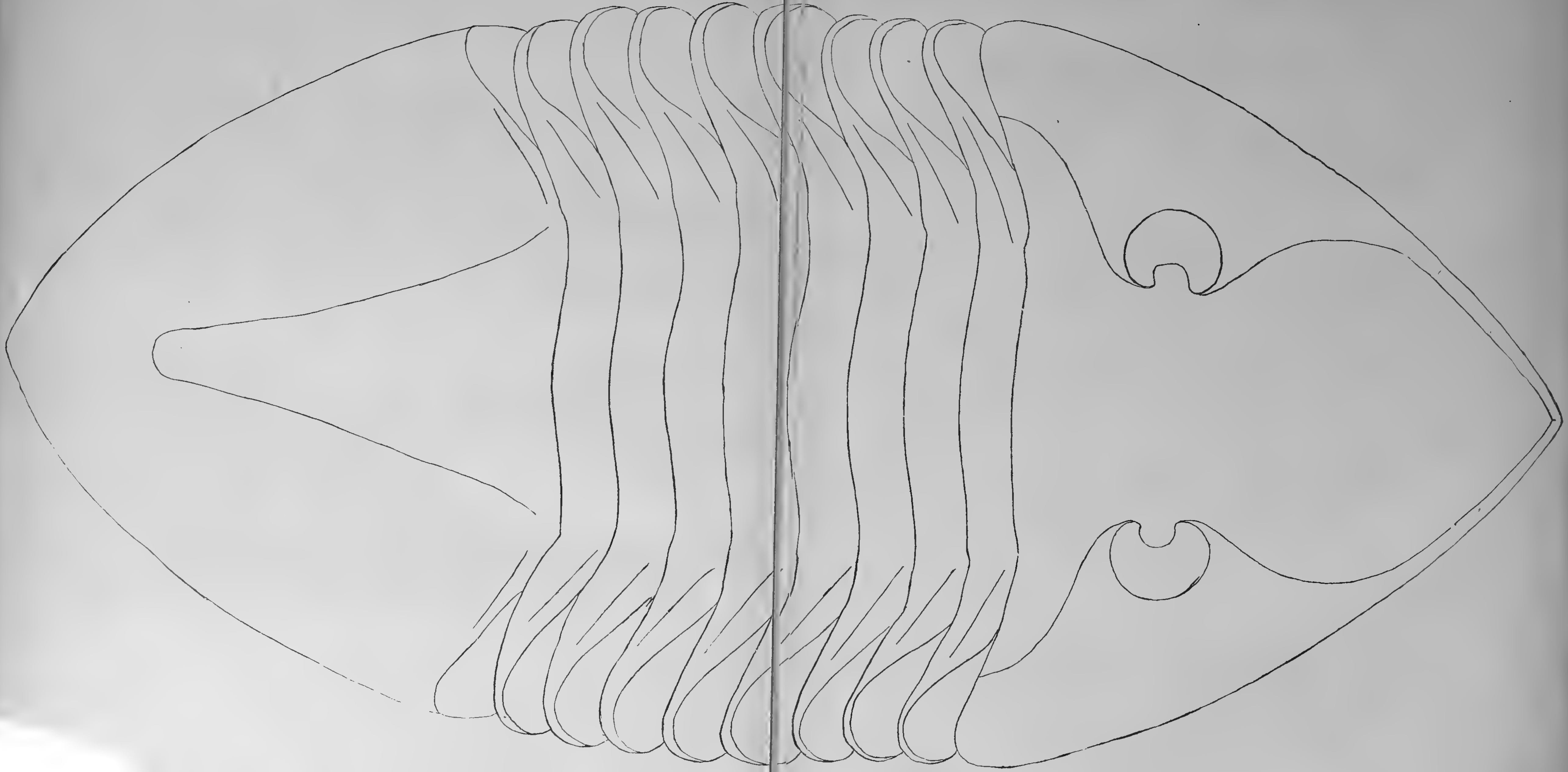
### ISOTELUS MAXIMUS *Locke,* 1838.

This is the name first proposed by Locke, who subsequently changed it, for euphony, to *I. megistos,* under which it has usually passed.

*Formation and locality.*—Trenton: Minneapolis, St. Paul, Rochester, Minn.; Mineral Point, Wis. Galena: Wykoff, Warsaw, Kenyon, Cannon Falls, Minn. Hudson River: Granger, Minn.

*Trans. Geological Society, vol. i, 2nd Series, pp. 199, 208, pl. 27. 1822.

†The Trenton rocks of New York contain a distinct species known at present only from its pygidium. This has passed under the name *I. gigas*, and is figured in the Palæontology of New York, vol. i, (pl. 61, figs. 3*g*, 3*b*), associated with cephala of corresponding size, but which may or may not belong to it. It is characterized by its broad, blunt, somewhat elevated posterior termination, and flat upper surface and axis. Notwithstanding the flatness of the surface, the axial furrows are clearly defined, and the segmentation of both axis and pleuræ are discernible even to the extremity of the shield, especially on the internal casts. The fossil is not especially common, though I have seen several characteristic examples. The species may be distinguished by the term, *Isotelus jacobus*, being dedicated to Prof. James Hall.



Outline of Isote[illegible]us gigas *DeKay*.
(Natura[illegible]l Size.)

ISOTELUS CANALIS *Whitfield*, sp.

*Asaphus canalis* WHITFIELD, 1886. Bull. Am. Mus. Nat. Hist., vol. i, p. 336, pl. 34, figs. 1—8.
*Asaphus canalis* WHITFIELD, 1889. Bull. Am. Mus. Nat. Hist., vol. ii, p. 64, pls. 11, 12.

This name, which has been ascribed to Conrad by both Profs. Hall* and Whitfield,† and also by Mr. Billings,‡ had no particular meaning until Whitfield described under it a nearly entire individual from the Fort Cassin beds on lake Champlain. To credit the species to Conrad is merely a matter of courtesy, as it was used only in his manuscript and even then applied to a specifically unidentifiable part of the pygidial doublure. The relations of that fossil, or of those described by Hall under this name from the Chazy limestone, to Mr. Whitfield's species are quite uncertain. There are two extended and nearly entire specimens from the lower or Birdseye horizon of the Trenton group in Fillmore county, Minn., and a single pygidium

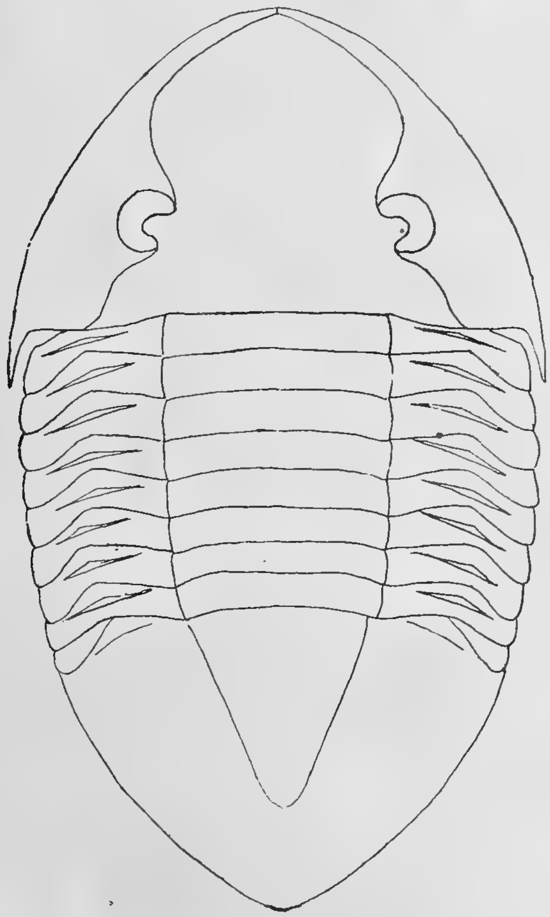


Fig. 9.—*Isotelus canalis?* Lower Trenton, Fillmore county.

from an equivalent position at Stanton, Minn., which may be provisionally referred to this species; though it is to be confessed that their differences from *I. maximus*

* Palæontology of N. Y., vol. i, p. 25, pl. 4 *bis*, figs. 17—19. 1847.
† *Loc. cit.*
‡ Palæozoic Fossils, vol. i, p. 255, p. 352, fig. 340, 1865; and Geology of Vermont, vol. i, p. 299, pl. 12, fig. 5, 1862.

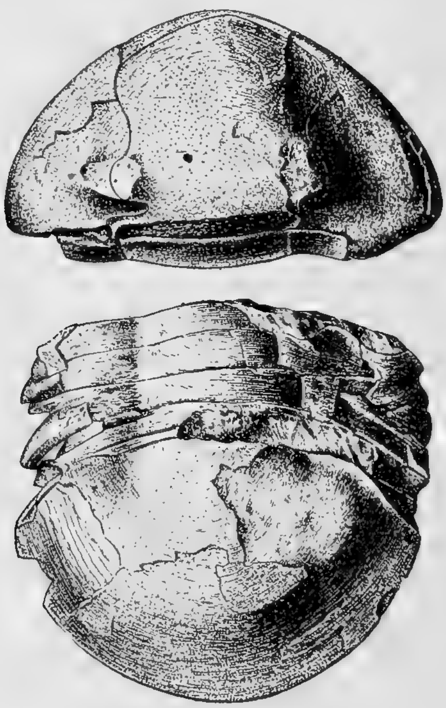
are not impressive. The smaller individual has a more decidedly flattened cephalic border than the larger, but this difference is probably due to circumstantial causes; its cheek spines are much the longer, extending to the sixth segment, while on the larger example they reach only to the second.

*Formation and locality.*—Lower Trenton; Fillmore county, and Stanton, Goodhue county.

## ISOTELUS SUSÆ *Whitfield,* 1882.

*Asaphus susœ* (GALVIN in MS.) WHITFIELD, 1882. Geology of Wisconsin, vol. iv, p. 236, pl. 5, fig. 3; pl. 10, fig. 8.

The features distinguishing this form from its allies in the same fauna lie mainly in the general proportions of the animal. Both cephalon and pygidium are broad and relatively short, their outlines being in contradistinction to the elongate and subangular head and tail shields of *I. gigas* and *I. maximus.* In addition, there is a general and very regular convexity of the parts, a sharper definition of the thoracic axis, deeper and more distant axial furrows on the pygidium; the facial sutures, also, on their anterior limb, make broad, sweeping outward curves and a large angle at their union. The description of the species has been given in detail by Mr. Whitfield in the work cited and it is only necessary here to indicate the differential characters.



Figs. 10, 11. Two views of an imperfect, partially enrolled individual of *Isotelus susœ* Whitfield.

*Formation and locality.*—Specimens having about the same dimensions as the original occur in the Hudson River group at Granger (Museum No. 8434) and two miles east of Spring Valley, Minn. (collection of Mr. Ulrich).

## Subgenus PTYCHOPYGE, Angelin, 1854.

### Ptychopyge ulrichi, *n. sp.*

This species is represented in the material before me by seven more or less complete pygidia; one small and entire, 21 mm. in length and 35 mm. in greatest width; another, a part of a very large one, fully 120 mm. in width across the top. The general form of the first is semi-oval except about the margins which are broadly concave.

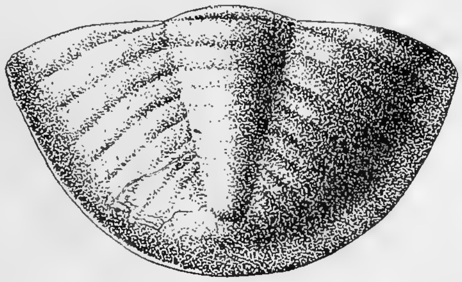


Fig. 12.—An entire pygidium of *Ptychopyge ulrichi*, Cannon Falls.

The lobation is clearly defined, the axis being relatively narrow, slightly more than one-fifth the entire length of the shield, and extending for somewhat more than two-thirds the length of the pygidium, ending in a blunt, not elevated extremity.

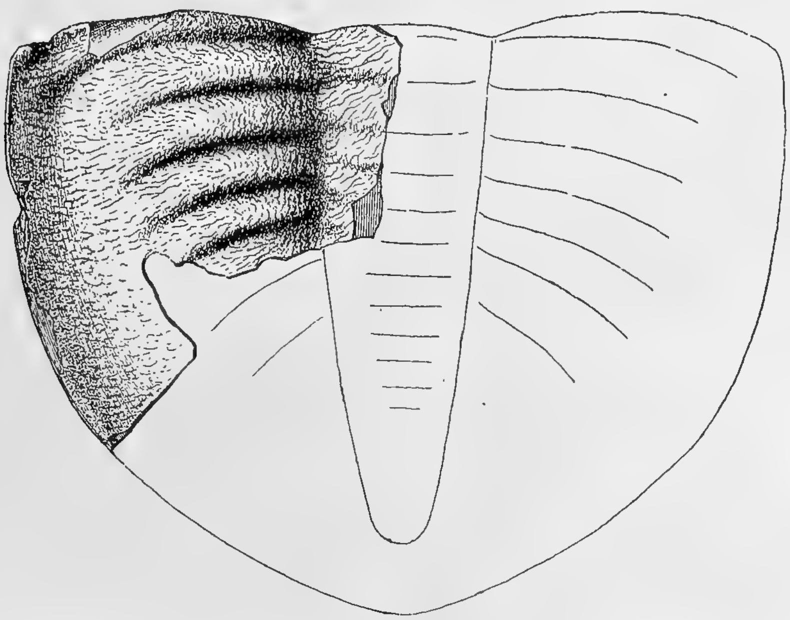


Fig. 13.—Fragment of a large pygidium of *Ptychopyge ulrichi*, with restoration of outline. Cannon Falls.

It bears eight or nine annulations, only the first three or four being well defined. The pleuræ are convex and rather short on account of the broad, concave margin. Besides the articulating segment there are five ribs, with a trace of a sixth; and on the internal cast seven or eight ribs may be discerned. Of these the first is the broadest; all are simple, unfurrowed, and all disappear quite abruptly at the marginal border. The posterior portion of the pleuræ is smooth, and the extremital area of the border is slightly bent upward. The entire surface of the shield is covered with anastomosing, racemose, elevated lines, which are very conspicuous on the larger specimen, and clearly apparent on the smaller. This ornament is one of the generic characters of the group given by Angelin: *"densissime striolatus."* This species is not widely different, so far it is known, from *Asaphus huttoni* Billings,* from the Quebec group of Table Head, Newfoundland, except in the length of the axis, which exceeds that of the latter species. It is an excellent representative of the strongly segmented type of *Asaphus* for which Angelin proposed the name *Ptychopyge.*

*Formation and locality.*—One of the smaller specimens is from the lower blue beds of the Trenton limestone at Mineral Point, Wis. (Museum No. 8402), and the others from an equivalent or Birdseye horizon at Cannon Falls, Minn. The latter are from the collection of Mr. Scofield.

## GERASAPHES,† n. subgen.

### GERASAPHES ULRICHANA, *n. sp.*

The form for which this name is introduced, though small, and even imperfectly known in certain respects, is one of no little interest in its relation to the ontogeny of the asaphids. The specimens of the single known species (named in compliment to its discoverer, Mr. E. O. Ulrich) consist of two cranidia and two pygidia, lying on the surface of fragments of a calcareous shale, from the horizon of the Utica slate, at the mouth of the Licking river, Ohio. Of these four examples, three are on the same piece of rock. The following description embodies not only the distinguishing characters of the subgenus, but also those of the typical species.

Fig. 14.—Cranidium of *Gerasaphes ulrichana*, × 4.

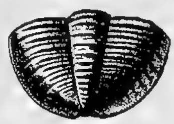
Of the two cranidia, one has a length of 4½ mm., the other of 2½ mm. The form of this part is distinctly asaphoid. The facial sutures take their origin on the posterior margin, making an acute angle with it, thence passing inward in a slightly convex curve to the palpebral lobes which are situated at about one-third the length of the cranidium from the posterior margin. These lobes are not large and the course of the sutures in front of them is that characteristic of *Isotelus*, being a broad

* Palæozoic Fossils, vol. i, p. 271. fig. 237, 1865.

† *Geraios*, old; *asaphes*, asaphus.

outward curve following the margins of the frontal glabellar lobe, and recurving anteriorly, the branches of the suture meeting at an angle in the median line at, or just within the frontal margin of the cephalon. Between the anterior limbs of the suture and the frontal lobe is a smooth, flat area.

The glabella is broad and expanded anteriorly, narrowing backwards, its anterior width being fully twice that at the occipital ring. Its surface is quite smooth and evenly convex with an obscure median longitudinal ridge traversing its entire length. The extreme lateral points of the frontal lobe lie about one-fourth the length of the glabella from the anterior margin; thence the lateral outlines converge in nearly straight lines to points just above the palpebral lobes, where there is a slight inward deflection on each side, which represents the position of the first glabellar furrows. Below this is a pair of more conspicuous depressions, or the second lateral furrows, which begin opposite the middle of the palpebral lobes, pass directly inward for a short distance and then backward, extending quite to the occipital furrow. These furrows are not deep but the lobes thus cut off are quite distinct. The posterior median portion of the glabella between these furrows is narrow and the low axial ridge traversing it terminates at the neck ring in a round, blunt elevation. These features, with the exception of the prominence of the basal lobes, are throughout characteristic of the typical *Asaphus*, and the accompanying figure may be compared with that of *Asaphus expansus* given on a preceding page. The occipital ring is arched and moderately prominent.



Figs. 15, 16.—Pygidia of *Gerasaphes ulrichana*, × 5.

Pygidium multisegmented, outline subparabolic, margin entire. Surface very convex medially, lateral portions depressed convex. Border broad and flat, being widest at the post-lateral edges, narrowest at the anterior angles and posterior extremity. At the latter point there is a slight incurvature of the margin. The outline of the convex portion of the shield is subtriangular and quite different from that of the margin.

Axis quite narrow, highly convex, longitudinally arched and extending to the marginal border. It bears 10—11 distinct annulations, the anterior ones being separated by broad grooves. Only the posterior extremity is unsegmented.

The pleuræ bear 7 ribs on each side; these are narrow, straight, transverse, very slightly reflected except at their outer extremities on the margin. Each of these sharply defined ribs is divided by a deep sulcus, broader than the interannular grooves which are linear. These sulci disappear at reaching the broad margin, but the interannular grooves are continued upon, and nearly across the marginal expansion. The surface appears to have been quite smooth.

The larger of the specimens measures 2 mm. both in length and width.

The distinctive features of this subgenus and species are those of early representatives of the asaphid type, which at maturity show a condition of distinct annulation. The form appeared at a period when the true asaphs were on the decline and near extinction. Both structure and size indicate that this was a paraemic modification of the asaphid stock, reproducing in the senility of the race the characters of immaturity.

*Formation and locality.*—Utica shale, mouth of Licking river, Ohio; probably also in the Hudson River shales, Rome, N. Y.

## Genus NILEUS, Dalman, 1826.

### NILEUS VIGILANS *Meek* and *Worthen*, (sp.) 1875.

*Asaphus vigilans* MEEK and WORTHEN, 1875. Geol. Surv. Illinois, vol. vi, p. 497, pl. 23, fig. 6.
*Illænus (Nileus) minnesotensis*, FOERSTE, 1887. Fifteenth Rept. Geol. and Nat. Hist. Surv. Minn., p. 478, fig. 1.

The description given by Mr. A. F. Foerste was based upon a single cranidium from the Trenton horizon at Minneapolis. There are before me a number of essentially entire individuals, most of them enrolled but several in an extended condition. Some of these are from Minneapolis but the majority from the Galena beds. Upon comparison of these with the description and original specimens of *Asaphus vigilans* Meek and Worthen, I find no basis of specific distinction.

Fig. 17.—*Nileus vigilans* Meek and Worthen. Cephalic view of an enrolled individual.

Fig. 18.—Profile of the same specimen.

General form elliptical with subcrescentic extremities; longitudinal lobation very obscure. Cephalon transverse, regularly convex. Margin very slightly thickened by a thread-like elevation. Genal angles obtuse. Frontal slope full but not projecting, terminating abruptly on the margin; lateral surface slightly depressed beneath the eyes; upper surface between the eyes flattened. Glabella, dorsal furrows, occipital furrow and ring not defined. Eyes small for this genus, but prominent; situated at points each one-third of the entire transverse diameter from the lateral margin and one-third of the longitudinal diameter from the posterior margin. Facial sutures making a broad outward curve on their anterior limb, incurving again near the anterior margin, reaching it in front of the center of the eyes and traversing the margin without angulation; posterior curves intersecting the posterior margins at large angles not far from the genal extremities.

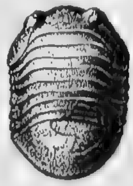


Fig. 19.—*Nileus vigilans* Meek and Worthen. An entire individual, with cephalon inclined.

Thorax composed of eight broad, flat segments. Longitudinal lobation very obscure, axis very broad, covering three-fourths of the entire width of the thorax. The segments are broad in the middle, narrowing somewhat at the axial furrows; on the pleuræ they are very narrow, not grooved, and the beveled articulating planes extend for the entire distance from the dorsal furrows.

Pygidium comparatively short, subsemicircular on the margins. Surface smooth, sloping equally to the sides and posterior extremity, slightly concave just within the margin; without external evidence of lobation or segmentation. On the cast of the inner surface the axis is seen to be considerably narrower at the anterior margin than at the termination of the thorax, and its lateral margins taper regularly to a point not distant from the posterior extremity of the shield; in a favorable light eight annulations may be counted on the axis and five on the pleuræ. The articulating ring and groove on the anterior margin are broad and conspicuous. Doublure broad, coarsely striated as in *Isotelus.* Surface ornamented, especially on the extremital portions, by coarse venation traversing the test transversely.

A very young entire example has a length of 16 mm.; the largest extended specimen is 26 mm. in length, and the largest enrolled example 50 mm. in length. It is evident from certain isolated pygidia that these dimensions were frequently exceeded.

*Formation and locality.*—Lower Trenton (Black River), Minneapolis; Galena shales, Wykoff, Pleasant Grove, Minnesota. The species was originally described from the Hudson River fauna of Carroll and Kendall counties, Illinois.

*Observations*—This species resembles in many respects the *Bumastus trentonensis,* with which it is associated; but it will be readily distinguished therefrom by the position of the eyes, form of the facial sutures, shallowness of the cephalon, and great breadth of the thoracic segments. Normal forms of the genus *Nileus* are characterized by the great length of their eyes. This feature is seen in *N. armadillo* Dalman, the type of the group, in *N. palpebrosus* Angelin, and in the three species described by Billings from the Quebec group, *N. scrutator, N. macrops, N. affinis.** These long, sublunate eyes are forcible evidence of morphological immaturity, which is corroborated by the earlier age of such forms of the genus. Diminution in strength and increase in hight of the eyes, as in *N. vigilans* is undoubtedly the accompaniment of phyletic maturity in this group. Hence I have felt no hesitation in endorsing Mr. Foerste's generic reference of this fossil; though if another name were current, it might be useful as indicating the different stage of development attained by the later forms.

*Paleozoic Fossils, vol. vii, 1865, pp. 273-275.

## Genus ILLÆNUS, Dalman, 1826.

### Illænus americanus *Billings*, 1859.

*Illœnus americanus* Billings, 1859. Canad. Nat. and Geol., vol. iv, p. 371.
*Illœnus taurus* Hall, 1861. Geol. Surv. Wisconsin; Rept. Progress, p. 49.
*Illœnus americanus* Billings, 1865. Palæozoic Fossils, vol. i, p. 329, figs. 316*a–d*.
*Illœnus taurus* Meek and Worthen, 1868. Geol. Surv. Illinois, p. 320, pl. 3, fig. 2.
cf. *Illœnus crassicauda* (Wahl.) Hall, 1847. Palæontology of New York, vol. i, pl. 229, p. 60, figs. 4*c*, *d* (not 4*a*, *b*).

This species is of frequent occurrence in various localities in Minnesota, and as its dismembered parts bear certain similarities to other species with which they are associated (*Thaleops ovata*, *Bumastus trentonensis* and *B. orbicaudatus*), it will be useful to quote the very exact and detailed description given by Billings:

Oblong, distinctly trilobed; length two or three inches; width from three-fifths to five-sixths the length. Head large, strongly convex, its hight usually a little greater than its length measured on a straight line, sometimes abruptly bent down at less than half the length from behind, often uniformly arched from the front to the posterior margin, equal to about one-fourth of a sphere; length from front to posterior margin about two-thirds the width between the cheek angles in a straight line. The glabella is moderately convex; the dorsal furrows extend from one-fourth to a little more than one-third the whole length of the head, measured on the curve, and have an obscure sigmoid curve, at first outwards and then inwards, their anterior extremties usually turning a little outwards; they are distant from each other not quite one-half the whole width of the head. The eyes are of moderate size, about two lines in length, about half their length from the posterior margin, and half the width of the glabella from the dorsal furrows. The cheek angles are rounded, and the posterior margin of the head makes with the lateral lower margin, as seen in a side view, usually a right angle, but in some specimens an obtuse angle of nearly 100°, owing to the variable extent to which the front part of the head is produced downwards. In some the portion of the posterior margin outside of the eye curves forwards, and brings the cheek angle

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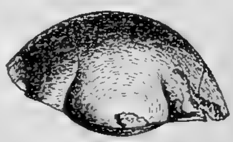

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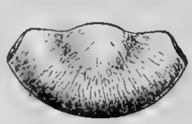

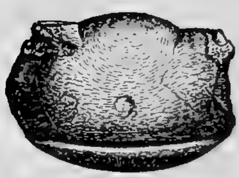

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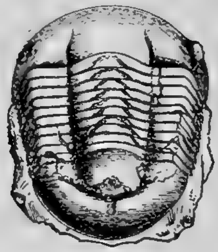

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Figs. 20—23.—*Illœnus americanus* (after Billings). Fig. 20.—Upper side of head. Fig. 21.—Front view of the same individual. Fig. 22.—Pygidium of the same. Fig. 23.—A nearly entire individual.

to a position in front of the eye. In others it is behind the eye. The space between the eye and the dorsal furrows is convex, and the eye itself seems to be rather protuberant or subconical. The movable cheek is subtriangular, its width at the posterior margin about once and a half the distance of the eye from the dorsal furrow, its length along the lower margin a little greater than its posterior width. The anterior margin of the whole head is uniformly rounded, with the exception of a slight concave curve just outside of the suture. In some specimens in which the front part of the head is most abruptly bent down the middle portion of the front margin is depressed convex or nearly straight.

Thorax with ten segments. Axis moderately convex, from a little more than one-third to nearly one-half the width of the whole animal, a little wider at the anterior than at the posterior segment; the sides sometimes straight and sometimes slightly curved outwards. On each side of the axis there is a flat space between the side of the axis and the head of the pleuræ. The width of the space is between one-third and one-half the width of the axis. The pleuræ are bent at the fulcra at an angle which varies in different individuals, from 25° to 45°, and at nearly one-half their length from the side of the axis.

Pygidium usually a little shorter than the thorax; varying from moderately to rather strongly convex; the posterior margin broadly and uniformly rounded; the anterior angle truncated nearly half the whole length of the pygidium; the straight sides formed by the truncation forming an angle of from 40° to 60° with the longitudinal axis of the body. The axis of the pygidium is well defined at the anterior margin by the dorsal furrows, which die out at about one-third or one-half the length, converging towards each other, and sometimes obscurely defining the apex.

The surface characters of the species are peculiar although somewhat variable. The specimen on which the species was originally founded, has the whole of the head and pygidium covered with short squamose fissure-like striæ; one edge of each fissure being more elevated than the other, gives to the surface a wrinkled appearance. These striæ vary in length from half a line to two or three lines, and are from one-eighth to one-fourth of a line distant from each other. On the tail they seem to radiate irregularly from the axis as a center. Near the front margin and parallel with it, are a number of straight continuous fissures. This latter character occurs in other species of this genus. In other specimens the striæ are more distinct and distant, but still are of the same character. In a specimen in Dr. Grant's cabinet, the middle portion of the front of the head is nearly smooth, and in addition to the striæ, is coarsely punctured.

Mr. Billings also called attention to the close approach of *I. americanus* to *I. crassicauda* Wahlenberg; and I am of the opinion that the same fossil had been described by Hall in 1847 (*loc. cit.*) under the latter name.

It appears from the observations made by Holm* that this species (*I. crassicauda* Wahl.) has been generally misapprehended from the date of its description (1821). Holm has redescribed the specific characters from the type specimens, and, as a result, eliminates from this association all other fossils which have been comprehended under this designation. Thus restricted, the author regards the species as unknown outside of Dalecarlia, Sweden, and as having a very short vertical range "from the youngest layers of the Orthoceras-limestone to the oldest of the Cystidean-limestone" (an immediately succeeding zone). With *I. crassicauda* thus limited, *I. americanus* appears to be its nearest relative; indeed, there is excellent reason for holding the latter but a variety of the former. The similarities in the two are both general and detailed; the differences which may be indicated are a somewhat deeper anterior convexity of the cephalon in the American form, a less sharply limited glabella and pygidial axis. Otherwise the contour of the parts, all and several, the surface sculpture with its variations on the different parts, marginal outlines and curves of facial sutures are all alike.

Some of the internal casts of the cephalon from the Galena limestone at Wykoff show, at the anterior termination of the dorsal furrows, two lunate cicatrices like those mentioned in the description of *Bumastus trentonensis* and *B. orbicaudatus*. In finely preserved specimens from the Trenton of New York there is seen to be a smooth interruption of the external ornamentation directly over these spots. The Minnesota specimens are usually in a dismembered state and are frequently some-

* Zeitschr. der deutsch. geolog. Gesellsch., vol, xxxii., p. 559, pl. 33, 1880.

what abraded and in rather an unfavorable condition for study. An enrolled specimen from Kenyon retains the parts better than any other observed.

*Formation and locality.—Illænus americanus*, like *I. crassicauda*, has a very restricted vertical range, though of distinctly later date than the latter. Billings speaks of it as a rare species occurring in the "Trenton limestone only," at Ottawa, L'Orignal, and lake Huron. In the Trenton limestone of Trenton Falls it is not uncommon and is exquisitely preserved. In Minnesota it is known only in the Galena limestone and shales at Wykoff, Kenyon, Old Concord, Cannon Falls, and in Goodhue county; also at Oshkosh, Wisconsin, and Galena, Illinois.

### ILLÆNUS; compare I. INDETERMINATUS *Walcott.*

*Illænus indeterminatus* WALCOTT, 1879. Thirty-first Ann. Rept. N. Y. State Mus. Nat. Hist., p. 70.

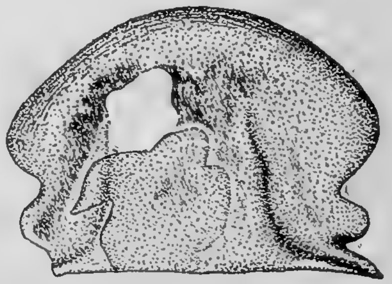


Fig. 24.—Cranidium of *Illænus; cf. I. indeterminatus* Walcott.

There is a single cranidium of comparatively large size, from the lower Trenton beds at Janesville, Wisconsin (Museum No. 8413), which agrees very well with the description given by Walcott, and is characterized by the conspicuous development of the dorsal furrows, which clearly define the lateral outline of the glabella. Mr. Walcott's original specimens were from Herkimer county, N. Y. (Black River limestone), and from Plattesville, Wisconsin.

## Subgenus THALEOPS, Conrad, 1843.

### THALEOPS OVATA *Conrad*, 1843.

*Thaleops ovata* CONRAD, 1843. Proc. Acad. Nat. Sci. Phil., vol. i, p. 332.
*Thaleops (Illænus) ovatus* HALL, 1843. Palæontology of New York, vol. i, p. 259; pl. 67, figs. 6*a*, *b*.
*Illænus ovatus* WHITFIELD, 1882. Geology of Wisconsin, vol. iv, p. 238; pl. 5, figs. 1-2.
*Illænus herricki* FOERSTE, 1887. Fifteenth Ann. Rept. Geol. and Nat. Hist. Surv. Minnesota, p. 479, fig. 2.

This appears to be the most abundant of the Minnesota trilobites; and though I have seen but two essentially entire specimens, separated heads and tails are of frequent occurrence. The species is very characteristic in its structure and was clearly described by Mr. Conrad from entire individuals. The diagnostic features indicated by him, and which lead at once to the identification of the species, are the deep lobation of the cephalon, the attenuate cheeks, divergent, tapering, peduncular eye-nodes, and the complete isolation of the axis of the pygidium. The first of these features varies more or less and is better defined on internal casts than on the external surface.

General form ovoid, broadest anteriorly, attenuate and salient at the angles of the cephalon. Axial length and greatest width equal. Cephalon broadly semicircular on the anterior margin, slightly incurved or contracted laterally and again prominent at the genal angles which are narrow and produced beyond the general outline of the body into blunt, short spines. Posterior margin gently convex on the cheeks and much more convex axially. Dorsal furrows clearly defined on the posterior half of the cephalon, disappearing at or in front of its summit. On internal casts these furrows are quite deep and though becoming faint anteriorly may sometimes be traced nearly to the front margin of the shield. The glabella thus outlined is subquadrate, expanded anteriorly, its median width being about one-third the entire width of the cephalon. Where faintly delimited on its anterior portion its width is one-third greater than at its base. A single pair of very short lateral glabellar furrows makes a slight indentation on each margin, serving to divide the part into an anterior or frontal lobe and a single pair of lateral lobes. The occipital furrow and ring which are scarcely discernible on the outer surface are clearly distinguishable upon the cast. The anterior slope of the glabella is deep, nearly vertical for a short distance and convex above. The fixed cheeks are less convex than the glabella and along the dorsal furrows on the cast, bear an indentation opposite and corresponding to the lateral lobes of the glabella. The general surface tapers to the narrow, subcylindrical palpebral lobes which are depressed below the rest of the surface and lie nearly in the plane of the thorax. The free cheeks are abruptly constricted beneath and in front of the eyes and take the form of divergent slightly recurved spines or horns. The facial sutures rise rapidly from the occipital margin to the summit of the eye-nodes, thence rounding gradually forward to the anterior margin which they intersect opposite the anterior extremities of the dorsal furrows.

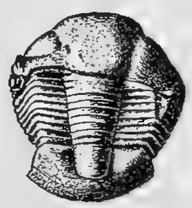


Fig. 25.—Internal cast of *Thaleops ovata* Conrad.

Thorax subquadrate, tapering; composed of ten segments. Surface strongly lobed. Axis convex, narrow. Pleuræ geniculated at about one-third their length. Segments flat and, upon the axis, moderately broad, not furrowed on the pleuræ, recurved toward their extremities.

Pygidium short, transversely subquadrate, the posterior margin being a very broad curve; width equal to nearly twice the length. Axis very prominent, much narrower than at the termination of the thorax. It tapers very gradually and

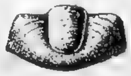


Fig. 26.—Pygidium of *Thaleops ovata* Conrad.

Fig. 27.—The same viewed from behind.

terminates bluntly in an elevated extremity, which is faintly bilobed. The axis is thus entirely surrounded by the dorsal furrows. Its length is about one-half that of the pygidium and its extremity lies at the beginning of the convex posterior deflection of the shield. Anterior margin of the pleuræ straight for one-half their extent, thence deflected at nearly right angles. Surface flat above, curving abruptly to the margins. All annulation of the pygidium is very faint, but in well preserved.

Fig. 28.—*Thaleops ovata* Conrad. Outline of head viewed from the front; showing the terete genal extremities. From an impression of the external mould of the specimen shown in figure 25.

specimens under favorable illumination, traces of five may be counted on the axis The surface of the cephalon is covered with epidermal punctæ. On the cheeks and over the anterior portion of the glabella these are vertical and isolated; over the posterior surface of the glabella they become oblique and confluent, making an irregular series of elevated anastomosing striæ. The segments of the thorax appear to be quite smooth. On the pygidium, especially over the anterior portion of the axis, the punctations are deep, coarse, and arranged in transverse rows.

*Formation and locality.*—Trenton limestone, Minneapolis, Minnesota; Beloit, Janesville, Mineral Point, Wisconsin; Dixon, Rockton, Illinois; Decorah, Iowa.

*Observations.*—The peculiar extension of the palpebra and the long, attenuate and projecting cheeks are features which appeared in an earlier species, *Illænus arcturus* Hall, of the Chazy limestone, and reappeared in the *I. pterocephalus* Whitfield, from the Niagara limestones of Wisconsin. In the typical forms of *Illænus* (group of *I. crassicauda* Wahl.), the structure of these parts is so different (low, sessile eyes and broad, obtuse, unprojecting cheeks) that Conrad's term *Thaleops* may well be retained for the subordinate type of structure represented by *I. ovatus*. Mr. A. F. Foerste's *I. herricki*, was evidently described from an entire head of *I. (Thaleops) ovatus*, and must hence fall into the synonymy of the species.

## BUMASTUS TRENTONENSIS *Emmons* (sp.), 1842.

*Illænus trentonensis* EMMONS, 1842. Geology of New York; Rept. 2d Dist., p. 390, fig. 3.
cf. *Illænus crassicauda* (WAHL.) HALL, 1847. Palæontology of New York, vol. i, p. 229; pl. 60, figs. 4*c*, 4*d*.
*Illænus milleri* BILLINGS, 1859. Canad. Nat. and Geol., vol. iv, p. 375.
*Illænus milleri* WALCOTT, 1879. Thirty-first Ann. Rept., N. Y. State Mus. Nat. Hist., p. 71.
Not *Bumastus trentonensis* EMMONS. Geology of New York; Rept. Second Dist , p. 390, fig. 1.
Not *Illænus trentonensis* HALL. Palæontology of New York, vol. i, p. 230; pl. 60, fig. 5.
Not *Illænus crassicauda* HALL. *loc. cit.*, pl. 60, figs. 4*a*, 4*b*.

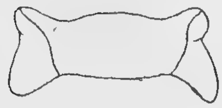


Fig. 29.—Outline of head of *Illænus crassicauda* Wahlenberg, viewed from in front.

Dr. Emmons in 1842 noticed, under the name *Illænus trentonensis*, a small *Bumastus* from the Trenton limestone at Watertown, N. Y., giving a profile and dorsal view of a single entire specimen. These figures are here introduced. In the same place he gave a figure of a much larger and quite distinct species, from presumably the same horizon, referring to it by the name *Bumastus trentonensis*. This use of the same specific name for species evidently distinct, and which the author regarded as generically different, has been the source of the confusion of the two. *Illænus trentonensis* Emmons, has not been recognized by later writers; *Bumastus trentonensis* Emmons was referred by Hall (*loc. cit.*) to *Illænus*, while Emmons' *Illænus trentonensis* was not noticed by this writer. This involution of names is the probable cause of both of Emmons' terms being referred to *I. trentonensis* in the catalogues of Miller and Vogdes.

The *Bumastus trentonensis* Emmons (*I. trentonensis* Hall), as represented in the original figure, is a large species with *Illænus*-like cephalon and broadly lobed thorax and pygidium. The longitudinal lobation is so pronounced, and the median lobe of the body so narrow, as to make the reference of the species to *Bumastus* incongruous. It appears from the description of this species given by Mr. Hall (*loc. cit.*) that the original specimen was lost, and that his account, as well as his figure of it, was drawn from a plaster cast. One or the other of these figures must have been quite inaccurate, for the latter represents a fossil in which the lobation is altogether obsolete, except for the faint evidences of dorsal furrows upon the cephalon. The animal, as represented thus, would be an excellent *Bumastus*. I am

Figs. 30, 31.—*Bumastus trentonensis* Emmons (sp.). Copies of the orginal figures of the species.

disposed to believe the original figure the more reliable; it is certainly the more natural in appearance, and was executed by Mr. Ebenezer Emmons, jr., whose skill as a delineator of fossils is widely and favorably known. We may safely leave to this species the name *Illænus trentonensis*; and shall therefore revive for the smaller, now before us, the term *Bumastus trentonensis,* this process involving simply the interchange of the generic names originally applied to the species. The original of *B. trentonensis* was not described, but the wood cuts given of it show in both views only *eight* thoracic segments. There is no evidence from these figures that any of the segments have been lost or forced beneath one or the other of the extremital shields.

Mr. Billings' species *Illænus milleri* (from various localities in the Trenton limestone about Ottawa, and also from the Black River limestone in the township of Hull, Canada) is inseparable from *B. trentonensis.* It was described as having *nine* thoracic segments; Mr. Walcott, however, in identifying *I. milleri* in the Black River and Trenton limestone of New York and the Trenton of Platteville, Wisconsin (*loc. cit.*), suggests that one of the segments of the original was concealed, as his specimens showed *ten* segments. Before me are two entire individuals of this species from the Trenton limestone of Trenton Falls; one of them shows ten thoracic

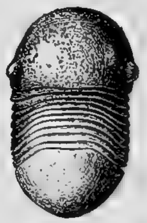


Fig. 32.—*Bumastus trentonensis* Emmons (sp.). An entire individual with ten segments. Trenton Falls, New York.

segments, the other agrees with Emmons' original in having but *eight.* The latter has been eroded in such a manner as to afford a complete longitudinal section of the specimen, which fully demonstrates that no segment has been lost and that this animal at this stage of development possessed no more than eight segments. An enrolled individual from the Black River limestone at Poland, N. Y., shows nine of these segments.

Among the numerous examples of the species which have been received from localities in Minnesota and Illinois, enrolled individuals are common, while but a

Fig. 33.—*Bumastus trentonensis* Emmons (sp.). An entire but disjointed individual, with nine segments.

single extended example has been observed. This, from the Galena beds at Pleasant Grove, Minnesota, has nine segments; coiled specimens from the middle Trenton shales at St. Anthony Park and from Minneapolis have nine, and a single coiled example from the Galena shales at Stanton, Goodhue county, Minnesota, has but eight. These differences in degree of segmentation, unaccompanied by any palpable distinction in other respects do not afford a basis of specific separation. They are apparently only developmental conditions, not of the individual so much as of the specific type.

Among all the western specimens examined there is no great difference in size. None are larger than the specimens from Trenton Falls bearing ten segments, and those from the Black River limestone with nine. The habit of the western specimens is somewhat smaller, though separated heads from Dixon, Illinois, attain the usual size of the New York examples. None of the specimens from Minnesota appear to have possessed ten segments, and this local variation is similar to that occurring among the Canadian examples.

Such variations in the degree of segmentation are not, indeed, usual in the mature conditions of a species; they are, however, altogether in harmony with the laws of morphogeny, and deviations from the normal Trenton type with ten segments are to be interpreted as phylogenetically immature or senile phases of the specific type. Under the description of *Illænus milleri* the detailed structure of this species has been clearly given by Billings.

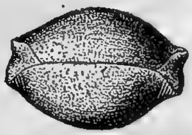


Fig. 34.—Front view of an enrolled individual of *Bumastus trentonensis* Emmons (sp.). ×2.

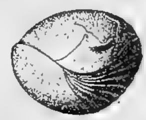


Fig. 35.—Profile of the same specimen.

A peculiar feature which *B. trentonensis* possesses in common with *B. orbicaudatus* is a pair of lunate depressions on a transverse line between the eyes. These are longitudinally elongate, each about half way between the eye and the axial line, and much more clearly apparent on the cast than on the outer surface. It seems probable that such cephalic cicatrices were areas of insertion of muscular bands attached to similar scars on the inner surface of the hypostoma.

Normally there is no trace of longitudinal lobation on the cephalon or pygidium, and the axial furrows of the thorax are very obscure. Slight vertical compression, however, serves occasionally to emphasize these features in the head and thorax, and also lessens the convexity of the former.

*Formation and locality.*—Trenton limestone: Minneapolis and St. Paul, Minnesota; Dixon, Illinois; Platteville, Wisconsin. Galena shales: Pleasant Grove, Cannon Falls, Stanton and Kenyon, Minnesota.

BUMASTUS ORBICAUDATUS *Billings* (sp.), 1859.

*Illænus orbicaudatus* BILLINGS, 1859. Canad. Nat., vol. iv, p. 379.
*Illænus orbicaudatus* BILLINGS, 1866. Cat. Silur. Foss. Anticosti, p. 27, fig. 10.

There is a single cranidium from the Galena shales at Wykoff, Minnesota (Dr. Robbins' collection), which appears to represent this species, described originally from the Trenton or Hudson River horizon at English Head and elsewhere, Anticosti.

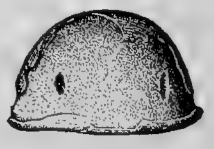


Fig. 36.—*Bumastus orbicaudatus* Billings. Galena shales, Kenyon.

*Bumastus orbicaudatus* and *B. trentonensis* resemble each other in many respects, though specimens of the latter are of decidedly smaller size and greater convexity of cephalon. The Wykoff specimen measures 20 mm. in length, and 26 mm. in width across the base. Certain large, smooth, unsegmented pygidia from the Galena shales at Kenyon are probably parts of the same species.

Genus BATHYURUS, Billings, 1859.

BATHYURUS EXTANS *Hall*, (sp.), 1847.

*Asaphus? extans* HALL, 1847. Palæontology of New York, vol. i, p. 228, pl. 60, figs. 2*a*–*c*.
*Asaphus extans* HALL, 1850. Third Ann. Report N. Y. State Cab. Nat. Hist., p. 174, pl. 3, figs. 1*a*–*c*.
*Bathyurus extans* BILLINGS, 1863. Geol. Canada, p. 153, fig. 114.
cf. *B. longispinus* WALCOTT, 1876. Twenty-eighth Rept. N. Y. State Mus., p. 94.

This species was founded on a pygidium from the Birdseye limestone, professor Hall's description of 1847 being supplemented by an account of the cephalon and a portion of the thorax, in 1850. Mr. Billings proposed the genus *Bathyurus* in 1859 (Canadian Naturalist, vol. iv, p. 364), taking this species as its type and giving, in 1863, the first figure of the entire test. Mr. Walcott's *B. longispinus*, from the Black River limestone of Russia, N. Y., and the Trenton horizon at Platteville, Wisconsin, appears to me the same species.

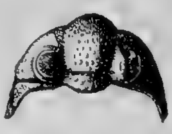


Fig. 37.—Portion of head of *Bathyurus extans* Hall, Cannon Falls.

Among the specimens loaned for my study by the late Mr. Scofield, is one of this species retaining most of the cephalon and an impression of part of the thorax and pygidium, from the lower Trenton or Birdseye horizon at Cannon Falls, Minnesota. It is the only example observed which may be safely referred to the species.

BATHYURUS SPINIGER *Hall*, (sp.), 1847.

*Acidaspis spiniger* HALL, 1847. Palæontology New York, vol. i, p. 24, pl. 64, fig. 5.

With the aid of a series of specimens from High Bridge, Kentucky, and Dunleith, Illinois, it has been possible to complete in a measure our knowledge of this species. The original was an imperfect cranidium showing a closely tubercled, ovoid glabella slightly broadest anteriorly, and a wide occipital ring produced axially into a spine.

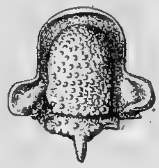


Fig. 38.—Cranidium of *Bathyurus spiniger* Hall.

The specimens in hand have the same characters, and the following additional features may be indicated. In spite of the coarse and closely set tubercles, covering the upper surface of the glabella, two pairs of lateral grooves are discernible. Both are short, the first being transverse, the second directed backward. The glabellar lobes are all indistinct, the frontal lobe covering fully one-half of the glabella. The frontal border is narrow, but broader than in *B. extans*, concave about the glabella, and turned up at the edge. The palpebral lobes are moderately large, approximate and posterior. The occipital ring is tubercled and its central spine about one-third the length of the glabella.

Associated with these cranidia, in both the localities mentioned, are pygidia, entire on the margin, and having the general form of *B. extans*, but more highly convex, the lateral slopes being quite abrupt. The axis extends to the narrow, gently concave margin where it ends abruptly. It bears three distinct annulations, with traces of a fourth and fifth. The first of these has a small median, spinous tubercle; on the second the tubercle is not so large; on the third it is again more conspicuous. Close behind this lies the base of a strong, erect or slightly recurved spine, and with it, in some of the specimens, the spinule on the third annulation is merged. There is also a row of small tubercles on each side of the axis. The pleuræ bear four flat ribs, the first of which is grooved.

Figs. 39, 40.—Pygidium of *Bathyurus spiniger* Hall; with outline profile showing the probable size of axial spine.

*Formation and locality.*—The original specimen of this species was said to be from "the central part of the Trenton limestone in the Mohawk valley, and in a similar position near Montreal." The horizon of the specimens from Dunleith, Ill., is essentially equivalent to this, though those from High Bridge, Kentucky, are said by Mr. Ulrich (by whom both have been loaned), to be from the upper part of the Birdseye beds.

## Bathyurus schucherti *n. sp.*

This new form is represented by a series of cranidia and a single pygidium. Though I am reluctant to add to the imperfectly known representatives of this genus, these specimens present some distinctive differences from those before described.

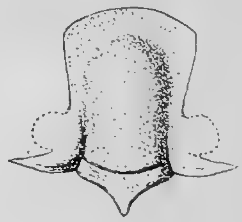


Fig. 41.—Cranidium of *Bathyurus schucherti.*

The glabella is of rather large size, elongate subovoid, and gently convex, the dorsal furrows broad and shallow, the frontal border narrow, concave and upturned at the edge. The glabella bears the faintest trace of lobation, and its surface is smooth except for a fine granulation toward the posterior extremity. The basal edge of the glabella is straight and its slope to the occipital groove abrupt. Occipital ring broad, smooth and produced into a short median spine.

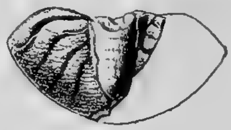


Fig. 42.—Pygidium of *Bathyurus schucherti*, partially restored. × 2.

The pygidium accompanying and undoubtedly belonging to the same species is rather short, very broadly concave on the pleuræ, only the portions near the dorsal furrows being convex. Axis moderately convex, proportionally narrow, terminating abruptly at the concave margin. As far as preserved, it appears to be obscurely segmented on its anterior moiety. The pleuræ bear three broad ribs (beside the articulating rib), which are simple, separated by linear furrows extending over the concave area to the edge of the shield. Surface smooth.

*Horizon and locality.*—Trenton limestone: Minneapolis, Minnesota; collected by C. L. Herrick, (Museum No. 5084.)

Note.—In the Twelfth Annual Report of the Geological and Natural History Survey of Minnesota (1884), p. 8, Capt. A. W. Vogdes described, under the name *Bathyurus stonemani*, a pygidium said to have come from the Trenton limestone at Minneapolis. Professor Winchell informs me that the data concerning the origin of the specimen when it was placed in Capt. Vogdes' hands for description were not only vague but misleading, as it had been found by a gentleman unused to careful distinctions in such matters. Upon re-examination, the pygidium proves to be that of a *Proetus*, whose structure alone would indicate an early Devonian age, apart from its association in the small fragments of light brown limestone with an *Atrypa reticularis* and a *Cyrtina.* It appears to be unlike other known Devonian species of the genus and will hence retain its specific name as *Proetus stonemani.* The rock is presumably a fragment from the northwestern drift picked up in the vicinity of Minneapolis.

# Family BRONTEIDÆ.

## Genus BRONTEUS, Goldfuss, 1839 (em. 1843).

### Bronteus lunatus *Billings*, 1854.

*Bronteus lunatus* Billings, 1855. Geol. Surv. Canada, Rept. Progress, p. 338.
*Bronteus lunatus* Billings, 1853. Geology of Canada, p. 188, fig. 187.

*Bronteus lunatus* is the earliest representative of the genus known in America, and the only species yet described from the lower Silurian rocks of this country. The characters of the species were given at length by Billings, his originals coming from the Trenton limestone of Ottawa where, as said by him, it is not of infrequent occurrence. In the Geology of Canada (*op. cit.*) an excellent wood-cut of an entire individual was given.

The specimens from Minnesota, while all more or less incomplete, agree throughout with the Canadian species and we have therefore introduced Billings'

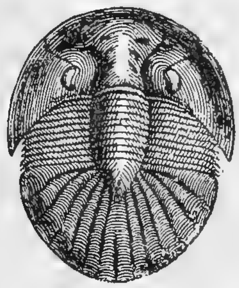


Fig. 43.—*Bronteus lunatus*, after Billings.

figure as more satisfactory to the student than any which might be derived from the material before us. The latter consists of a somewhat broken individual having the parts together from the Trenton limestone near Spring Valley, Minnesota (No. 4071 of the Museum collection), a cranidium from the Galena limestone at Wykoff (Mr. Ulrich's collection), and a fine external impression of a pygidium from the same locality (Dr. Robbins' collection).

Throughout the species of *Bronteus* there is a certain homogeneity in structure which renders the generic group more compact and sharply delimited than is usual among the trilobites. But few suggestions of a division of the genus have been made and only one of the proposed subordinate generic terms has met with even a partial acceptance. This is *Thysanopeltis*, one of Corda's terms, designed to include species with marginal spines on the pygidium, and which has demonstrated its title to recognition, since the group has proven to possess a quite definite stratigraphical value as a structural variation prevailing in Hercynian faunas.

In *B. lunatus* the various parts were not involved in the development of any unusual characters. The species possess a short axis on the pygidium, which shows a distinct trace of a single annulation, but none of any vertical lobation, such as that characterizing most of the upper Silurian species. The median rib of the pygidium is bifurcated toward its extremity. Corda* attempted a division of the *Brontei* on the basis of the simplicity or duplication of this rib, proposing for such species as show a bifurcation the name *Dicranactis*, and for those in which it is simple, *Holomeris*. It has, however, become evident that the duplication of this rib is a feature of minor significance, probably marking a degree of development in the individual, and varying in definition even in apparently full grown animals. Barrande observed† that a division of the species of *Bronteus* might be based upon the number of ribs on the pygidium, which are either six, seven or eight on each side of the median rib. By far the greater number of species possess seven ribs. *Bronteus lunatus*, in the possession of but six such ribs, is brought at once into comparison with the only other forms known to have that number, viz., *B. laticauda* Wahlenberg, from the lower Silurian of Sweden, and *B. hibernicus* Portlock, from an equivalent horizon in Ireland (Caradoc-Bala). These two, with *B. lunatus*, are the only known lower Silurian members of the genus, all from equivalent faunas, and all possessing the same degree of variation from the type of the genus, and, it may be added, showing in this respect an adolescent condition of development, with reference to the more highly annulated normal *Bronteus*.

*Formation and locality.*—Trenton limestone, near Spring Valley; Galena limestone, Wykoff.

## Family PHACOPIDÆ.

### Genus DALMANITES, (Emmrich,) Barrande, 1872.

### DALMANITES ACHATES *Billings*, 1860.

*Dalmanites achates* BILLINGS, 1860. Canad. Nat., vol. v, p. 63, fig. 9.
*Dalmanites achates* BILLINGS, 1863. Geology of Canada, p. 187, fig. 186.

A single fragment of the very characteristic pygidium of this species has been observed from the Galena beds at Wykoff, Minn. (Collection of Mr. Scofield). Mr. Billings' original specimen was from the Trenton limestone of the city of Ottawa, and he speaks of it as being of rare occurrence, though at Trenton Falls, N. Y., it is not uncommon. In Mr. Ulrich's collection are a number of heads and tails from a soft calcareous shale of the Hudson River group at Cincinnati. These have the characteristic broad curve of the frontal margin of the head, carried to an extreme, and the anterior lobe of the glabella correspondingly broad and short, giving the cephalon as a whole a much shorter and more quadrate appearance than the New

*Prodrom einer Monographie der böhmischen Trilobiten, pp. 58, 59. 1847.
†Système Silurien, vol. i, p. 840.

York forms. To indicate to the student and collector the structure of the entire animal I introduce a figure drawn from one of the New York specimens.

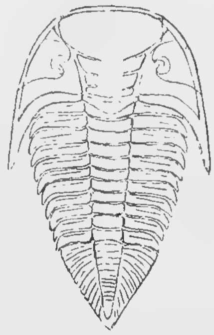


Fig. 44.—Outline of *Dalmanites achates* Billings. Trenton Falls, N. Y.

## Subgenus PTERYGOMETOPUS, Schmidt, 1881.

### PTERYGOMETOPUS INTERMEDIUS *Walcott*, (sp.) 1877.

*Dalmanites intermedius* WALCOTT, 1877. Adv. Sheets Thirty-first Rept. N. Y. State Mus. Nat. Hist., p. 16.
*Dalmanites intermedius* WALCOTT, 1879. Thirty-first Rept. N. Y. State Mus. Nat. Hist., p. 69.

Mr. Walcott's species has not heretofore been figured, but after careful comparison with the description, and with the aid of the original specimen, I have little hesitation in referring to it the commonest of the species of *Pterygometopus* occurring in the Silurian rocks of Minnesota. Without entering into a detailed description of this form, which has been given by Walcott, some of its differential features may be emphasized.

The outline of the cephalon is rendered subtriangular by a slight anterior projection of the margin. The facial sutures also make a slightly salient angle at this point, and frequently here the surface of the glabella is impressed or casually forced down. The anterior limbs of the suture cut off or traverse the lateral angles of the frontal lobe, as in all species of *Pterygometopus;* the posterior extension of these sutures over the cheeks is marked by an elevated line. The eyes are relatively small, their anterior angles not reaching the first glabellar furrows, while their posterior angles are distant from the occipital furrow. The glabella is characterized by the slight anterior or outward convexity of the first lateral furrows, the graceful rotundity of all the lobes and the decidedly depressed, though slightly convex median region between the first and second pairs of lateral lobes. On account of this depression the lobes are quite isolated and not confluent with the middle of the glabella. The second furrows are linear, deep only at their proximal extremities, but distinctly continued to the dorsal furrows. The third or occipital lobes are small but clearly defined, not confluent with the second lobes at their outer margin. The occipital ring is moderately broad, considerably elevated and without evidence of spine or central tubercle. At the angles of the cheeks are short, sharp spines, not extending beyond the second thoracic segment. The lateral margins of the cheeks are bordered by a thickened rim.

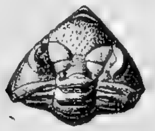


Fig. 45.—*Pterygometopus intermedius* Walcott. Cephalic view of an enrolled individual. × 2.

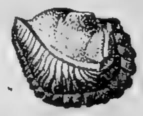


Fig. 46.—Profile of the same.

Fig. 47.—Pygidium of another individual. × 2.

Although the thorax is preserved in several very neat, enrolled specimens, there is nothing of diagnostic value to add to the description already given. It tapers more rapidly than is usual in the later dalmanitids, but by no means as much so as in *Dalmanites achates* Billings.

The pygidium is eminently triangular in marginal outline, the sides making a sharp posterior angle, which, when the animal is enrolled, projects conspicuously beyond the anterior margin of the head. This is, however, not a spine. The lateral slopes of the pygidium are decidedly abrupt, especially toward the posterior extremity. Our specimens agree with those described by Mr. Walcott, in having from 10 to 14 (when clearly retained) annulations on the axis, and 8, with sometimes traces of 2 more, ribs on the pleuræ. The first three or four of the latter are usually faintly sulcate. The surface of the glabella is very sparsely tubercled; usually only traces can be seen, and hence the generally smooth aspect of the head.

*Formation and locality.*—Lower Trenton (Black River horizon): Chatfield; Trenton: Lake Street Bridge, St. Paul; Minneapolis; Galena: Wykoff, Minnesota.

PTERYGOMETOPUS EBORACEUS, *n. sp.*

This is a New York form, closely allied to the foregoing species, though differing from it in some interesting structural details. The glabella is of the same

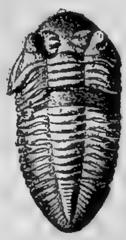


Fig. 48.—*Pterygometopus eboraceus.*

general form in both; but here the median portion between the first and second lobes is decidedly convex and scarcely depressed. The first, second and third lateral lobes have the same relative size as in *P. intermedius;* but the separating furrows are very short, deeply incised at their inner extremities, while the lobes themselves are all confluent along the dorsal furrows.

A single step further in the obliteration of the second lateral furrows, causing the first and second lobes to become wholly confluent, would produce that condition of the glabella which Schmidt has regarded of subgeneric value, proposing for species of this structure the name *Monorakos** (*Monorachus* emend.). With the evidence of close specific relationship between *P. eboraceus* and *P. intermedius*, it would be inadmissable to employ this term here, though the former may be regarded as a stepping stone from the typical *Pterygometopus* to that condition of extreme coalescence of the glabellar lobes exemplified by *Monorachus*,

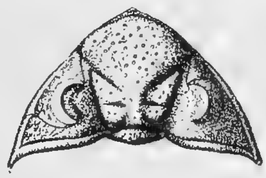


Fig. 49.—Cephalon of *Pterygometopus eboraceus*, from the same specimen; somewhat restored. × 2.

The occipital ring of *P. eboraceus* is broader than in *P. intermedius* and bears a conspicuous tubercle at its center. Genal spines are also present. The surface of the glabella is generally tubercled, and on the free cheeks there are faint, ramifying, minutely punctated grooves. The general form of the thorax is somewhat less tapering than in *P. intermedius.*

The pygidium is scarcely triangular, the lateral slopes gentle. The axis bears about ten annulations, and the pleuræ eight ribs which are quite flat, separated by very narrow furrows, the first of which is shorter than the rest, becoming obsolete at a considerable distance from the margin; six of the ribs bear fine, oblique linear sulci.

*Formation and locality.*—Trenton limestone, Rawlins Mills, N. Y.

### Pterygometopus schmidti, *n. sp.*

This name is proposed for a species whose features are altogether characteristic, though no single example has been observed which retains all the parts. Most of the specimens are heads and tails, and the best of them a cephalon with nine thoracic segments. As the characters of the more common species of the Minnesota rocks, *P. intermedius*, have been described, it will be sufficient to point out the differential characters of *P. schmidti*, which does not vary from the former in general size.

*Ueber einige neue ostsibirische Trilobiten und verwandte Thierformen; Bull. de l'acad. impér. des Sciences de St. Petersb., p. 415, 1886 (Type, *Phacops lopatini*, Schmidt; pl. xii, figs. 6—9).

The cephalon is short, but pointed at the anterior extremity and bears a depression at the meeting of the facial sutures, as in *P. intermedius.* Cheeks quite narrow and the angles produced into very short, round spinules. Glabella likewise

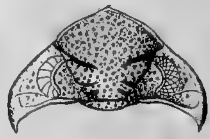


Fig. 50.—Cephalon of *Pterygometopus schmidti.*

short, the frontal lobe covering more than one-half its length. It is, however, proportionally wide anteriorly, the dorsal furrows approaching rapidly so that the glabella at its base is but one-third its width in front of the eyes. The first lobes are narrow, transversely triangular, their general direction being obliquely forward toward their distal extremities. The second lobes are quite small, transverse and subrectangular, directed obliquely backward; the third lobes are two very obscure tubercles. The general surface of the glabella is regularly convex, there being no depressed area between the inner extremities of the first and second lobes. None of the lobes are confluent. The first glabellar furrows are transverse and concave anteriorly, while in *P. intermedius* they are convex. All these glabellar lobes are clearly defined and show no tendency to obsolescence. Occipital groove narrow, occipital ring also relatively narrow and not greatly elevated. Eyes proportionally very large, extending from the first glabellar furrows to the occipital ring. The size of these organs renders both the fixed and free cheeks remarkably small. Between the base of the eyes and the lateral margins is a broad, smooth, thickened but not elevated area. The entire surface of the glabella, the palpebral lobes and a small triangular area at the base of the eyes between the occipital ring and the border, is coarsely and abundantly tubercled. More scattered and finer tubercles are seen on the marginal border.

The thoracic segments show no differentials of importance. Their extremities are obtusely rounded as in *Phacops.*

The pygidia associated with these heads are similar to that of *P. callicephalus* of the Trenton limestone of New York, having a rounded subtriangular outline, narrow, very gradually tapering axis and broad, evenly convex pleuræ. There is, however, a difference in the segmentation of the parts, the axis having 8—10 annulations which make a double sigmoid curve, and the pleuræ having 5—6 ribs, which are simple for about one-fourth of their length and then bifurcate. None of the ribs are continued to the margin which is broad and smooth. In sharp internal casts there are but four duplicate ribs, the posterior division of each disappearing toward the margin much sooner than the anterior. Behind these may be seen the trace of three or even four simple obscure ribs. The extremity of the axis, which is considerably removed from the termination of the shield, is also seen to be faintly bilobed.

The association of these pygidia with the form of cephalon described is to some degree a matter of presumption, though their intimate concurrence in the same rocks and other accessory evidence, favors it. It gives me pleasure to dedicate this species to my esteemed friend, Prof. Fr. Schmidt, the founder of the genus *Pterygometopus.*

*Formation and locality.*—Trenton limestone; Minneapolis (Museum No. 5084); Galena horizon: Kenyon (Museum No. 6768), Wykoff (Collection of Dr. Robbins); Galena shales: Cannon Falls, Minn.

PTERYGOMETOPUS CALLICEPHALUS *Hall* (sp.)

*Phacops callicephalus* HALL, 1841. Palæontology of New York, vol. i, p. 247, pl. LXV, figs. 3*a–i*.

The original illustrations of this species are of themselves insufficient to determine its differential characters. An examination of the type specimens in the American Museum of Natural History, which have been kindly placed in my hands by Prof. R. P. Whitfield, has shown that in structure of cephalon and pygidium, *P. callicephalus* differs from the form which we have described at length as *P. schmidti*, mainly in the absence of genal spines on the former.

Between the typical specimens referred to and separated heads and tails from Kenyon, Fountain and Cannon Falls, Minnesota, and Mercer county, Kentucky, the

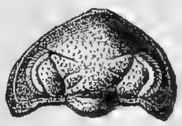


Fig. 51.—Cephalon of *Pterygometopus callicephalus* Hall.

following points of agreement are evident. The cephalon has a short triangular anterior projection; genal angles broad, round and thick, without indication of spinules; eyes large, reaching to the occipital groove; basal glabellar lobes small and altogether independent; cheeks punctated beneath the eyes; surface of glabella

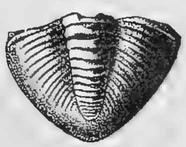


Fig. 52.—Pygidium of *Pterygometopus callicephalus* Hall. × 2.

coarsely tubercled. The axis of the pygidium has incurved margins and sinuous annulations; of the latter there are from 8 to 10; on the pleuræ there are 5 duplicate ribs, with trace of a sixth.

*Formation and locality.*—Galena horizon: Kenyon, Fountain, Cannon Falls, Minn. According to Mr. Ulrich's determination the horizon of the fossil in Mercer county, Kentucky, is Upper Trenton.

## OBSERVATIONS ON THE AMERICAN LOWER SILURIAN PHACOPIDÆ.

A sufficient number of species of the Phacopidæ has now been described from the Lower Silurian of the United States and Canada, to render the discrimination between the specific forms a matter of some nicety. Of these species, some are yet known only from dismembered parts or isolated heads, but of them all the greater number conform to the *Pterygometopus* type of structure, in the high marginal termination of the posterior limbs of the facial suture, the transection of the lateral expansions of the frontal glabellar lobe by the anterior limbs of the suture, and the usually rounded pygidium without caudal spine.

The more typical or normal of these species are *P. intermedius*, *P. schmidti* and *P. callicephalus*. Of the other Phacopidæ known from these rocks, *Dalmanites achates* Billings, *D. bebryx* Billings, *D. carleyi* Meek, *D. breviceps* Hall, *Chasmops troosti* Safford and Vogdes, and *P. eboraceus* Clarke, all show transitional characters in one direction or another. Thus we have noticed the difficulty of making a specific distinction between *Pterygometopus intermedius* and *P. eboraceus*, except in so far as the latter, by the incipient coalescence of the first and second glabellar lobes along the dorsal furrows, manifests an inclination toward *Monorachus*, a subgeneric group differing from *Pterygometopus* only in the extreme to which this tendency to coalescence is carried. *Dalmanites bebryx* and *Chasmops troosti** are species of the same character. It would on many accounts be convenient to apply to this developmental (in a phyletic sense) stadium of the early phacopidean type, the term introduced by Schmidt, *Monorachus*, but such a designation would fall short of its purpose unless accompanied by an equivalent term to designate the same phase of development in those early Devonian species which follow the appearance of typical *Dalmanites*, namely, such species as those to which the name *Chasmops* was applied in the Palæontology of New York, volume vii, e. g., *D. anchiops* Green, of the Schoharie grit.

The first appearance in the lower Silurian of this phase of partial coalescence of the first and second lobes was simple; its re-appearance in the Devonian was complicated with a variety of ornamental modifications, occurring at a period when the trilobites generally were garnished with all sorts of dermal extravagances.

*This species is described (Proc. Acad. Nat. Sci., Phila.; p. 167, fig. 3) as "not in a condition to record the minor details of the head." The figure, however, shows the third and a part of a large second lobe, sufficient to demonstrate that it is not a *Chasmops*; while the known structure of the species in other respects evinces a close approach to *D. bebryx* Billings. *Chasmops troosti*, mentioned by Safford in 1869, but first described and figured by Safford and Vogdes in 1889, is from the Trenton horizon at and near Murfreesboro, Tennessee.

Several convenient subgeneric names have been applied to these later forms, such as *Odontocephalus*, where the frontal limb of the cephalon bears a row of incisor-like processes; *Corycephalus*, in which similar processes extend to the genal angles; *Coronura*, where the pygidium has an echinate margin and its posterior extremity is erected into a semicircular collar. These names are taxonomically subordinate in the third degree to the term *Dalmanites;* that is to say, we conceive that they all, with the inclusion of those Devonian species referred to above as "*Chasmops*" (forming a homotaxic group) are subsidiary to a division whose diagnostic feature is the more or less complete coalescence of the first and second lateral glabellar lobes, and for such a subgeneric division a designation is needed (e. g., *Synphoria).*

The typical expression and phyletic normal of *Dalmanites* is represented by a series of upper Silurian and earliest Devonian forms, in which the glabellar lobation is perfect and the pygidium caudate. An excellent example is the *D. limulurus* Green, of the Niagara group. This type is foreshadowed in the lower Silurian by *D. achates* Billings, of the Trenton limestone, and perhaps by *D. carleyi* Meek, of the Hudson River group. *Dalmanites achates* still maintains the facial suture of *Pterygometopus*, with the complete glabellar lobation, anterior width of glabella and acuminate pygidium of typical *Dalmanites.*

The acmic or mature type of *Dalmanites* becomes simply ornamented by rostrate processes on the cephalon, both in the later (Waldron) Niagara (*D. bicornis* Hall*)*, and in the Lower Helderberg (*D. nasutus* Conrad, *D. tridens* Hall), or may have short triangular spines extending partially or entirely about the margin of the cephalon (*D. dentatus* Barrett, *D. dolphi* Clarke). With the close of the Lower Hederberg the type seems to have abruptly disappeared, but it reappeared in the Hamilton fauna devoid of other dermal ornament than the broad, flat marginal extensions of the pygidium, *Cryphæus.* This is the last of the race in American faunas.

These appearances are, I apprehend, to be interpreted and summarized as follows: The lobal coalesence of the early Silurian species, *D. bebryx*, *Ch. troosti*, *P. eboraceus*, is indicative of immature or epacmic development. The relation of *Monorachus* to these forms was close and probably ancestral. After passing the acmic period, when phyletic senility manifests itself in the variety and extravagance of the dermal ornamentation, the reversion to the epacmic condition of lobation is but an accompaniment of the decline of the series.

*Pterygometopus* represents but a secondary stage in this process, a stage more advanced than that indicated by *D. bebryx*, &c. But in certain species of the genus, there is a lateral expansion of the first and second glabellar lobes, giving to the glabella as a whole a somewhat globose aspect. From such species is the point of departure toward the true *Phacops*, leading thence through the little Upper Silurian *P. trisulcatus* Hall, and *P. orestes* Billings, into the typical forms of the Devonian.

*Chasmops* is a genus abundantly represented in the Scandinavian and Russian Lower Silurian, but with a single American representative, *D. breviceps* Hall,* from the Hudson River group of Ohio. In this genus the first glabellar lobes are extravagantly developed at the expense of the other pairs and extend frequently from the first glabellar furrows to the occipital ring.

## Family CERAURIDÆ.

### Genus CERAURUS, Green, 1832.

#### CERAURUS PLEUREXANTHEMUS *Green*, 1832.

*Ceraurus pleurexanthemus* GREEN, 1832. Monogr. Tril. North Amer., p. 83; cast 33, plate 3, fig. 10.
*Ceraurus pleurexanthemus* HALL, 1847. Palæontology of New York, vol. i, p. 242, pl. 65, figs. 1*a*–*n*: pl. 66, figs. 1, 1*h*.
*Ceraurus pleurexanthemus* WALCOTT, 1881. Bull. Mus. Comp. Zool., Harvard Coll., vol. viii, p. 211 pl. 5, figs. 1–6.

This species abounds at several localities, and specimens do not materially differ in size and habit from those of the Trenton limestone of New York. It has a very considerable vertical range, having been found at the following localities. Lower Trenton, or Birdseye limestone, Janesville and Mineral Point, Wisconsin; Black River horizon, Minneapolis; Trenton horizon, St. Paul; Galena horizon, Kenyon; Hudson River horizon, Spring Valley, Minnesota.

### Subgenus PSEUDOSPHÆREXOCHUS, Schmidt, 1881.

#### PSEUDOSPHÆREXOCHUS TRENTONENSIS, *n. sp.*

The remains of this fossil are quite imperfect, but the occurrence of this type of structure in the Trenton fauna of New York is worthy of notice.

This division of the *Ceraurus* group, *Pseudosphærexochus*, was introduced for such species as differ from *Ceraurus* in the subtrigonal rather than subquadrate outline of the glabella, its convex or bullate contour, the posteriorly directed glabellar furrows (the third pair being the largest, but not reaching the occipital furrow), and the very large size of the third pair of glabellar lobes; all of which are features in strong contrast to their disposition in the restricted genus *Ceraurus*.

Our specimen is a single glabella of large size, regularly convex surface, and rather abrupt slopes to the frontal and lateral margins. Its length to the occipital furrow is 19 mm., and the occipital ring is 3 mm. in width and decidedly flat on the axis. The width of the glabella at its base is 21 mm. The three pairs of glabellar

* Adv. Sheets, Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 16, 1866; Twenty-fourth do., p. 223, pl. viii, figs. 15, 16, 1872; Palæontology of Ohio, vol. ii, p. 108, pl. iv, figs 16, 17, 1875.

furrows are distinct, the first being the shortest, originating close to the frontal margin, the length of each being just about one-half the distance between their outer extremities measured in a straight line. The second furrows are longer, parallel for about one-half their length with the first pair, thence directed more strongly backward. The third furrows are again longer than the second, subparallel to them but deflected abruptly backward at their extremities where they are widened into a slight pit or excavation. The last do not reach the occipital furrow.

Figs. 53, 54.—Glabella of *Pseudosphærexochus trentonensis.*

The frontal lobe is relatively small and spherically subtriangular; the first pair of lateral lobes elongate rectangular, the second pair similar, though broader and deflected somewhat posteriorly at both extremities, the third pair is short, clavate, one-half wider at its outer than at its inner extremity. The surface of the glabella is covered with low but distinct tubercles.

*Formation and locality.*—Middle Trenton group, Trenton Falls, New York.

## Subgenus CYRTOMETOPUS, Angelin, 1854.

### Cyrtometopus scofieldi *n. sp.*

This species is known only from its cranidium, of which a few examples are at hand. The part is small, having an axial length of about 6½ mm., and a width between the extremities of the cheek spines of 16 mm. Glabella elongate-subquadrate in outline, broadly rounded in front; dorsal furrows straight and subparallel; length to occipital groove equal to width at base. General contour depressed

Fig. 55.—Cranidium of *Cyrtometopus scofieldi.*

convex, flattened above. Frontal lobe large, first and second lobes small, obscurely defined, the former transversely subrectangular curving backward towards the dorsal furrows, the latter subtriangular and broadest within; third lobes moderately large, having a form just the reverse of that of the second lobes, and almost if not wholly set off from the glabella by the deep bounding furrows. The first and second pairs of glabellar furrows are exceedingly obscure and may be discerned only in an oblique light. Occipital furrow narrow and deeply impressed; occipital ring broad in the middle, highly arched on the axis, which is scarcely as wide as the base of the glabella. On the cheeks the occipital ring gradually widens, at its extremity meets the outer marginal rim of the border, and is continued into a short, outwardly directed spine. The occipital furrow is also sharply defined upon the cheeks.

Eyes of moderate size, not elevated to the hight of the glabella. Suture normal; ocular ridge from the anterior angle of the eye to the frontal margin broad and conspicuous. The entire surface of the shield is minutely and uniformly pustulose over all its parts.

This species has somewhat the general aspect of *Ceraurus pleurexanthemus,* but differs from it characteristically in the obscure lobation of the glabella, the surface granulation, and the shortness of the genal spines. It is, I believe, wholly distinct from any of the various species "*Cheirurus*" described by Billings from the Lower Silurian, though the usual imperfection of Billings' material renders a decisive opinion impossible.

*Formation and locality.*—Lower Trenton limestone, with *Orthis pectinella* and *Strophomena subtenta,* Minneapolis; and the Glades, Lebanon, Tennessee. Collection of Mr. Ulrich.

## Note on the Subgeneric Classification of the American species of the Genus Ceraurus.

The wide variation in the form and degree of lobation of the glabella and form of the pygidium in species which have been referred to *Ceraurus,* led Angelin, Schmidt, and some others, to introduce a number of subordinate and useful designations for what appear to be natural groups. The structure of *Ceraurus* as exemplified by its type species, *C. pleurexanthemus,* is characterized by its subquadrate glabella with moderately large frontal lobe, short, subequal lateral lobes separated by horizontal furrows, the third lobes being apparently isolated by a linear depression extending from the actual inner termination of the furrow to the occipital groove. The surface of the inner cheeks is characteristically marked by deep pittings scattered among the tubercles, while the pygidium bears two or three pairs of marginal spines, the first being of very great length.

The principal points of deviation from this type are manifested in the composition of the glabella. The glabella in *Cyrtometopus,* Angelin, *Pseudosphaerexochus,* and *Nieszkowskia,* Schmidt, is subtriangular, broadly clavate or subovoid, the lateral furrows and lobes being directed posteriorly. In *Cyrtometopus* the glabella is evenly and not greatly convex, and the third lobe is usually not wholly separated from the glabella. The ridge extending from the eyes forward to the anterior margin of the glabella is continuous with the broad frontal margin of the cephalon. Of American species representing this subgenus we may cite: *C. apollo* and *C. mercurius* Billings, from the Quebec group, *C. rarus* Walcott, from the Trenton limestone and *C. scofieldi* Clarke, from the Galena shales.

In *Pseudosphærexochus* the glabella is very convex, the third lateral furrow stronger than the others, and the third lobe larger and not separated from the body of the glabella. The pygidium bears eight marginal spines of subequal length. Under this division may be placed *C. prolificus* Billings, of the Quebec group, and *P. trentonensis* Clarke, of the Trenton limestone.

*Nieszkowskia* Schmidt, has the glabellar furrows very oblique posteriorly, the glabella most convex behind and usually produced into a posterior spine; the third furrow is the strongest and the third lobe is not separated from the body. To this division may be referred Billings' *C. glaucus*, and *C. perforator*, of the Quebec group, *C. satyrus*, of the Chazy limestone, and *C. numitor* of the Hudson River group.

Schmidt includes among these subgenera, *Sphærocoryphe* Angelin, in which the anterior portion of the glabella, embracing the frontal lobes and the first and second lateral lobes, becomes extremely convex and subspherical, without traces of lateral furrows. The third lobes only are apparent, and these quite obscure.

Of the foregoing divisions, all except *Pseudosphærexochus* have a pauci-annulate pygidium, with usually two or three annulations and ribs, and the first pair of ribs much the largest and extended at their free extremities far beyond the rest. In *Pseudosphærexochus* the *eight* free points of the pygidial ribs are sharp and angular. In *Eccoptochile* Corda, there are but *six* of these extensions and they are flat, broad and blunt at their extremities, and do not extend beyond the general marginal arc; while in *Crotalocephalus* Salter, these are likewise six in number, but narrow, incurved, distant, and acute. The structure of the glabella in *Eccoptochile clavigera* Corda, the type of the subgenus, is essentially similar to that of *Ceraurus*, though the glabella is rather more rotund and ovoid; but in *Crotalocephalus* there is a large, convex and protuberant frontal lobe. The first and second lobes are short and horizontal, and the third or basal lobes isolated by the union of the third glabellar furrows with the occipital groove. *Eccoptochile* is represented in the Hudson River fauna by *Ceraurus icarus* (Billings) Meek. Of the typical *Crotalocephalus* we probably have but one representative, the *C. niagaraensis* Hall, of the Niagara shales of Lockport and Rochester, N. Y., and the magnesian limestones of Illinois and Wisconsin.

We may summarize and tabulate the subgeneric relations of the best known American representatives of *Ceraurus*, in the following manner:

1. Pygidium with first pair of ribs much produced and embracing the short extension of the other one or two pairs.

   *a.* Glabella depressed, subquadrate; glabellar furrows short and horizontal: *Ceraurus* s. s.
   - *C. pleurexanthemus* Green.
   - *C. polydorus* Billings.
   - *C. pompilius* Billings.
   - *C. nuperus* Billings.
   - *C. tarquinius* Billings.

   *b.* Glabella ovoid, convex; glabellar lobes posteriorly oblique, third lobe not separated; ocular ridge continuous with frontal border: *Cyrtometopus.*
   - *C. apollo* Billings.
   - *C. mercurius* Billings.
   - *C. rarus* Walcott.
   - *C. scofieldi* Clarke.

   *c.* Glabella elliptical, convex behind, with obliquely posterior furrows; third lobes not separated; usually a spine on the posterior portion of the glabella: *Nieszkowskia.*
   - *C. glaucus* Billings.
   - *C. perforator* Billings.
   - *C. satyrus* Billings.
   - *C. numitor* Billings.

   *d.* Frontal and first and second lateral lobes confluent and highly convex or subspherical: *Sphærocoryphe.*
   - *S. robusta* Walcott.
   - *S. salteri* Billings.

2. Pygidium with free pleural ribs not extending beyond the posterior arc.

   *e.* Glabella subquadrate, rounded and full in front; lateral furrows short and horizontal; third lobe not separated; pygidium with four pairs of broad obtuse marginal extensions: *Eccoptochile.*
   - *C. icarus* (Billings) Meek.

   *f.* Glabella with large and convex frontal lobe; members of first and second lateral furrows confluent; third lobes wholly isolated. Pygidium with six distant, sharp, incurved caudal spines: *Crotalocephalus.*
   - *C. niagarensis* Hall (=*C. insignis* Beyrich.)

   *g.* Glabella convex, ovoid or subtriangular; frontal lobe small, lateral furrows oblique; third lobe large and not isolated. Pygidium with eight divergent spines: *Pseudosphærexochus.*
   - *C. prolificus* Billings.
   - *P. trentonensis* Clarke.

# Family ENCRINURIDÆ.

## Genus ENCRINURUS, Emmrich, 1844.

### ENCRINURUS VANNULUS, *n. sp.*

Animal small, ovate in outline, tapering posteriorly from the base of the cephalon; protuberant anteriorly. Cephalon with entire, broadly subcircular anterior margins, genal angles obtusely rounded, surface elevated, flattened above. Glabella protuberant, its convex frontal lobe extending considerably beyond the anterior margin of the shield; obovate; greatest width across the anterior portion of the frontal lobe and equal to the axial length. Anterior margin subcircular to the dorsal furrows which are deep, convergent and slightly incurved. Lateral furrows obscure, but still more distinctly developed than is usually the case in species of this genus. The first pair lies a short distance from the anterior extremities of the dorsal furrows, is short and directed somewhat anteriorly; the second and third furrows are but slightly longer, somewhat more transverse. None of these pass far inward and their inner extremities are separated by a regularly convex median portion of the glabella. They are equidistant and the lobes are, therefore, of about the same size. One-half the length of the glabella is taken by the frontal lobe and the width of the glabella at its base is one-half its width at the base of the frontal lobe. Occipital groove narrow, occipital ring broader than the lateral lobes and extending considerably beyond the base of the glabella, forming a proportionally broad axis. Eye-nodes very convex, the eyes themselves being small, elevated and situated at about the middle of the cheeks. Outwardly, beneath the eyes, the surface is depressed convex. The facial sutures terminate posteriorly, directly at the genal angles. The occipital groove is clearly defined over the cheeks and is continuous with a lateral marginal groove. Surface coarsely and evenly tubercled over the glabella and the cheeks, within the marginal furrow.

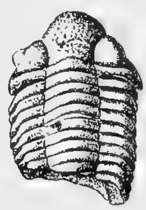


Fig. 56.—*Encrinurus vannulus.* × 2.

Thorax broad, flattened above, abruptly depressed at the sides. Segments normally eleven, but ten are preserved in the single specimen in which this part is retained. Axis broad, gently convex; it widens posteriorly from the first to the fifth segment, thence gradually tapering. The pleuræ, at about the middle of their width, are deflected abruptly, each segment terminating in a broadly obtuse extremity. From the line of geniculation they are bent abruptly backward. The segments are simple throughout, or with but very faint sulci.

Pygidium subpentagonal in outline; length and width equal. Axis relatively narrow, the lateral articulating surface sloping abruptly backward so that the outer lateral margin of the shield begins at a point fully two-thirds the length of the shield from the anterior margin. Post-lateral slope abrupt. Axis convex, with 6 or 7

Fig. 57.—Pygidium of *Encrinurus vannulus.* × 3.

rounded annulations, which extend entirely across, and behind these 8 or 9 more which are interrupted medially by a smooth area. The axis, which tapers rapidly, is continued beyond the annulations, its extremity reaching almost to the margin, and enveloped by an elevated oval ridge having the appearance of an adventitious pleural rib. The pleuræ bear six short, simple ribs which are elevated at their proximal extremities on the dorsal furrows and curve abruptly backward. The first three of these may end in free, blunt tips; the last three are confluent with the margin of the shield, the final pair enclosing the peculiarly enveloped extremity of the axis. Length and width of the typical specimen, 7 mm.

*Formation and locality.*—Lower blue beds of the Trenton limestone, Janesville, Wisconsin (Museum No. 8410); upper beds, Beloit, Wisconsin (Museum No. 8418).

Of this species I have observed but three specimens: a pygidium and a part of the cephalon from the former locality, and a cephalon with ten segments of the thorax from the latter. The species probably approaches *E. raricostatus* Walcott (of which as yet but the pygidium is known) more nearly than any other American form. That species is said to possess from 13 to 16 smooth continuous annulations on the axis of the pygidium, and it is upon the difference of the two forms in this respect together with the additional knowledge of the other parts of the animals, that this proposed species is grounded.

### (?) Encrinurus raricostatus *Walcott*, 1877.

cf. *Encrinurus raricostatus* Walcott, 1877. Adv. sheets, Thirty-first Rept., N. Y. State Mus. Nat. Hist., p. 16.
*Encrinurus raricostatus* Walcott, 1879. Thirty-first Rept., N. Y. State Mus. Nat. Hist., p. 69.
*Encrinurus raricostatus* Safford and Vodges, 1887. Proc. Acad. Nat. Sci. Phil., p. 167. fig. 2.

There is a single pygidium in the material before me, from the Trenton limestone at Mineral Point, Wisconsin (Museum No. 8403), the original locality of Mr. Walcott's species, that has the axis annulated for most of its length and the six lateral ribs relatively larger, blunter at both extremities and with a less abrupt posterior curve than *E. vannulus.* It agrees well with the original description which was based upon this part alone, and with the only figure yet given of the species, that published by Safford and Vogdes, of a specimen from Lebanon, Tenn.

ENCRINURUS CRISTATUS, *n. sp.*

There is a portion of a small cranidium from the horizon of the Hudson River group at Spring Valley, Minnesota, which presents a series of striking characters, and in the absence of negative evidence may provisionally be regarded as a new

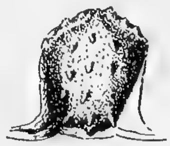


Fig. 58.—Cranidium of *Encrinurus cristatus.* × 3.

species. The glabella is obconical, its narrow, blunt extremity being directed posteriorly and conspicuously elevated. It extends almost if not quite to the occipital margin, over-hanging the posterior edge. The dorsal furrows are very deep and constrict the glabella laterally. The glabellar furrows are represented by three deep punctæ at the bottom of the dorsal furrows, and these afford evidence of four pairs of lateral lobes; the first very small on the margin and limited by a faint groove extending upward over the surface of the glabella; the second and third also narrow and linear, are immediately merged into the median lobe, while the fourth pair is better developed than the rest, extends entirely across the dorsal furrows, connecting the eye-node with the anterior extremity of the glabella.

The glabella bears upon its upper surface a few (25) coarse, distant tubercles, which on the posterior portion are elongated, directed obliquely backward and upward, and take on the form of blunt spinules. From the middle point on the anterior margin of the glabella diverges a pair of shallow grooves, which skirt the ante-lateral margins and become obsolete on the lateral slopes. These grooves, which apparently indicate the course of the facial sutures on their anterior limbs, cut off a narrow ridge on each side of the anterior margin and each of these ridges bears a single row of four strong spiniform tubercles. The lateral and posterior concave slopes of the glabella are smooth. The length of this glabella is 5 mm.

A portion of the left eye-node is retained and appears to have been moderately elevated though not to the hight of the glabella; the eyes were approximate and posterior. Among the Russian species of *Encrinurus* described by Schmidt, we find a very close ally to *E. cristatus* in his *E. seebachi*, from the Wesenberg horizon (*op. cit.*, pl. XIV, figs. 16—26). In the latter the glabella is less convex and more abundantly tubercled; but the posterior tubercles are equally spiniform, and the anterior row is clearly delimited though not divided in the center.

## Genus CYBELE, Lovén, 1845.

### Cybele winchelli, *n. sp.*

There is a single extended individual of this genus, considerably defaced about the head, so that the glabella is wholly lost; but the outline and proportions of the cephalon and the structure of the other parts are preserved. General outline linguate, tapering from the head backward to a subacute extremity; axial length

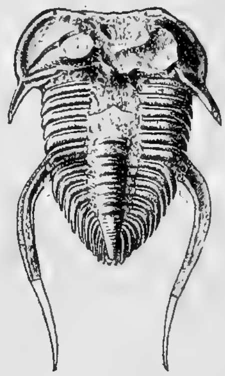


Fig. 59.—*Cybele winchelli.*

36 mm., greatest width 26 mm. Surface convex, flattened above. Cephalon transverse, broadly rounded at the sides, somewhat concave on the frontal margin which was slightly elevated. Length 10 mm.; width 26 mm. As the structure of the glabella is lost, a figure is here introduced copied from one of Schmidt's drawings of

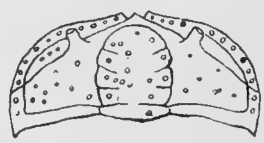


Fig. 60.—Cephalon of *Cybele bellatula* (after Schmidt).

*C. bellatula* Dalman. This shows the three distinct pairs of lateral lobes, the rather small frontal lobe and the peculiar projection of that portion of the shield lying between the upper anterior extremities of the facial sutures.

Eye-nodes large and elevated, situated near the transverse diameter of the shield and directed somewhat anteriorly. Facial suture taking its origin on the outer margin considerably above the genal angles, whence its course may be traced as far as the eye-node. Margin of the cephalon thickened, convex and somewhat spreading on the ante-lateral limb, receding and becoming concave posteriorly, thence produced into rather short divergent genal spines. Occipital ring and groove well marked.

Thorax subquadrate, tapering; 20 mm. in width at the anterior extremity; 8 mm. in width at the posterior extremity; length 20 mm. Composed of twelve segments. Axis proportionally narrow and convex throughout, having about one-fourth the width of the thorax at any point. The segments are slender and distinctly grooved for their entire length or within a very short distance of their extremities. The first five segments appear to be obtusely rounded at their terminations, but the last seven are acute. The sixth segment, though no broader than the rest within the articulating lines, is greatly expanded at the line of geniculation and each extremity is produced as a stout spine, considerably beyond the termination of the pygidium; these curve outward at first, thence recurve and approach each other. Though their entire length is not preserved, they could not have been less than 20 mm. long. The last six segments are like the first five, except that they are curved more abruptly backward, their terminations being acute.

Pygidium short, narrow in front, all the annulations being curved abruptly backward. Anterior diameter 7.5 mm.; length 9 mm. The articulating ring of the axis is very large and conspicuous; behind it is a single annulation extending entirely across the axis, three others which extend from the dorsal furrows partly across, these being followed by five or six rings which do not reach the dorsal furrows and are separated medially by a flattened area, like that in *Encrinurus*. The axis ends acutely and does not reach the extremity of the pygidium.

Each of the pleuræ bears four or five ribs, the first of which is quite narrow, and is, probably, the anterior moiety of the second, as it does not reach the margin. There may also be seen a trace of a similar intercalary rib between the second and third ribs. The second, third, fourth and fifth ribs end in acute, free points which were directed outwardly.

Surface finely tubercled, the tubercles being coarsest on the border of the cephalon and the ribs of the pygidium. The surface of the free cheeks was slightly pitted or punctated.

*Formation and locality.*—Galena limestone (?), Fillmore county, Minnesota (Museum No. 8435). This specimen was found loose, and its exact geological position is, hence, uncertain.

*Observations*—This is the most completely known species of *Cybele* from the American faunas, indeed the only species of the genus observed here except that figured by Billings under the name *Encrinurus mirus*, from the Quebec group of Newfoundland;* and of all the forms of this genus that have been illustrated no specimen shows better the general form and relation of the parts.

*Cybele* is an eminently lower Silurian genus, attaining its maximum development and variation of form in the Scandinavian and Baltic Silurian districts, at an horizon equivalent to that of *C. winchelli*. The unfortunate condition of the glabella of our specimen precludes a thoroughly reliable comparison with other forms; but the character of its pygidium, with short free terminations of the ribs, suggests a specific relationship with *C. revalensis* Schmidt,† from the étage $C_1$, a somewhat earlier stage of the Trenton period than that represented by the Galena limestone. None of the Russian species possess the long cheek spines of *C. winchelli*.

*Palæozoic Fossils, vol. i, p. 292, fig. 282, 1865. The species was founded on a glabella, which is suspiciously like that of *Amphion;* the pygidium, however, associated with it in the illustration but not in the description, is probably that of a *Cybele*.

†Revision der ostbalt. silur. Trilobiten, Abth. 1, p. 207, pl. XIII, fig. 20; pl. XV, figs. 6, 7; pl. XVI, fig. 40.

## Family ACIDASPIDÆ.

### Genus ODONTOPLEURA, Emmrich, 1849.

#### ODONTOPLEURA PARVULA *Walcott* (sp.), 1877.

*Acidaspis parvula* WALCOTT, 1877. Adv. sheets, Thirty-first Rept., N. Y. State Mus. Nat. Hist., p. 16.
*Acidaspis parvula* WALCOTT, 1879. Thirty-first Rept., N. Y. State Mus. Nat. Hist., p. 69.
*Odontopleura parvula* CLARKE, 1892. Forty-fourth Rept., N. Y. State Mus., p. 101.

The few fragments of this species which have been observed in the Minnesota formations present no differences from the New York form. As the species is frequently preserved in an entire condition in the Trenton limestone of Trenton Falls, N. Y., a figure of such a specimen is here introduced.

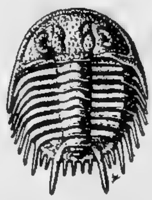


Fig. 61.—*Odontopleura parvula* Walcott. × 3. Trenton Falls, N. Y.

*Formation and locality.*—Galena shales, St. Paul, Minnesota.

## Family LICHADÆ.

### Genus LICHAS, Dalman, 1826.

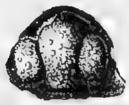
### Subgenus ARGES, Goldfuss, 1839.

#### ARGES WESENBERGENSIS *Schmidt*, var. PAULIANUS, *n. var.*

Cephalon convex, subsemicircular in anterior outline, projecting medially; lateral extensions not exsert.

Glabella regularly convex, anterior and lateral slopes the more abrupt. Median lobe broadest on the anterior margin where it covers three-fourths of the entire width of the glabella, regularly rounded, most convex just in front of its center. Anterior and posterior glabellar furrows continuous and deep, setting off a pair of simple, rounded, subovoid lateral lobes, bounded on the outside by the dorsal furrows which are somewhat shallower than the inner furrows. The first and second lobes are thus wholly coalesced, the third or occipital lobes being represented by a pair of elongated nodes which at their union with the narrow posterior portion of the median lobe form an obscure annulation. Occipital furrow broad; occipital ring narrow, elevated on the axis and aspinous. The fixed cheeks and eye-node are convex, the latter appressed to the glabella and somewhat posterior in position.

The outer cheeks are abruptly convex below the eye, are there broadly grooved by a furrow which widens toward the margin, where it produces a rather deep emargination of the periphery. Genal extremities recurved, tapering to an acute angle, but not narrowed on the posterior surface. Occipital furrow broad and distinctly defined.



Figs. 62, 63.—Cranidium of *Arges wesenbergensis.* var. *paulianus.* × 3.

The cephalon is covered with tubercles which are coarsest over the glabellar lobes; on the cheeks they become scattered, vary more in size, and the coarser are gathered along the posterior margin. No single specimen of the head retaining all these parts in apposition has been observed, but in the cranidia the size is about the same, an average glabella measuring 5½ mm. in length; 6½ mm. between the eyes.

Of the thorax only a few scattered segments have been seen.

Fig. 64.—Pygidium of a somewhat smaller individual. × 3.

Pygidium short, transversely semielliptical in outline. The axis is convex and has about one-third the width of the shield on its anterior margin. Its sides are straight or slightly incurved, scarcely tapering, for about one-half the length of the shield. Posteriorly it is broadly rounded and terminates in an elongated ridge which extends to, and is confluent with the marginal thickening of the shield. Three annulations are distinctly defined and behind these are one or more transverse rows of fine tubercles. The pleuræ are depressed convex, thickened about the margins. There are two distinct pleural ribs, the anterior being deeply sulcate and its two divisions uniting to form a single narrow, acute, moderately long spine. The second rib is also broadly sulcate, is much smaller than the first and its parts unite outwardly to form a second marginal spine longer than the first. Behind these two ribs there are two tubercled spaces extending to the median prolongation of the axis. On the margin, besides the first and second pairs of spines, there is a third or terminal pair somewhat shorter than the others, and between them and the second pair is a small and short accessory pair, making in all eight short, rounded spines. On the under side or doublure these are more flattened than above.

Length of average specimens 4 mm.; anterior width 5 mm.

Hypostoma transversely elongate, subquadrate, anteriorly convex, posteriorly broadly marginate. Central lobe distinctly defined and with two short, lateral, transverse sulci or indentations.

*Formation and locality.*—Trenton limestone, Minneapolis; Galena shales, St. Paul; Wykoff, Minn.

*Observations.*—This species is quite abundant in the calcareous Galena shales at St. Paul, much more so than at the other localities cited.

There can be no question as to the unity of the parts described above as there is no other species in these faunas to which any of them could be referred, and they are moreover closely commingled in the fragments of rock studied.

The species is characterized by the lobation of the head in which it corresponds to the type of structure represented by the genus *Arges* Goldfuss, as interpreted by Schmidt. We accept provisionally this subgeneric reference, though it is to be borne in mind that the type of *Arges* is a Devonian species (*A. armatus* Goldfuss).

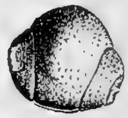
Upon close comparison of our specimens with those described and figured by Schmidt,* I have little hesitation in concluding that the two forms are specifically identical. Slight varietal differences may be observed in the rather more complete isolation of the lateral glabellar lobes on their posterior margin and in the somewhat greater length of the marginal spines of the pygidium in the American specimens. This species from the Trenton-Galena, the *Arges phlyctenoides* Conrad, from the Niagara, a hitherto undescribed form from the Lower Helderberg† and the *Arges contusus* Hall, from the Upper Helderberg, form an interesting series in which the subgeneric characters of the cephalon are maintained throughout. *Arges wesenbergensis* is from Schmidt's étage E, or the Wesenberg zone, associated with *Plectambonites sericea* and *Strophomena deltoidea*.‡

## Subgenus PLATYMETOPUS, (Angelin) Schmidt, 1885 *(emend.)*.

### PLATYMETOPUS CUCULLUS *Meek* and *Worthen* (sp.), 1865.

*Lichas cucullus* MEEK and WORTHEN, 1865. Proc. Acad. Nat. Sci. Phila., p. 266.
*Lichas cucullus* MEEK and WORTHEN, 1868. Geol. Surv. Ill., vol. iii, p. 299, pl. I, figs. 6*a*–*c*.

This species which was described from the Trenton horizon of Alexander county, Illinois, is characterized by the simplicity of its glabella, there being but a single



Figs. 66, 67.—Portion of cranidium of *Platymetopus cucullus* Meek and Worthen, Galena limestone, Wykoff, Minnesota.

pair of furrows, which meet the occipital ring at right angles; and by the slight concavity of the median lobe of the glabella on its posterior slope, which gives it a

* Revision der ostbalt. Silur. Trilobiten, Abth. 2, p. 44, pl. VI, figs. 1–4. 1885.

† ARGES CONSANGUINEUS, *nom. prapos.* This species may be best described as differing from *A. wesenbergensis*, var. *paulianus*, in the narrower and much less convex frontal lobe, smaller and less elevated lateral lobes, nodiform and not

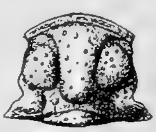


Fig. 65.—Cranidium of *Arges consanguineus*.

annular third lobes, larger and more elevated ocular nodes, broader and more highly arched occipital ring. The glabella is notably less convex, and, taken as a whole, proportionally smaller. The two species average about the same size.

From the Shaly limestone of the Lower Helderberg group, near Clarksville, N. Y. The type specimens have been presented by the writer to the New York State Museum.

‡ See Schmidt, On the Silurian Strata of the Baltic Provinces of Russia: Quart. Jour. Geol. Soc., Nov. 1882, p. 522.

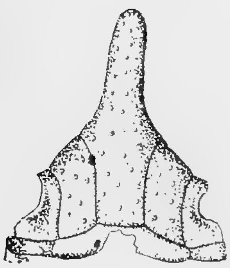
peculiar subconical protuberance. It is mainly in the latter feature that the species, so far as its parts are known, differs from the *Lichas trentonensis* Conrad. A well preserved glabella of *P. cucullus* occurs among the material from the Galena limestone of Wykoff, Minnesota, loaned by Dr. Robbins, and a fragment which may represent the same species comes from the Trenton beds at Janesville, Wisconsin (Museum No. 8414).

### PLATYMETOPUS ROBBINSI *Ulrich*, (sp.), 1892.

*Lichas (Hoplolichas) robbinsi* ULRICH, 1892. Two new Lower Silurian species of Lichas (Subgenus Hoplolichas). Amer. Geologist, vol. x, No. 5, p. 271, figs. 1*a*-*b*.

The original and, as far as I am aware, the only observed specimen of this species, is a cranidium lacking only the anterior portion of the glabella. The species is an interesting addition to the American lichads and presents some especially noteworthy features. Among these is the stout baculiform anterior extension of the frontal lobe of the glabella, which appears to be homologous with the produced lobe of the well known lower Silurian species, *L. celorrhin* Angelin* and *L. pachyryncha* Dalman, var. *longirostrata* Schmidt,† rather than with such spinous processes as those possessed by *L. bicornis* Ulrich, *Hoplolichas tricuspidata* Beyrich and *H. proboscidea* Dames.

The character of the glabellar furrows, also, is of importance. These are very narrow and sharply impressed, have the usual degree of curvature anteriorly, but posteriorly become quite parallel and straight, debouching in the equally narrow occipital furrow at right angles. Thus, as in so many of the American Silurian species of *Lichas*, these grooves represent the continuous anterior and posterior furrows, the median pair being lost by the coalescence of the first and second lobes. The third pair of lobes we regard as obsolete.



Figs. 68, 69.—The cranidium of *Platymetopus robbinsi* Ulrich; with outline profile.

Elsewhere we have expressed the conviction that the lobation of the glabella must be given first importance in the subdivision of the genus *Lichas*, and the nature of this lobation with the total loss of the third lobes places this species with the

* Palæontologia scandinavica, pt. i, p. 69, pl. xxxv; figs. 1*a*-*c*. 1878.

†Schmidt, Revis. d. ostbalt. Silur. Trilob. ii. Acidaspiden u. Lichiden, pl. I. fig. 12. 1858.

subgenus *Platymetopus.* I regret being unable to concur with Mr. Ulrich's reference of this and the following species to Dames' proposed subdivision *Hoplolichas,* but in the latter the third lobes are well defined. Dames ascribed much importance to, and indeed, found the suggestion of his term in the stout, sometimes forked spine borne by the occipital ring,* while the possession of anterior extensions of the frontal lobe, though of much the same significance structurally, is taxonomically unessential. It would seem, in fact, that if there is any basis for the admission of the division *Hoplolichas,* it lies in the presence of this ornamental or defensive character. The original specimen of *P. robbinsi* is broken near the center of the occipital ring but there is no indication that it possessed a central nuchal spine.

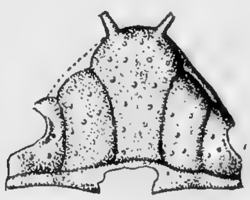
In the possession by different subgenera of *Lichas,* of similar frontal extensions of the glabella, as in *L.* (*Metopias*) *pachyrhyncha,* var. *longirostrata* Schmidt, *L.* (*Hoplolichas*) *proboscidea* Dames and *L.* (*Platymetopus*) *robbinsi* Ulrich, we find an instance of morphic equivalence in a certain structural character coexisting with subgeneric features essentially distinct.

*Formation and locality.—Platymetopus robbinsi* is from the middle beds of the Galena limestone, at Wykoff, Minnesota. (Collection of Mr. E. O. Ulrich).

## PLATYMETOPUS BICORNIS *Ulrich,* (sp.), 1892.

*Lichas (Hoplolichas) bicornis* ULRICH, 1892. Two new Lower Silurian species of Lichas (Subgenus Hoplolichas); Amer. Geologist, vol. x, p. 272, figs. 2*a*–*b*.

This interesting species has precisely the same character of glabellar lobation as the preceding, and the remarks made upon the generic relation of the former apply as well to this. In the possession of a pair of divergent spines on the frontal lobe it would seem to bear a similar relation to *Hoplolichas tricuspidata* Beyrich, as *P. robbinsi* does to *H. proboscidea.* The characters of the species, as far as known from a single cranidium, have been sufficiently described by Mr. Ulrich, and will be apparent from the accompanying figures.



Figs. 70, 71.—Cranidium of *Platymetopus bicornis* Ulrich, with outline profile.

*Formation and loality.*—Hudson River group; two miles east of Spring Valley, Minnesota. (Collection of Mr. E. O. Ulrich).

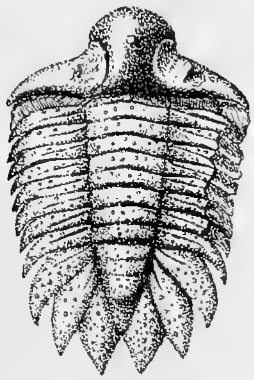
* See Dames, Zeitschr. d. deutsch. geolog. Gesellsch., vol. xxix., p. 794, pl. 12-14, 1877.

## Subgenus CONOLICHAS, Dames, 1877.

### CONOLICHAS CORNUTUS *n. sp.*

The specimen to be described was entire when found, but before coming into my hands, suffered from unskillful manipulation to such an extent as to obscure the lobation of the glabella and the segmentation of one side of the thorax. Notwithstanding, the condition of its preservation is much better than can usually be hoped for, in this group of fragile trilobites, for a *Lichas* with its parts in normal juxtaposition is a rare occurrence.

Cephalon transverse; narrowed and attenuate toward the lateral extremities;



Figs. 72, 73.—*Conolichas cornutus.*

greatly elevated axially. Length 11 mm.; width 31 mm. Glabella prominent; anterior margin the arc of an ellipse, projecting conspicuously beyond the general outline of the shield. The surface is convex, rising in a deep curve from the anterior margin to a well defined apex, marked by the base of a strong spine. This point is $8\frac{1}{2}$ mm. above the horizontal plane of the anterior margin. The lateral slopes of the glabella are less curved, and the posterior slope is long, straight or slightly incurved. The lateral and posterior lobes of the glabella are so obscured that only the delimitation of the former can be made out. It is evident that no middle glabellar furrow existed, but the anterior and posterior furrows were confluent and continuous. This furrow, originating on the anterior margin, rises nearly vertically along the sides of the glabella, making at first a slight inward curve, and, at about one-half the length of the median lobe, curving outward, terminating near or in the occipital furrow. The lateral lobes thus set off are large, though they were probably not greatly elevated, and represent the first and second lateral lobes of species in which the median glabellar furrow is developed. Whether the third or occipital lobes existed cannot be ascertained. Cheeks elongate and tapering; but slightly curved posteriorly toward their extremities. Where they unite with the glabella they are so much narrower than it as to effect an abrupt indentation in the ante-lateral margin. Their posterior margin is slightly concave, and from this incurvature the cheeks are made to stand away from the thorax, as in *Arges*, etc. Their surface is convex and the slope rather the more abrupt on the posterior side.

Thorax subquadrate, narrowing posteriorly, composed of nine segments, the first of which is obscured. Length of this part (entire), 20 mm.; anterior width 30 mm. Axis proportionally broad; on the anterior segments having rather more than one-third the width of the thorax, but relatively narrower behind. Each segment is flat or depressed convex, and there are no nodes or thickenings at their junction with the axial furrow. The axis is regularly convex, and the lateral furrows broad and not deeply impressed. Pleuræ flat for about one-third of their width, the outer moiety being evenly deflected. Segments broad, recurved and tapering to acute terminations.

Pygidium comparatively large, being 17 mm. in length, which is more than one-third the length of the entire animal. Axis very prominent, tapering gradually to a blunt protuberance at about two-thirds of its length, whence the surface becomes abruptly depressed, and the marginal furrows incurve, meeting on the posterior margin. The elevated portion of the axis bears one distinct annulation, and a second one whose posterior groove does not extend to the axial furrows. The ribs of the pleuræ are in three pairs. Each is broad, gently convex, the pleural grooves being narrow and sharply incised. Adjoining ribs are united for rather more than one-half their length. The first two pairs are elongate lanceolate, curving backwards. Both of these pairs bear linear grooves on their surface. The members of the third or posterior pair are rhombiform, still with a slight inward curve toward the axial line.

The surface is covered with fine and coarser tubercles or pustules, which are especially conspicuous upon the pygidium and axis of the thorax. There is no evidence of any other spine upon the test than that rising from the apex of the glabella.

*Formation and locality.*—Middle Trenton limestone, Trenton Falls, N. Y.

## Observations on the Subordinate Generic Relations of the American Species of Lichas.

Probably in no genus of Trilobites are the characters upon which dependence is usually placed for taxonomy, so variable as in *Lichas.* Hence arises the fact that essays toward subgeneric division of the very considerable number of known species have been of but very restricted utility.

The lichads were thin-shelled Crustacea, and in the tenuity of the test and its ready adaptation to modifications of the interior may be found one cause of the wide variation in the form of lobes and protuberances, the length of grooves and ridges of the surface. In this respect the genus stands in strong contrast to such compact and thick-shelled genera as *Phacops* where the parts of the test have become rigidly condensed and present throughout the existence of the genus a stable resistance to all modifying agencies.

The subdivisions of the genus *Lichas* which have been suggested by the eminent investigators, Angelin, Fr. Schmidt, Dames, and Hall, may perhaps be characterized as well adapted to the material which the authors had before them, and to strictly typical specimens, but losing a degree of applicability when a more extended use of them is attempted. Such a criticism is easily made of any classification, and it is sufficiently evident that these authors were alive to the difficulties presented by these multiform species.

There has been a diversity of opinion as to the best basis of subdivision. The majority of students have, perhaps, made use of the variation in the lobation of the glabella, as the most conspicuous and essential source of structural difference, and there can be no doubt of the primary importance of such variation in the trilobites generally. Some authors, appreciating the instability of the characters of the head, have had recourse to the differences in the structure of the pygidium; but this is, also, an equally variable part. It is evident that any satisfactory classification must take into consideration concomitant variations of all the parts, and in this respect, the elaborate work of Dr. F. Schmidt upon the Silurian species of the East-Baltic Provinces must be regarded as the nearest approximation to a successful classification.

Barrande, conservative in his treatment of the classification of all the trilobites, recognized no subgeneric divisions; and this is by far the easiest solution of the taxonomic difficulties arising in the group, but the structural, faunal and stratigraphical value of modifications of the generic type are thereby left in obscurity. Subgeneric divisions are inadmissable or useless in series of compact acmic forms like *Phacops*, *Trinucleus*, etc., or a slightly oscillating group like *Proetus*, but the plastic *Lichas*, presenting the widest range of variation, affords an excellent opportunity for empiric skill at classification.

The typical species of the genus *Lichas* is the *L. laciniatus* (Wahlenberg)* Dalman, founded upon a pygidium, an outline copy of the original figure being

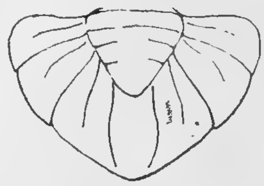


Fig. 74.—Outline of pygidium of *Lichas laciniatus* Wahlenberg (after Dalman).

introduced in this place. The remaining structure of the species is not known; but the pygidium bears two broadly falciform extensions on each side, and terminates in a single acute undivided median lobe. It is quite similar to the pygidium referred to *Platynotus trentonensis* Conrad, given by Hall;† and if the imperfect cephala from the Trenton limestone of New York given by this author represent the same species as the entire individual quoted and figured in the work cited as from the blue limestone of Ohio, the cephalic structure of *Lichas* in its typical or restricted meaning is very simple, the lateral furrows debouching at right angles in the occipital furrow, there being no middle grooves and no third lobes.‡ This is the structure of the New York specimens of *L. trentonensis*, of which the pygidium is not definitely known, that referred by Hall (*loc. cit.*, fig. 1*b*) to this species, being probably a part of our *Conolichas cornutus*. This structure, however, is the same as that predicated of *Platymetopus* Angelin (as interpreted by Schmidt). We have therefore to face a dilemma in the application of these terms. The precise value of the restricted term *Lichas* is not yet demonstrated, but knowing the meaning of *Platymetopus* we may provisionally employ the term while awaiting fuller evidence of its relation to the

* Ueber die Palæaden, pp. 53, 71, 72, pl. VI, fig. 1, 1828.

† Palæontology of New York, vol. i, pl. CXIV, fig. 1e.

‡ To illustrate the normal lobation of the cephalon in the highest development of the lichad type of structure a figure is here reproduced of the *L. palmata* Beyrich. (Barrande, Syst. Sil., vol. i, pl. XXVIII, fig. 45.)

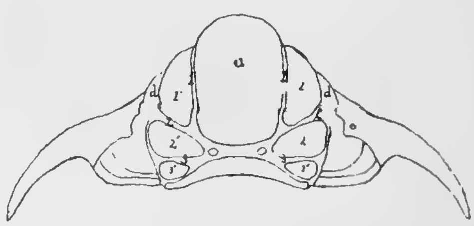


Fig. 75.—Glabella of *Lichas palmata* Beyrich. (After Barrande.)
*d.* dorsal furrows.
*a.* median or frontal lobe.
*1'*, *2'*, *3'*. anterior median and posterior lateral lobes.
*1*, *2*, *3*. anterior median and posterior lateral furrows.

true *Lichas.* A difficulty, more apparent than real, in assigning the species of lichads to their natural groups, arises from the frequent recurrence of extravagant styles of ornamentation in groups having a totally different character of cephalic lobation. Thus in *Metopias*, *Platymetopus* and *Hoplolichas* may occur a long, club-like extension of the frontal lobe; *Platymetopus* and *Conolichas* may both have subconical frontal lobes, concave on their posterior slope; *Platymetopus* and *Hoplolichas* may have the frontal lobe garnished with erect tubercle-spines. These are instances of morphic equivalence in diverse groups, which cannot be accorded a high significance in the association of the species.

We may suggest the following subgeneric division of the North American species of *Lichas:*

ARGES, Goldfuss.—Middle glabellar furrows obsolete, posterior furrows more or less indistinct; outer lateral margins of glabellar lobes convex; third lobes obsolete. Pygidium with 2—3 annulations on the axis, and narrow, round spines on the margin. A longitudinal ridge extends from the extremity of the axis to the margin. Elevated portions of the body often echinate.

*A. wesenbergensis* Schmidt, var. *paulianus* Clarke. Galena.
*A. phlyctenoides* Green. Niagara.
*A. consanguineus* Clarke. Lower Helderberg.
*A. contusus* Hall. Upper Helderberg.
*L. (Conolichas) hispidus* Hall. Upper Helderberg.
*L. (Conolichas) eriopis* Hall. Upper Helderberg.

The last two seem to be more at home here than in the subgenus *Conolichas*, on account of substantial differences from the latter in glabellar lobation and form of the pygidium.

PLATYNOTUS, Conrad.—Glabella depressed; middle furrows obsolete; frontal lobe depressed at its narrowest point; third lobes obscure, but present. Pygidium with three pairs of broad, acute, flat spines; axis short with 1—2 annulations.

*L. harrisi* Miller. Hudson River.
*L. boltoni* Bigsby. Niagara.
? *L. nereus* Hall. Niagara.
*L. breviceps* Hall. Niagara.

PLATYMETOPUS, (Angelin) Schmidt.—Lateral glabellar furrows open directly into the occipital furrow; no third lobes; all lobes depressed-convex, all furrows narrow; dorsal furrows concave inward. Pygidium with two pairs of lateral spines and a bluntly bispinous caudal termination.

*L. jukesi* Billings. Quebec.
*L. minganensis* Billings. Chazy.
*L. trentonensis* Hall. Trenton.
*L. cucullus* Meek and Worthen. Trenton, Galena.
*L. robbinsi* Ulrich. Galena.
*L. bicornis* Ulrich. Galena.

CERATOLICHAS, Hall and Clarke.—Frontal lobe elevated, lateral lobes large and highly convex, all spiniferous; third lobes absent. Occipital ring broad, with double axial spine. Dorsal furrows convex. Ocular node very small. Border broad.

*C. dracon* Hall. Upper Helderberg.
*C. gryps* Hall. Upper Helderberg.

TERATASPIS, Hall.—Frontal lobe ovoid, constricted below; dorsal and lateral furrows very broad; lateral lobes not sharply defined, highly elevated, directed posteriorly, spinous. Occipital ring very broad centrally, with baculate processes. Pygidium with four pairs of long, spiniferous caudal processes.

*T. grandis* Hall. Upper Helderberg.

HOPLOLICHAS, Dames.—Frontal and lateral lobes equally convex; occipital lobes present. Occipital ring with median simple or forked spine. No typically developed representative of this group is known to occur in American faunas. The fossil described as *L. (Hoplolichas) hylæus* Hall, from the Upper Helderberg group, known only from a portion of its cephalon, appears to be the nearest of any to this type of structure.

CONOLICHAS, Dames.—Frontal lobe highly elevated or conical. Occipital lobes conspicuous. Pygidium with two pairs of falcate spines and a broadly bispined terminal lobe.
*C. cornutus* Clarke. Trenton.

The *L.* (*Conolichas*) *pustulosus* Hall, of the Lower Helderberg, has a totally distinct form of pygidium, with but two pairs of broad lateral spines and a broad, undivided terminal lobe, like some of the forms of *Homolichas*, while the glabella with its elevated frontal lobe is unlike that of the latter subgenus and more similar to *Conolichas*, save in the absence of the occipital lobes. The composition of this species is peculiar and it will probably be found to stand as a distinct type of structure. *L.* (*Conolichas*) *hispidus* Hall, and *L.* (*Conolichas*) *eriopis* Hall, appear to be less like the normal *Conolichas* of the Silurian than the typical *Arges* of the Devonian.

There are some American species which can not be placed with any of the foregoing divisions. Of these the one best known in all its parts is the *L. halli* Foerste (with which *L. faberi* Miller is synomymous), from the Hudson River group of Cincinnati, Ohio. This species is close in all structural features with *L. margaritifer* Nieszkowski, from the Lyckholm beds of the Baltic provinces, or uppermost Lower Silurian; and for the latter Schmidt was unable to find a place among any of the subgenera adopted by him. The head has a broad and not very convex frontal lobe, sharply isolated lateral lobes, distinct occipital lobes and prominent ocular nodes. The pygidium has two broad spines on each side, and a rounded terminal lobe divided by a short and sharp median incision.

### PROETUS PARVIUSCULUS *Hall*, 1866.

*Proetus parviusculus* HALL, 1866. Adv. Sheets, Twentieth Rept., N. Y. State Cab. Nat. Hist., p. 17.
*Proetus parviusculus* HALL, 1872. Twenty-fourth Rept., N. Y. State Mus. Nat. Hist., p. 223, pl. VIII, fig. 14.
*Proetus parviusculus* HALL and WHITFIELD, 1875. Palæontology of Ohio, vol. ii, p. 109, pl. IV, fig. 18.

A few fragments, cranidia, free cheeks, and a single pygidium, of this species have been observed in rocks from the base of the Galena shales at St. Paul. Some of the glabellas, through compression, have the lobation more distinct than in the usual forms from Cincinnati; and in all, the granulation of the entire surface is a conspicuous feature. (Collection of Mr. Ulrich).

## Genus HARPES, Goldfuss, 1839.

### Subgenus HARPINA, Novák.

### HARPINA MINNESOTENSIS, *n. sp.*

The original of this evidently new form is a part of a *cephalon* (considerably more than one-half), preserving the outline of the frontal and lateral limb and the configuration of the surface. The anterior curve is subsemicircular, broadly rounding to the sides where the margin is straight for a considerable distance, thence incurving rather abruptly at the angles of the genal expansions. The outline thus formed may be termed subquadrate-ungulate, and its peculiar curve is a distinguishing character of the species.

Fig. 76.—Cephalon of *Harpina minnesotensis.*

General surface of cephalon moderately elevated. Glabella subtrigonal, tapering anteriorly to an obtusely rounded extremity. Length about one-half that of the cephalon axially; slightly greater than the width across the base. The top of the glabella is somewhat abraded but its lobation is quite distinct, showing that the frontal lobe is long and conical, extending for about one-third the glabellar length, the first pair of lateral lobes faint, the second pair a little longer; the third pair is comparatively large, ovoid, attached by a narrow neck to the basal and most elevated portion of the glabella. Of the glabellar furrows the third are largest and deepest. Occipital furrow broad and shallow; occipital ring narrow in the middle widening to the axial furrows. The frontal limb is broad, convex just in front of the glabella becoming deeply concave and elevated at the margin, to the full hight of the glabella. This general concavity of the marginal area is continued over the cheek, to the extremity of the cheek-spine, becoming, however, less, posteriorly. The outer marginal rim is thickened all around; the inner margin elevated but not thickened except at the continuation of the occipital ring on the cheeks. Eyes situated in a transverse line which crosses the glabella at about one-third its length from the anterior extremity, elevated and widely separated from the glabella by the broad dorsal furrows. A low ocular ridge extends from them obliquely backward toward the posterior extremity of the glabella.

Surface deeply pitted over the free cheeks and marginal expansions. The punctæ are circular, large, attaining their greatest size where the surface is most deeply concave. They appear not to be confluent at any place, but become obsolete on the marginal rim.

The single specimen observed has an axial length of 12½ mm.; length to end of cheek spine, 23 mm.; basal width 26 mm.

It is hardly necessary to indicate the particulars in which this fossil differs from the described species of *Harpes.* The character of the ornamentation, the form of the glabella and its lobation, the absence of broad, lobate expansions about the basal angles of the glabella, the oblique direction of the ocular ridges, as well as the curve of the marginal outline, are all distinctive characters.

*Harpes* is a genus which is not abundantly represented in species in any country, though its species are found from the Lower Silurian to the middle Devonian. It is a curious fact that all American species are from the Lower Silurian with the possible exception of the *H. consuetus* Billings, from the Island of Anticosti, which may belong to a middle Silurian, or a Hudson River-Clinton fauna. In Bohemia none of the forms described by Barrande are from the Lower Silurian but are distributed throughout the Upper Silurian and lower Devonian, while in Germany it ranges through the Devonian faunas disappearing with the fauna of *Gonitatites intumescens* (Intumescens-kalk).

The late Dr. Ottomar Novák called attention* to the intermittent occurrence of *Harpes* in the faunas of the Bohemian basin. Two of the eleven known species appear early in the Lower Silurian (étage $D_1$), but from that horizon to the étage $E_2$

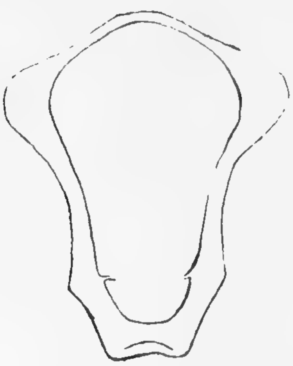


Fig. 77.—Hypostoma of *Harpes venulosus* Corda, enlarged. (Étage $F_2$). After Novak.

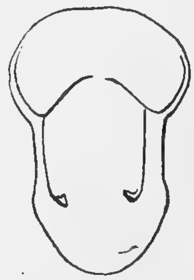


Fig. 78.—Hypostoma of *Harpina prima*, enlarged (Étage $D_2$). After Novak.

including five of Barrande's stratigraphical divisions, there is no evidence of its existence. Novák, suspecting a structural difference between the Lower and Upper Silurian species, which is not apparent from the exterior except in a less number of

*Studien an Hypostomen der böhm. Trilobiten, No. ii, p. 4, pl. i, 1884.

thoracic segments in the former, investigated the nature of the hypostoma of both and found therein differences so notable that he introduced the name *Harpina* for the early Silurian species; a term which we retain as probably applicable to all our American forms.

*Formation and locality.*—From the middle portion of the Galena limestone, Hader, Minnesota. Collector, Mr. E. O. Ulrich.

HARPINA, cf. H. OTTAWENSIS *Billings* (sp.).

Among the material obtained from Dr. Robbins is a large horseshoe-shaped impression of the exterior of the submarginal doublure of the head-shield. It is quite flat and its ornament apparently consisted of a great number of fine punctæ of about equal size except along the inner margin where they are larger and confluent in radial lines, forming a series of short divergent furrows. The marginal

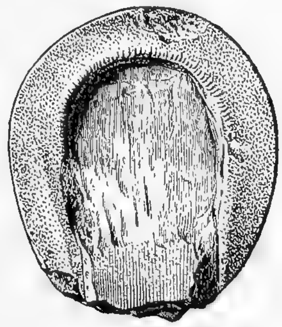


Fig. 79.—*Harpina*, cf. *H. ottawensis* Billings.

outline of the shield is quite similar to that of *H. ottawensis* Billings,* of the Trenton limestone of the city of Ottawa. Indeed, the specimen conforms almost exactly in size and curvature with the original figure of that species. We have above observed that species with a concave cephalon may have a perfectly flat doublure, and I am disposed to believe that this specimen probably represents an individual of *H. ottawensis*, with which it presents an additional point of agreement in the character of the surface punctæ.

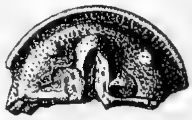
*Formation and locality.*—Galena limestone, Wykoff, Minnesota.

HARPINA RUTRELLUM, *n. sp.*

An hitherto undescribed species is represented by a head-shield with the following characters: Size moderately small, outline subsemicircular. Surface convex, somewhat depressed above; marginal border not so broad as in *H. minnesotensis*; deeply concave. Margin thickened, smooth and slightly upturned. Genal extremities not retained. Glabella subconical, extending more than one-half the

*Palæozoic Fossils, vol. 1, p. 182, fig. 165, 1865.

axial length of the shield, anterior extremity narrow and obtuse. Basal lobes very broad and large, together making the glabella considerably broader at the occipital ring than it is long. These lobes are separated from the glabella by short, posteriorly oblique lateral furrows, and from the cheeks by deep grooves which are abrupt and



Figs. 80, 81.—Portion of cephalon of *Harpina rutrellum*, with sectional outline showing the character of the doublure.

ridged on their outer margins. The occipital ring is narrow, elevated and well defined over about one-half the extent of the cheek. Cheeks somewhat flattened above, abruptly deflected to the concave margin. Eyes small, nodiform, distant from the glabella and situated in a transverse line cutting the shield at its center. Surface of convex portion of shield covered with coarse, deep, irregular punctures which are coarsest about the eyes and on the anterior slope of the shield, become finer and more nearly circular about the margin. The glabella is covered with shallow, irregular pits, while the basal lobes and occipital ring are smooth. Doublure flat, its width equalling that of the concave part of the upper surface; thence it is bent upwards at a right angle, its distal portion becoming parallel to the anterior slope of the shield, as in the accompanying figure. The outer surface of the flat area is covered with large and very coarse circular punctæ. Length of specimen 9 mm.; probable width at base, 16 mm.

Though there is but a single example of the head, the characters above given are sufficiently distinctive. Whether a second specimen showing only the flat portion of the doublure belongs to the same species it is impossible to decide definitely, though the character of the punctation is essentially similar, and the vertical section shows that the upper surface was concave about the margin. Perhaps the species most closely allied to ours is Prof. Hall's *Harpes escanabæ** from the Trenton horizon on the Escanaba river. This was based upon the marginal rim of a small cephalon described as being strongly pitted with the punctæ arranged along the outer and inner edges of the finer and more abundant perforations in the middle. This agrees with the character of the *under* surface of the second of our specimens, but not with the upper surface of the first and more typical example.

*Harpina rutrellum* may also be compared with *H. antiquata* Billings, of the Chazy limestone.

*Formation and locality.*—The cephalon described is from the Galena beds at Cannon Falls, Minn. (Mr. Ulrich's collection); and the fragment of the doublure is from the Trenton at Minneapolis (Museum No. 8420).

* Foster and Whitney's Rept. Geology of Lake Superior, p. 211, pl. XXVII, fig. 2*a*, 1851.

## Genus CYPHASPIS, Burmeister, 1843.

### CYPHASPIS ? GALENENSIS, *n. sp.*

This name is applied to a single minute cranidium bearing an ellipsoidal, very convex glabella surrounded by deep dorsal furrows and tapering about equally toward both extremities; and with narrow convex fixed cheeks. All evidence of the lobation of the glabella is very obscure, indeed consisting only of a slight lateral indentation on one side, at about the middle of its length, and of three equidistant elevated lines on the other. The surface is smooth or very faintly granulose on the glabella and more coarsely papillate on the cheeks.

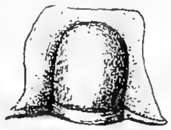


Fig. 82.—Cranidium of *Cyphaspis? galenensis.* (× 5).

The fossil evidently represents an undescribed species and may therefore take the name here proposed, but its generic relations remain quite uncertain. In general appearance, form of glabella, convexity of cheeks and curve of facial sutures, it is like *Cyphaspis*, but it altogether lacks the basal glabellar lobes of that genus.

Two other species from the Lower Silurian faunas of America have been referred to *Cyphaspis: C. girardeauensis* Shumard,* a normal representative from the Trenton horizon, and *C.? brevimarginata* Walcott,† from the Pogonip group of Nevada, a form having characters not unlike those of *C.? galenensis.*

* Geol. Rept. Missouri, p. 197, pl. VIII, fig. 11, 1855.

† Palæont. Eureka District of Nevada, p. 93, pl. XII, fig. 10, 1884.

*Formation and locality.*—The Minnesota specimen is from the Galena shales at Cannon Falls.

# COMMUNICATION.

Professor N. H. WINCHELL, *State Geologist.*

SIR:—At your request I have prepared the following chapter, embracing descriptions of the Cephalopoda of the Lower Silurian rocks of Minnesota, which is herewith respectfully transmitted.

I have the honor to remain, sir,

Very truly yours,

JOHN M. CLARKE.

ALBANY, N. Y., September 10, 1894.

# CHAPTER IX.

# THE LOWER SILURIAN CEPHALOPODA OF MINNESOTA.

BY JOHN M. CLARKE.

## INTRODUCTORY.

The Cephalopoda or "head-footed" mollusks are distinguished from the other molluscan groups by the possession of a circlet of long fleshy tentacles or prehensile organs arranged about the head.

This group of animals is a very large one and, from its appearance in the early faunas of the globe to the present time, has been represented by species of limitless diversity in form and structure. Those with which we have to deal in this chapter represent only early and primitive types of structure.

The two *Orders* of the Cephalopoda generally recognized are:

1. Tetrabranchiata;
2. Dibranchiata;

terms which imply the possession respectively, of four and two *gills.*

The tetrabranchiates are typified by the living *Nautilus pompilius;* the dibranchiates by the *Loligo*, or squid, *Sepia*, or cuttle-fish.

The tetrabranchiates were wonderfully abundant throughout the Paleozoic and Mesozoic periods of the earth's history, but are to-day almost extinct, while the dibranchiates are the predominant cephalopods in existing seas, and their fossil representatives much less numerous and diverse.

The tetrabranchiates possess shells in which the animal occupies only the outer or forward portion, and the rest of the internal cavity is divided into successive chambers by a series of transverse or oblique plates, called septa. These septa are connected with one another and with the outer or habitation chamber by a fleshy tube or sipho passing though a perforation in each septum. This order is usually regarded as divisible into two *suborders* termed:

*a.* Nautiloidea.
*b.* Ammonoidea.

In both of these subdivisions the shell may be straight, arcuate or spirally enrolled; but in the Nautiloidea the *sutures*, or lines of junction of the septa with the walls of the shell or conch, are, as a rule, simple, without abrupt curvature and very seldom with sharp angles, while in the Ammonoidea these sutures are usually highly angulated or zigzagged; in the nautiloids the sipho is very variable in position, may be small and cylindrical, but is often large and its walls much thickened, while in the ammonoids the sipho is always cylindrical, always marginal in position and without a thickening of the walls.

In the faunas of the Lower Silurian no representatives of the dibranchiates or of the ammonoid tetrabranchiates are known. We have, therefore, to deal in this chapter only with the nautiloid tetrabranchiates.

As an illustration of the general structure of these bodies and to show the relation of the animal to the various parts of the shell, we have here inserted a drawing of *Nautilus pompilius*, reproduced from the well known figure by Richard


Fig. 1.—*Nautilus pompilius.*

*a.* Mantle.
*b.* Its dorsal fold.
*e.* Nidamental gland.
*g.* Shell muscle.
*i.* Sipho.
*k.* Funnel.
*n.* Hood.
*o.* Exterior digitations.
*p.* Tentacles.
*s.* Eye.
*x.* Septa.
*z.* Body chamber.

Owen. It represents the shell as sawn horizontally through its center or along the plane in which it is coiled, with the entire animal lying in the body-chamber; shows the air-chambers, septa and sipho, and the various external parts of the animal. Though this is a coiled shell, its structural characters are not different from many of the forms here discussed in which this shell is straight or but slightly curved.

## General Characters of the Lower Silurian Cephalopods here Described.

We have observed that the Cephalopoda met with in the early Silurian faunas are mainly of primitive types of structure. Their predecessors existed in faunas before the Silurian but their remains are of infrequent occurrence, and hence our knowledge of them is very restricted. With the opening of the Silurian certain progressed generic types, such as *Orthoceras* and the shells which must still be referred to *Cyrtoceras*, became fixed or static in their traits and were continued thereafter for long periods without essential modification.

Two structural features in these Silurian nautiloids are especially significant and invite brief attention.

1. *The form of the shell.* The straight, elongated shell or longicone exemplified in *Orthoceras*, *Cameroceras* and *Actinoceras*, is the prevailing type. It is known from

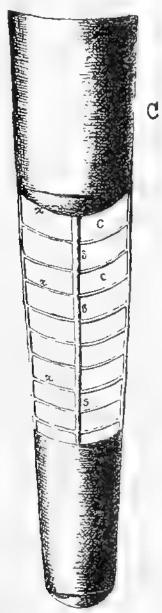



Fig. 2.—An *Orthoceras* represented as vertically sectioned for a portion of its length. C. body-chamber; *c*. air-chambers; *x*. septa; *s*. sipho.

the study of some of the later longicones that these shells, from their primitive formation onward through all intermediate phases to maturity, have maintained the straight mode of growth, and we may therefrom infer that such shells have been derived from ancestors whose shell was also straight. The formation of such regularly conical shells implies equal progress in the deposition of the shell-matter on all sides, but when the shell is coiled this effect is due to an obstruction of the shell growth on one side. In certain of the coiled genera we know that the enrolled portion of the shell represents only the immature stages of existence, while during later-growth stages the shell becomes straight.

This fact, illustrated by the genus *Lituites*, does not necessarily imply that such forms have been derived from primitive coiled types, but may with excellent reason

Fig. 3.—*Lituites lituus*. (After Rœmer).

be interpreted as follows: The straight conch of the full-grown animal may be regarded as a senile character expressing a return to, or towards a primitive growth-condition not otherwise represented in the individual, but indicating the source whence these generic traits have been derived.

In the peculiar genus *Ascoceras* the early growth of the shell is in the form of a long, very slender, gently arcuate cone with a regular succession of siphonated septa as in *Cyrtoceras*, but this mode of growth is abruptly terminated in later development by a lapse to a much more elementary condition of development evinced by the suddenly swollen conch and the incomplete and primitive septa. Several of the genera here considered are characterized by a swelling or expansion of the shell during later growth, and a sudden contraction at the close of the swelling near the aperture. This is observable in *Oncoceras*, *Clinoceras*, *Poterioceras* and the shells referred to *Cyrtoceras** The presence of this character in these early types might of itself be interpreted as indicative of primitive structure, as it has recently been shown that in certain Devonian species of the orthoceran genus *Bactrites* this expansion of the shell characterizes the growth stage directly succeeding the formation of the protoconch.

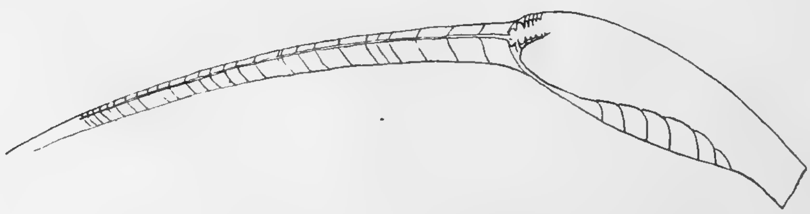


Fig. 4.—*Ascoceras manubrium*. (After Lindström).

*It is elsewhere observed that in the Devonian and typical representatives of this genus this swelling of the conch is usually absent, but it is more or less distinctly developed in the majority of the early Silurian species.

Much may be learned in regard to the phyletic status of genera and species from the ornamentation of the external surface of the shell. It has, for example, been demonstrated, and the fact is illustrated in the following pages by the species *Orthoceras bilineatum*, that the concentric rings or annulations which are found in a large number of orthocerans, are of secondary growth, the earlier parts of the shell being free from them; thus indicating that these annulated shells represent a more progressed condition of development than those with smooth surfaces.

2. *The structure of the sipho.* The sipho is, typically, a cylindrical tube connecting the air-chambers and continuous from one septum to another. Actually, however, in most of the primitive genera, such as *Nanno, Piloceras, Cameroceras* and *Vaginoceras,* it has not fully attained this condition, but is in formative and progressive stages. *Vaginoceras*, represented by *Orthoceras multitubulatum* and *O. longissimum* of the Black River limestone, both very rare species, is said by some investigators to have the place of the sipho filled by successive sheaths which are posterior continuations of the successive septa; these forms, hence, having no true sipho. This interpretation requires verification. Others have regarded these shells as having a distinct siphonal wall and the sheaths as confined to the siphonal cavity and occurring at intervals which have no direct connexion with the septa. If the former view be correct then *Vaginoceras* must be regarded as representing a highly elementary condition of development, but the latter interpretation of the structure renders it homologous with *Piloceras* in which we know that the siphonal

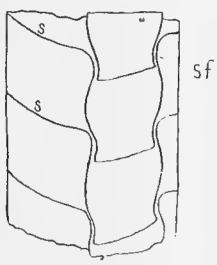



Fig. 5.—*Cameroceras burchardi*, showing overlapping siphonal funnels. (After Dewitz). *s.* septa; *sf.* siphonal funnels.

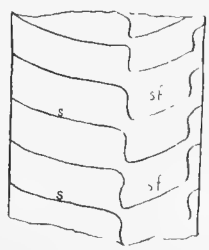



Fig. 6.—*Cameroceras proteiforme;* showing the the short siphonal funnels.

wall is developed for at least a portion of its length, as it is also in *Nanno* and *Cameroceras.* In the two genera last named the median and later portions of the sipho are constituted of deflected portions of the septa known as the siphonal funnels. These often extend from one septum to, or beyond the one preceding it, thus separating the siphonal cavity from that of the air-chambers; but not infrequently these funnels do not completely cross the air-chambers. In either case these funnels form a discontinuous siphonal wall. In *Piloceras, Cameroceras* and *Nanno* the continuous apical portion of the sipho is thickened by the extravagant deposition of testaceous matter in the cavity or between the successive siphonal sheaths. In

*Nanno* this solidified portion of the sipho protrudes behind the septate portion of the shell, indicating a primitive condition in which the inhabited shell was a simple aseptate and asiphonate cone.

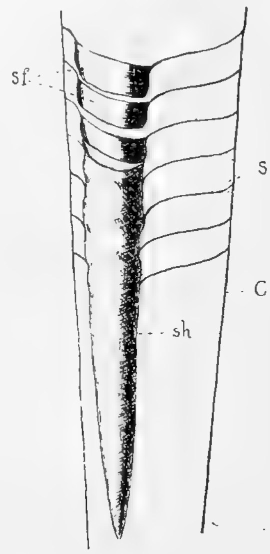



Fig. 7.—*Cameroceras proteiforme.*
*C.* outer shell or conch; *s.* septa; *sf.* siphonal funnels; *sh.* solid apical portion or guard of sipho.

In certain more advanced types, *Actinoceras* and *Gonioceras,* where the siphonal tube is continuous throughout its extent, as in *Orthoceras,* the sipho takes the form of a succession of beads expanding into the air-chambers and contracted where meeting the septa. Within the siphonal tube is a thick deposit of shelly matter, leaving a narrow central passage or endosiphon, which may be completely closed in the earlier siphonal beads and quite wide in those of the last air-chambers. The thickening of the siphonal wall is, thus, to some extent, a process common to all lime-secreting organisms, tending to fill up and close deserted cavities. From the endosiphon of *Actinoceras* are given off series of radiating filaments penetrating the thickened walls and reaching the true siphonal tube.

In the following pages about fifty species of these fossils are identified and described. The material which has been studied may be regarded as fairly representative in abundance although its usual retention in the form of internal casts leaves our knowledge of some parts of the species unavoidably imperfect. The identification of some of the species, especially those of *Cyrtoceras* and *Oncoceras* has been rendered difficult by the brevity and obscurity of the original descriptions and, in many instances, the absence of illustrations, but, as a careful comparison has been made of the material with the original specimens of such unillustrated species, reasonable security is felt in these identifications.

Many of the most interesting specimens are from the collection of the late W. H. Scofield; others have been loaned by Dr. C. H. Robbins and Mr. E. O. Ulrich.

# Class CEPHALOPODA.

## Order TETRABRANCHIATA.

### Suborder Nautiloidea.

## Family ENDOCERATIDÆ.

### Genus PILOCERAS, Salter, 1859.

#### Piloceras newton-winchelli, *sp. nov.*

PLATE XLVII, FIGS. 1–3.

Two specimens preserved in a white chert indicate a small undescribed species of this genus. The more complete of the two is obliquely fusiform, slightly arcuate on the siphonal side, and bears sixteen septa which are very oblique on the upper part but lose this obliquity toward the apex; the direction of the earliest septum is nearly transverse. The obliquity of the later septa is so great that the last septum exposed, in crossing the shell from the dorsal to the ventral side traverses the depth of five air-chambers on their antisiphonal exposure. The length of this specimen is 31 mm. and its width at the top measured along a suture, 21 mm; the transverse diameter at the top, 17 mm; at the base 7 mm. All the air-chambers are deepest at the antisiphonal edge. At the top of the specimen is the opening of a wide siphonal cavity. A longitudinal section of the specimen along the axis of this cavity shows some interesting points of structure. The mouth of the cavity is broad at the top, covering nearly one-third of the entire diameter of the shell. Its actual and relative diameter lessens, however, toward the apex. The position and relative size of the sipho and the difference in the direction of the septa on the two sides are shown in the accompanying figure. This cavity is not filled by a solid accumulation of siliceous matter, but is more or less cavernous. The siphonal walls, however, are encrusted and distinctly retained. It is very clearly evident from this section that the septa are not coalesced with the siphonal wall (*ws*). The edge of each septum lies close against, usually in actual contact with a thickened ridge or annulus on the outer surface of the sipho. The latter tube is, hence, a

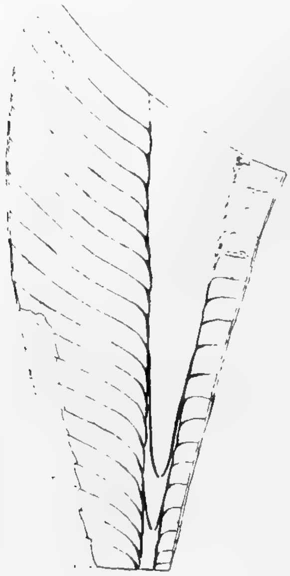


Fig. 8.—Median vertical section of one of the specimens described. × 2

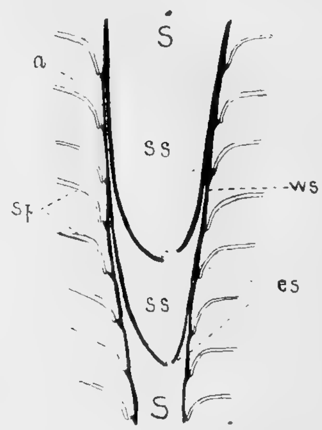



Fig. 9.—Enlargement of a portion of the same. *s.* sipho; *ss.* siphonal sheaths; *ws.* wall of sipho; *es.* endosiphon; *sp.* septa; *a.* annulus formed at junction of septum with sipho.

distinct sheath of itself, not originating from successive invaginations of the septa. The earlier portion of the sipho (*s.*) contains two siphonal sheaths (*ss.*) which are separated from each other by an empty space, and above the first of these sheaths there is also but a partial and irregular filling of silica. Below the second sheath the sipho is solidly filled. These sheaths take their origin from thickened walls of the sipho, the separation of the testaceous wall being very apparent at their origin. When the sheaths become fully free from the siphonal walls, they converge more or less rapidly. The first or uppermost of the sheaths is very plainly perforated at its apex, but this opening is less clearly retained on the lower sheath. These openings are undoubtedly to be construed as the passages of the endosiphon, as Hyatt has termed a small tube connecting successive deposits and compartments within the sipho. In the larger forms of *Piloceras* which have been described by Dawson and Whitfield (*P. amplum*, *P. explanator*) and whose siphones have become solid from the more rapid formation of these sheaths and the intermediate deposition of crystalline calcite, this endosiphon is sometimes very clearly retained,* but here where the chambers of the large cavity are open, nothing remains but the passages of the endosiphon through the sheaths. In this respect the structural difference is noteworthy as the case in hand is the only one observed in which the siphonal chambers

* See Dawson, Canadian Naturalist, new series, vol. x, No. 1, 1881, p. 1-4; and Foord, Geological Magazine, Dec. III, vol. iv, No. 12, 1887.

are so large and have not been rendered more or less completely solid by the extravasation of organic deposits.

The second and less complete specimen of the species exposes a portion of one side (12 septa), toward the lower part of which, by cross fracture, the siphonal tube is left open and shows the terminal extremity of the internal solid cast of one of the siphonal chambers and a considerable portion of another later and enveloping sheath. The apex of this internal cast does not show satisfactory evidence of perforation.

There are seven described species of *Piloceras*, six of which are recorded as from American faunas. All are of much larger size than *P. newton-winchelli*, and so far as known, have greatly broader siphones. All are from the early faunas of the Lower Silurian; Billings' species *P. canadense*[1] from the Calciferous horizon, *P. wortheni*[2], *P. triton*[2] and *P. gracile*[2] (the last two but little known) from the Quebec group; *P. explanator* Whitfield[3], from the Calciferous fauna of Vermont and New York (Fort Cassin beds), *P. amplum* Dawson,[4] from a corresponding horizon near Montreal, and *P. invaginatum* Salter[5] (the type of the genus), from the Durness limestone of Sutherlandshire, Scotland, associated, according to Salter, with *Orthis striatula* Emmons (not Schlotheim), *Ophileta compacta* Salter, *Orthoceras matutina* Hall, and *O. undulostriatum* Hall.

The Shakopee formation of Minnesota is regarded by professor Winchell as probably equivalent in part to the Calciferous sandstone of eastern North America[6].

*Formation and locality.*—The locality of the specimens described is given as section 19, Union township, Houston county.

*Collector.*—N. H. Winchell.

*Museum Register*, No. 2444.

## Genus NANNO,* gen. nov.

This genus has been briefly described by the writer in a preliminary notice published in the American Geologist, vol. xiv, pp. 205-208, pl. vi, 1894.† Its distinctive characters are elucidated in the description of the species following.

(1) Canadian Naturalist and Geologist, vol. v, p. 171. 1860.
(2) Palæozoic Fossils, vol. i, pp. 256, 257, fig. 240. 1865.
(3) Bull. American Museum Natural History, vol. i, No. 8, p. 323, pl. xxviii. 1886.
(4) Canadian Naturalist, new series, vol. x, p. 1. 1881.
(5) Quarterly Journ. Geological Society, London, vol. xv, p. 376. 1859.
(6) Twenty-first Ann. Rept. Geol. and Nat. Hist. Surv. Minnesota, p. 4, table. 1893.
* Greek *Nanno*, a player upon the flute.
† Nanno, a new Cephalopodan Type.

## NANNO AULEMA, *sp. nov.*

PLATE XLVII. FIGS. 4—11.

The material which represents this interesting type of cephalopod structure was collected by Messrs. E. O. Ulrich, Charles Schuchert and the late W. H. Scofield, from various localities in the Trenton series of Minnesota. No similar forms have heretofore been found in the American faunas, and their novel character was recognized and studied by the first two of these gentlemen. Like bodies had, however, been found and described by Gerard Holm,* derived from the lower Silurian of Oeland and Esthland, and in the drift boulders about Eberswalde; they were referred by him to the genus *Endoceras,* under the designation, *E. belemnitiforme* Holm, but we feel guilty of no temerity in regarding them as representatives of a distinct type of structure.

Our description is based essentially upon the American fossils, though supplemented by comparisons with the European species.

The usual form which these bodies assume is somewhat that of a small *Belemnites.* The apical and posterior portion has a rounded, evenly tapering surface, which would give it the form of a true cone were not one side, when the body is viewed laterally, quite oblique, while the other is nearly vertical. Thus viewed the shells are asymmetrical laterally, but as seen from the dorsal and ventral sides they are bisymmetrical. After the conical expansion has extended for about one-half the length of the body, there is a rather abrupt contraction on the oblique side and the shell becomes more circular and much smaller in cross-section. Thus toward the upper extremity of the shell a cylindrical tube is formed.

The normal position, however, of the conical posterior portion is such that the straight and the oblique side converge at the same angle; this diverts the cylindrical or upper portion of the body to one side.

These peculiar bodies are siphones; that represented in figure 10 shows the oblique impressions left by the septa upon its surface, and figure 6 affords a conception of the relations of these siphones to the septate part of the shell. In the latter is seen the central and symmetrical position of the apical cone with reference to the entire shell, its abrupt contraction and the deflection of the cylindrical portion of the sipho to one side. At the point where the contraction of the sipho begins, its diameter is that of the shell, and from the apex to this point there is no trace of septa. With the appearance of the septa begins the contraction of the sipho. That the septa did not completely encircle the sipho beyond the diameter of the siphonal funnels is shown by several of the specimens which present a smooth surface on the dorsal or outer side, the marks of the septa being there

*Ueber die innere Organization einiger silurischer Cephalopoden; Dames und Kayser's Paläontologische Abhandlungen, Bnd. III, Heft 1, pp. 4—9, pl. i, 1885.

interrupted. One of the specimens has the wall of the conch adhering to the siphonal wall along this surface. The same fact is shown in Holm's figure of *Endoceras* (*Nanno*) *belemnitiforme*. It will be observed from the figure that the cylindrical portion of the sipho has about one-fifth of the diameter of the entire shell at its widest point.

Upon examination of the interior structure of these siphones they are found to be completely solid in the apical portion for usually about one-half the length of the præseptal cone, but in some instances this solidification extends for the entire length of the cone and into the cylindrical part of the tube. The cavity of the sipho above this filling is a narrowly conical chamber whose walls gradually become thinner from the apex upward, their upper edge appearing to be rounded off and finished.

The substance of the siphonal cone and walls is invariably very compact, radially crystalline calcite, indicating, inasmuch as all the specimens have been found in calcareous shales and clayey limestones, a simple modification of the original organic deposit; the internal cavity is filled with the mud of the sediment. Cross-sections of the cone in both directions show evidence of a dark, concentric, presumably organic discoloration, which may represent an internal sheath, but this seems the less probable as this layer affords no surface of easy displacement of the parts, nor does the radial structure of the calcite appear to be at all interrupted by it. I should be disposed, rather, to regard it as a trace of an organic remnant of the fleshy sipho, left in its anterior progress with the growth of the shell.

The sections have afforded no evidence of a tube connecting the apices of these sheaths, the *endosiphon* of Hyatt. The addition of the septate portion of the shell, as shown in a single specimen which appears to be nearly complete, gives the species a fusiform and symmetrical appearance, broadest below the aperture, the sipho seeming to extend nearly the entire length of the shell. The septa are gently and regularly concave, slightly inclined toward the sipho, and there were apparently about twelve in the length of the shell as preserved. The first septum seems not to conform to the contracted surface of the cone which has a much greater obliquity, and thus the first air-chamber appears to be an irregular, wedged-shaped cavity between these two surfaces, but there is no evidence whatsoever that the conical end of the sipho was in any way involved in this cavity except at its proximal surface. The apical cone was unquestionably external except so far as ensheathed by a mere coating or film of the shell-tube.

The dimensions of these specimens are as follows: A nearly complete sipho has a length of 36 mm.; its greatest width is at 19 mm. from the apex and measures 10 mm. in major, and 8.5 mm. in minor axis; its apertural diameters are 8 and 6 mm.

Another and more slender specimen measures 40 mm. in length and is broken at the aperture. Here the length of the apical cone is 22 mm. The most complete example has a length of 58 mm.; the apical cone measures 15 mm.; the entire diameter of the shell is 18 mm. at its widest part and 16 mm. at or near the aperture.

Dr. Holm's species, *E.* (*Nanno*) *belemnitiforme,* is considerably larger than *N. aulema.* The author's figures shows that the siphonal cavity may be entirely filled with crystalline calcite while the air-chambers contain only the mud of the matrix. This is a mode of preservation which we find to be not infrequent in forms of true *Endoceras* or *Cameroceras.* Others of these figures (Plate I, figs. 2*a, b*) show the actual thickness of the true calcareous wall of the præseptal cone, and indicate that it is considerably thinner than in *N. aulema.* Figure 1*b* shows that the wall of the conch becomes thinner toward the posterior cone and actually disappears upon the surface of the latter, though we are justified in the assumption, supported by the slight evidence afforded by the Minnesota shells, that the true conch was represented by a tenuous layer over the proximal surface of this cone. In *N. belemnitiforme* the siphonal funnels are seen to extend each the length of two air-chambers. Notwithstanding the reference by the Swedish author of such shells to the genus *Endoceras,* we believe it to be proper and necessary to remove them from that association. Were the initial parts of the abundant forms of *Endoceras* (*Cameroceras*) constituted of such solid cones, they would be the portions of the shell most readily preserved; just as in *Nanno aulema* the siphonal cones are the parts almost exclusively met with. But no such bodies are known except in these two species. Our own observations upon *Endoceras* lead us to the belief that the thickened posterior end of the sipho in that genus was nearly, if not wholly, enclosed by the chambered shell; and this impression is in accordance with Holm's statement that a specimen of *Endoceras burchardi,* with a posterior diameter of but a few millimeters, was already septate. The continuance of an aseptate condition for a considerable period in the early history of *Nanno* is of itself indicative of an important difference from *Endoceras* (*Cameroceras*) and *Piloceras,* inasmuch as this determines it to have been a more elementary organism than either. Of the initial parts of *Piloceras* little or nothing is known, but with what we are justified in assuming in regard to the early conditions in both *Cameroceras* and *Piloceras,* and with what we know concerning *Nanno,* the last presents to us the simplest known type of cephalopod structure.

In these shells we have before our eyes the abrupt change from a simple conical cavity, which was not only a potential sipho but an actual chamber of habitation, to a septate conch with an actual sipho continuous with the primitive habitation chamber. Holm has expressed in an interesting manner the course of the modifications through which the animal and its shell pass from their primitive condition onward, and we take the liberty of quoting this passage: "The visceral sac of the animal had obtained a considerable size. Its form was pointed posteriorly. The mantle had secreted a shell of like form. This shell was thus quite open and of conical shape. It now formed but a single chamber which was both initial and habitation chamber, wholly filled by the animal. With the growth of the animal the shell was, naturally, lengthened on the anterior margin. As the animal [shell] at last became too heavy and had need of a hydrostatic apparatus in order to raise and sink itself, the air-chambers, by which the hydrostatic problem is solved for the tetrabranchiates, were formed. The first of these originated in this way: On one side of the upper portion of the visceral sac a circular and almost enclosed constriction was produced. The fold of the mantle thus formed deposited shell-matter making an inclined wall and a division of a part of the originally open initial chamber. The resulting chamber was empty and formed the first air-chamber. This chamber is, thus, bounded by only one septum and in this case lies behind the wall corresponding to the first septum in *Nautilus*. It therefore corresponds to the initial chamber in that genus. As it here has the same function as the other air-chambers, I have termed it the first air-chamber, although, in fact, it is a remnant of the open initial chamber. Moreover, the second air-chamber is probably formed in part from the anterior portion of the initial chamber. The visceral sac of the animal was now divided by a constriction into an anterior and posterior portion. * * * * The anterior portion now forms the actual habitation chamber, but the great visceral sac also fills the posterior portion. The growth of the shell progresses; the shell is again lengthened about the aperture. The animal becomes again too heavy and must form another air-chamber. It loosens itself from the wall of the conch, the visceral sac extends itself along the constriction and the animal moves forward a step in its shell. The mantle surfaces form a new septum and about the elongated portion of the visceral sac the calcareous deposit takes the form of a sheath or siphonal funnel. Thus originates the siphonal cord of the animal. Hence the sipho of *Endoceras belemnitiforme* must have had its origin in a differentiation of the visceral sac." (*Op. cit.*, pp. 6, 7.)

The præseptal cone of *Nanno* must be regarded as a great protoconch expressing in its form the primitive nature of the longicones and brevicones of the tetrabranchiates.

It may be suggested that the solidification of the præseptal cone may have been to some extent due to such secondary causes as have produced the solid guard in *Belemnites*. The appearance of these siphones and the crystalline structure of their substance strongly suggest that genus, even though there is little superficial similarity in the relations of these parts to the septate portions of the shell in the two genera.

*Formation and locality.*—The material which has been studied consists of seven specimens obtained from the Trenton shales at Minneapolis and from the Galena shales near Chatfield, Minnesota. Collections of W. H. Scofield and E. O. Ulrich.

*Museum Register*, No. 7631.

*Nanno belemnitiforme* Holm, is from the upper red *Orthoceras*-limestone on the island of Oeland, from the lowest beds of the *Echinosphœrites*-limestone in Esthland, and from boulders of like age at Heegermühle in the vicinity of Eberswalde.

## Genus CYRTOCERINA, Billings, 1865.

The shells which have been referred to this genus are cyrtoceran in form and are characterized by the great size of the sipho, which is situated on the ventral side and is not fully enclosed by the septa. Hyatt places the genus with the *Endoceratidæ* and considers it of similar structure to *Piloceras*, with inverted siphonal sheaths, though no conclusive evidence of such structure is to be derived from Billings' descriptions of the two known species, *C. typica*, from the Black River limestone, and *C. mercurius*, from the Quebec group. The species herewith described is provisionally referred to the genus on account of the ventral position of the sipho and general agreement in the form of the shell. It is the only specimen among the cyrtoceran shells in the Silurian material from Minnesota which possesses this feature, and though many Silurian and Devonian species having the septa thus placed have been referred by authors to *Cyrtoceras*, I hesitate to place this shell in that association.

### CYRTOCERINA (?) SCHOOLCRAFTI, *sp. nov.*

PLATE XLVII, FIGS. 12–14.

This form is represented by a small portion of a very rapidly expanding and sharply arcuate shell, which, in a length of 7 mm., tapers from a dorso-ventral diameter of 10 mm. to one of 5 mm. The outlines of the septa are distinctly ovate, broadest toward the ventral side and subacute on the dorsum, the dorso-lateral surfaces being somewhat compressed and the obscurely ridged dorsum a noticeable feature of the exterior. Sipho ventral, submarginal and fully enclosed, large in comparison with species of *Cyrtoceras*. On the lagert septums, which has a diameter of 10 mm. the sipho is 1½ mm. in diameter. Septa apparently closely appressed. External shell surface marked by faint concentric growth-lines.

*Formation and locality.*—In the Trenton shales, one-half mile southeast of Cannon Falls, Minn. Collection of E. O. Ulrich.

## Genus CAMEROCERAS, Conrad, 1839.

*Endoceras*, HALL, 1847.

The collection is fairly abundant in specimens referable to this genus. Few, however, are sufficiently complete to justify the determination of their specific characters, though the evidence afforded by them indicates the probable presence of several species. Of more interest than the variation in specific features is the interesting illustration of the structure of the sipho which is represented by many and various forms of internal casts of the organ. With all that has been written upon the relation of the sipho of this genus to the septa and conch, there still remains much to be learned in regard to the structure of *Cameroceras*, and some light is thrown upon obscure points by these specimens. We have here adopted without reserve Conrad's term *Cameroceras* in place of the more generally accepted name *Endoceras*. Whitfield has employed the former term with a suggestion that there may prove to be a generic difference in the two structures, but this seems to us, with the present evidence, scarcely possible. The distinction which has been recognized between the two by Hyatt is that in *Endoceras* the siphon is not lined by a continuous shell layer but is composed of a succession of septal funnels, overlapping at their edges, while in *Cameroceras* (which this author regards as a synonym of *Sannionites*, Fischer de Waldheim, 1837), the siphon is a continuous layer. The typical species of *Endoceras* (*E. proteiforme* Hall) is vastly better known than that of *Cameroceras* (*C. trentonense*), and while it has been impossible for me to carry out a generic distinction in the two, the fact must be recognized that the latter term was introduced in 1839 and the former not until 1847. Conrad, also, in 1839 employed the name *Diploceras* (*D. vanuxemi*, type) for a shell from Trenton Falls, N. Y., which is unquestionably a *Cameroceras*, and the species probably the same as *Endoceras proteiforme*. Hall*, Whitfield†, Dewitz‡, Holm§, Foord‖ and others have shown the existence of a continuous sheath situated at, and composing the apical portion of the sipho, often thick-walled, and extremely so about the apex itself. These have been sometimes termed "embryo-tubes" and also "siphonal sheaths," as though they existed within the sipho and were not an integral part of the sipho itself. Such bodies, of which internal casts abound in the Trenton formation of Minnesota, are the thickened extremital portions of siphones; the septa lie against them (or at least, against their upper portions) in a normal position, and above its free edges the sipho is a discontinuous sheath composed of the overlapping and

† Bull. Amer. Mus. Nat. Hist., vol. i, no. 1, pp. 20—28. 1881.
* Palæontology of New York, vol. i, pp. 208 *et. seq.*. pls. 48—50, 53, etc. 1847.
‡ Zeitschr. der deutsch. geol. Gesellsch., vol. xxxii, pp. 371—393, pls 16, 17. 1860.
§ Dames and Kayser's Paläontologische Abhandlungen, Bnd. iii, Heft 1. 1885.
‖ Ann. and Mag. Nat. Hist., Dec., 1887, pp. 393—402.

retrally directed funnels of the septa. This is well illustrated by a very large and essentially entire internal cast of the sipho, measuring 3 feet 3 inches in length, a reduced drawing of which is shown on plate XLVII. The principal extent of the surface of this specimen bears traces of the contiguous or overlapping septal funnels which have thus created a discontinuous siphonal tube. The specimen is so drawn as to show the side nearest the margin of the conch; hence the remnants of the septa show a marked angularity due to their concavity. This is a trait characterizing all such siphonal casts in which the position of the sipho was lateral. With variation in the position of the sipho and in the concavity or obliquity of the septa, these siphonal funnels vary in their direction. It will be observed that at a short distance from the apex of this cast is an abrupt contraction in its diameter, which is continued to the apex. This apical portion is the internal filling of the solid and continuous sheath whose probable extent and thickness is indicated by a dotted line which carries the sipho to an apex according to the slope of the discontinuous sheath. The evidence afforded by this specimen is abundantly fortified by others which demonstrate that this solid apical portion of the sipho is but a filling and thickening of the vacated and discarded apical cavity of the otherwise discontinuous sheath.

The internal casts of this long apical cone are of far more frequent occurrence than those of the funnel-tube, because the parts of the latter are not often coherent and usually the latter are found to retain the overlapping or approximate parts of the septa upon their surface.

The great siphones of the dead shells of these creatures afforded favorite retreats for other and smaller cephalopods, and they are hence frequently found crowded with diverse species of *Orthoceras* and *Cyrtoceras*, sometimes three or four being crowded in side by side, or one within another, in such cavities.

The material examined does not afford the most satisfactory evidence of the duplication of the siphonal sheath, and it would seem that much of the evidence that has been adduced in regard to the presence of such duplicate sheaths requires re-examination, although it is by no means intended by this expression to cast doubt upon their existence. In some accounts of these fossils a careful distinction between the apical sheath, its filling, and such adventitious or hermit orthocerans as may have got in, has not always been made. Attention may be directed to the internal siphonal cast shown on plate L, fig. 3, which shows a portion of the filling of the discontinuous part of the tube and an acuminate terminal process which indicates a tubular cavity near the apex of the solid sheath. Whether or not this ever penetrated the solid sheath and thus represents a true endosiphon communicating with some other sheath, as in *Piloceras*, cannot be determined from such casts.

With all the knowledge that we can derive from the works of others and our own observations as to the early shell-growth in this genus, there seems to be no good reason for assuming that the solid sheath in *Cameroceras* was protruded beyond the septate portion of the shell, as is the case in our new genus *Nanno*. The close relation between *Nanno*, *Cameroceras* and *Piloceras* is evident. *Nanno* has a prominent solid guard at the apical extremity of the sipho, which is perhaps proportionally longer than the solid sheath of *Cameroceras*, and the sipho in *Nanno* bears evidence of being discontinuous through the later air-chambers. The siphones of *Nanno* being extremely lateral in position show the oblique attachments of the septa common in several species of *Cameroceras*.

There are here several species of *Cameroceras* which are indicated by the differences in these siphones, but which can not be otherwise described, as the character of the septate and external portions of the shell are not known. Various of these are illustrated, showing wide differences of form, partially resulting from differences in position in the conch, others showing a considerable variation in the depth of the air-chambers, and still others having the form of *Colpoceras*, a genus founded upon a sipho of *Cameroceras*.

Such species, whose characters have been made out with some degree of certainty, are described below.

### Cameroceras proteiforme *Hall*, 1847.

PLATE XLVIII, FIGS. 1, 2; PLATE XLIX, FIG. 2; PLATE L, FIGS. 1, 2, (3 ?); PLATE LI, FIGS. 1–3; PLATE LIII, FIGS. 4–5.

*Endoceras proteiforme*, Hall, 1847. Palæontology of New York, vol. i, p. 208, Pls. xlvi, figs. 1*a*–*b*, 2 (?); xlviii, figs. 1, 2 (?), 3, 4; xlxix. figs. 1*a*, *e*; l, figs. 1—3; lii. figs. 1*a*–*b*; liii, figs. 1*a*–*c* (*E. magniventrum*), 2; lv, fig. 1 (*E. duplicatum?*); lvii, figs. 1*a*, *b*.

To this species, so abundantly illustrated in the work cited, may be referred the majority of individuals of *Cameroceras* occurring in the Trenton limestone of Minnesota. Since the elaborate account of these fossils given by professor Hall, no attempt has been made to supplement or revise the original determinations, but it must now be observed that the number of species into which the genus was there divided and, especially, the numerous varieties ascribed to *Endoceras proteiforme* can hardly be regarded as wholly valid. At that early date, nearly a half-century ago, the structure of these remarkable bodies was, naturally, less clearly understood than to-day. Professor Hall's observations were almost the pioneer explanations of the peculiar siphonal structures and are by all means the fullest and most comprehensive illustration of these structures that has been given even to this day. A very natural misconception of certain structural features introduced some errors which, in the light of our increased knowledge, at once correct themselves. The composition of the entire sipho was not then fully understood. We have already adverted to the fact that it consists of a continuous and to some extent solid apical cone followed above through all the mature and later chambers of the shell by a discontinuous tube composed only of the deflected septal funnels. The continuous parts of such siphones were originally regarded and designated as "embryo-tubes" or "shells," and, as an easy inference, all apparently similar internal tubes were thus interpreted. We now refer to the shell of *Cameroceras* only the internal tube formed by the consolidation of the sipho and its few subsidiary sheaths. All other tubes are adventitious, hermit orthocerans or cyrtocerans of various species, which, as we have already observed, found favorite retreats in the great siphones of these dead shells. Such occurrences are extremely frequent, and the finding of as many as four or five such tramp shells ensconced side by side in a siphonal cavity is not unusual. Hence we are compelled to look upon such species as *Endoceras duplicatum* of the Trenton limestone of Middleville, N. Y. and *E. gemelliparum* of the Black River limestone of Jefferson county, N. Y., as based upon unessential and adventitious characters, and the latter as probably a portion of the mature shell of *E. proteiforme.** Furthermore, the several varieties ascribed to *E. proteiforme*, such as vars. *lineolatum*, *strangulatum*, *tenuistriatum*, are now known to have been founded upon incarcerated shells of *Orthoceras* and *Clinoceras*.

It may, in a general way, be said that *Endoceras proteiforme* is characterized by its enormous size, circular section, comparatively shallow air-chambers and great submarginal sipho. The size attained by the species is best indicated by the large cast of the siphon as shown on plate XLVII, and entire shells referable to this species have been found with a length of ten to fifteen feet, though all the material before me is of a smaller size. The difference in the aspect of these fossils at different parts of their length, where the siphonal tube is variously constructed and the septa subject to variations in distance, renders most appropriate the specific name *proteiforme*.

One of the characters. which is very helpful in distinguishing the siphonal casts of this from associated but rarer species of the genus, is the shortness of the siphonal funnels. The air-chambers are themselves shallow, but the funnels seem at times not even to extend from one to the next. The distance between the septa and consequently the length of the siphonal funnels increases toward the body-chamber, but this variation is rarely so abrupt as shown in plate XLIX, figure 2, where, at the

* These statements have no bearing upon the remarkable species *E. longissimum* and *E. multitubulatum* of the Black River limestone, in which the successive invaginated sheaths are part of the siphon. Such shells are representatives of the genus *Vaginoceras*, Hyatt.

upward termination of the continuous siphonal sheath, there is a sudden increase in the depth of the air-chambers.

The marginal or submarginal portion of the sipho explains the obliquity of the septal annulations upon this tube, and the gentle incurvature of the septal funnels, the annulation of this tube. There is nothing in the material in hand to indicate any essential differences from the New York specimens of this species.

*Formation and locality.*—The majority of the examples examined are from the Trenton limestone of Cannon Falls, Minnesota, and are from the collection of the late W. H. Scofield. The large siphon figured is from the same horizon at Wykoff, Minnesota (collection of Dr. C. H. Robbins), and other fragments from Decorah, Iowa.

### Cameroceras hennepini, *sp. nov.*

PLATE LII, FIGS. 1–3; PLATE LIII, FIGS. 1–3.

This a fine large species, the most complete of the fragments which represent it indicating a length of not much less than four feet, with shell very gradually expanding. In a distance of 230 mm. the transverse diameter increases from 94 to 100 mm. In section the shell is subelliptical being perceptibly flattened on the siphonal side, and less so on the opposite side, while the lateral curves are comparatively narrow and abrupt. The air-chambers are relatively narrow, those exposed averaging about 20 mm. in depth, without increasing in this respect toward the upper extremity. There are fourteen of these chambers in a length of 270 mm.

The sutures are not regular and simply transverse in their direction, but upon the siphonal side make a broad retral curve along the median line, bending forward again for one-third to one-half the depth of a chamber on the sides, but upon the antisiphonal side being more directly transverse and without curvature. The septa are very deep, sloping with broad, gently concave, almost, at times, plane surfaces to the sipho, about which there is a constriction. The sipho is very large, measuring 46 mm. in diameter where the septum is 90 mm. In the lower portions of the specimens a distinct and continuous siphonal sheath is retained. The vertical section of a fragment represented on plate LIII, fig. 1, shows the thickness of the siphonal wall, which has been preserved only on one side, the other having been destroyed in the process of fossilization. It is here seen that the mode of union of the septa to the sipho is a firm adhesion of the former to the outer wall of the latter, the septa being slightly thickened at their junction therewith. The structure of the shell substance shows with clearness that however firm the coalescence of these parts the distinction between the two is sharp. The specimen also shows the excentric position of the sipho, the shell not being much abraded on the siphonal side, but having lost considerably on the other side.

This species is readily distinguished by its close air-chambers, regular sutures and the subcentral position of the sipho.

*Formation and locality.*—The larger of the specimens here figured is from the Galena horizon, two miles northeast of Spring Valley, Minnesota. The smaller specimen is probably from the same horizon, but its precise locality has been lost.

*Museum Register*, No. 140.

## CAMEROCERAS, *sp.*

PLATE XLIX, FIG. 1.

A single long fragment of a slender sipho, 378 mm. in length, 45 mm. in its circular cross-section at the larger end, has very broad septal funnels, and these make but slightly oblique or undulating ridges about the sipho. These are characters in which the specimen is quite unlike anything heretofore described. The directness of the septal funnels indicates a subcentral position of the sipho, while the length of the funnels is much greater than observed in other species. The length of these funnels is from 18 to 20 mm. and they are seen to very considerably overlap each other.

The specimen indicates a distinct species of large size, though this example of the sipho constitutes our present knowledge of it.

*Formation and locality.*—In the Trenton limestone at Cannon Falls, Minnesota. Collection of W. H. Scofield.

## CAMEROCERAS, *sp. nov.*

PLATE LI, FIGS. 5–7.

Among the figures given by Bigsby in his work on the Geography and Geology of Lake Huron* is one which shows in section a *Cameroceras* with large marginal subtriangular sipho. No name has been applied to this American species, though the peculiar shape of the sipho indicates a form unlike any which bear names with us. Holm has described a species of this character from the Lower Silurian of Esthland (*Endoceras gladius.*)†

The specimen figured upon plate LI, figs. 5—7, is a very characteristic example of one of these bodies, having one side broad and flat and the other broadly rounded. The siphonal funnels on this cast are broad and distant, distinctly curved upward on the flat side, but regularly transverse on the rounded surface. From Bigsby's figure we infer that in their normal position in the shell these siphones were submarginal, had their curved surface towards the conch and their flat side inwards.

*Formation and locality.*—The specimen here figured is from the Trenton limestone at Zumbrota Goodhue county, Minnesota.

*Museum Register*, No. 3399.

* Trans. Geolog. Soc. London, vol. i, pl. 26, fig. 1. 1824.
† *Loc. cit.*, p. 13, pl. 2.

# Family ACTINOCERATIDÆ.

## Genus ACTINOCERAS, Bronn, 1837.

### ACTINOCERAS BIGSBYI *Stokes*, 1840.

PLATE XLVII. FIGS. 15–17.

*Actinoceras bigsbyi* STOKES, 1840. Trans. Geolog. Soc. London, sec. ser., vol. v, p. 707, (fig. in ditto, vol. i, pl. XXV, figs. 1—3. 1824).

Compare *Ormoceras tenuifilum* HALL. Palæontology of New York, vol. i. p. 55, pl. XV, fig. 1–1c; pl. XVI, figs. 1–1e; pl. XVII, figs. 1a, b.

Considerable uncertainty must long remain in regard to the specific values of the various orthoceran shells illustrated by Bigsby in 1824 and obtained from Thessalon and other islands in lake Huron.* Of the several plates of illustrations representing these, names were given only to the Huronias, and those by Stokes. It was only with the publication of Stokes' paper, cited above, that names were proposed for some, but not all of the examples of *Actinoceras* figured by Bigsby. All of these are weathered interiors, and there is an evident agreement among them all, including also those referred to the genus *Ormoceras*, notwithstanding the fact that later investigations have tended to indicate a more recent age to the species there termed *Ormoceras backi* and *O. bayfieldi*. *Actinoceras bigsbyi* is safely enough an early Trenton form, with many evident points of relationship to *Hormoceras tenuifilum* Hall, of the Black River limestone of New York. The two are undoubtedly congeneric, though the New York specimens are not often retained in such a manner as to show the endosiphon and its radial canals.

The Minnesota collections have furnished but two or three specimens which may be referred to this species, one exposing in vertical section twelve air-chambers in a length of 105 mm., with a width at the upper end of 36 mm. and at the lower end of 25 mm. The other specimen consists of an internal cast of four air-chambers, showing that the sipho is very large and excentric, extending quite to the margin. The great width, however, is at the lower surface of each air-chamber, its diameter greatly diminishing at the upper surface. The greatest width of the siphonal beads, extending thus into the chambers and resting with a broad base upon the septa, is fully two-thirds the diameter of the shell. The endosiphonal walls are thick especially where the beads are broadest, and the endosiphon seems to vary in size with its position in the shell. The casts of this tube show a wrinkled surface and bases of radial branches.

*Formation and locality.*—In the Trenton limestone at Minneapolis, and at Garrick's quarry, near Rochester, Minnesota.

*Museum Register*, No. 23, 159.

*The title of Bigsby's paper is: "Notes on the Geography and Geology of Lake Huron." Trans., etc., vol. I, pp. 177-209.

## ACTINOCERAS BELOITENSE *Whitfield*, 1877.

PLATE XLVII, FIG. 18.

*Orthoceras (Actinoceras) beloitense* WHITFIELD, 1877. Ann. Rept. State Geol. Wis. for 1877, p. 97.
*Orthoceras (Actinoceras) beloitense* WHITFIELD, 1882. Geology of Wisconsin, vol. iv, p. 226, pl. VIII, fig. 1; pl. X, figs. 9, 10.

*Original description:* "Shell large and robust, subfusiform, moderately expanding to the diameter of about four inches, then more gradually decreasing in size to the aperture. Section oval in all the examples noticed, and usually a little more flattened on one side than on the other, with the siphuncle submarginal on the flattened side. Septa shallow and not often symmetrically arranged; from seven to eight chambers occupy a length equal to the diameter of the largest of the number measured; toward the outer portion of the shell the septa become more crowded, and just below the outer chamber are sometimes less than half the usual length. Siphuncle large, strongly beaded within the chambers, with an inner core, in the casts, having radiating filaments extending to the center of the bead in each chamber. Surface of the shell unknown."

This species is represented in the collections by two fragments, one retaining sufficient of the air-chambers to show the characteristic form, and also displaying the relatively small sipho which serves as a distinguishing feature from *Actinoceras bigsbyi* Stokes. The casts of the sipho in both specimens show a highly crenulated, gathered and puckered surface for the interior of the siphonal tube (endosiphon) and a series of fine canals connecting with the outer siphonal wall, below the funnel of each septum, and this possibly forming a means of communication between the endosiphon and the air-chambers. Each cast of the endosiphon bears upon the proximal or siphonal side a deep longitudinal groove, representing a prominent ridge on the wall of this tube.

*Formation and locality.*—In the Trenton limestone at Janesville, Wisconsin.
*Museum Register*, No. 8279.

## ACTINOCERAS REMOTISEPTUM *Hall*, 1850.

PLATE LIV, FIGS. 1–3.

*Ormoceras remotiseptum* HALL. Third Ann. Rep. N. Y. State Cab. Nat. Hist., p. 173, pl. IV, fig. 3.

*Original description:* "Cylindrical, gradually tapering; septa moderately convex, distant half the diameter of the tube; siphuncle excentric, large, swelling moderately between the septa and but slightly contracted at the junction of the septa; character of the external surface unknown.

"The specimen described is a fragment which is worn through the center of the siphuncle. The proportions of this part of the fossil and the great distance of the septa contrast very strongly with the *Ormoceras tenuifilum*, and with other known species of the genus.

"This species occurs in the higher part of the Trenton limestone, near Watertown, Jefferson county."

A large specimen from Cannon Falls, Minnesota, measuring upward of 300 mm. in length, much more complete than the original specimen of *Ormoceras remotiseptum*, has the dimensional characters of the latter, and upon sectioning a few of the air-chambers it shows a sipho in all respects like that of the type. The shell has been somewhat compressed, giving it a subelliptical cross-section where it was normally circular.

The rate of expansion of the conch is very slow as shown by the fact that at the lower end the diameter is 46 mm., while at the upper end, the length of the specimen being 350 mm., the diameter is 70 mm. The portion preserved retains no part of the body-chamber, and in this length of 350 mm. there are thirteen air-chambers, which increase considerably in depth from below upward, the first having a depth of 20 mm., the last of 33 mm. The sutures are normal and regular, possibly a little inclined towards the siphonal side, while the septa are deep and regularly convex. The sipho is large and submarginal. At the 7th septum, counting from below, the tranverse diameter of the sipho is 20 mm., that of the septum 58 mm. In section it proves to be decidedly constricted at the septa and makes a broadly nummuliform expansion in the air-chambers, its diameter there being one-third greater than at the septa. It is very thick-walled and is penetrated vertically through the center by a narrow canal or endosiphon which gives off more or less irregular branches into the substance of the endosiphonal wall. In the relative depth of the air-chambers and the general form of the shell this species presents an external resemblance to Hall's *Orthoceras amplicameratum*, from the Trenton limestone at Middleville, N. Y. In that species, however, the sipho appears to be small and suggests no relationship to *Actinoceras*.

*Formation and locality.*—The single specimen observed is from the Trenton limestone at Cannon Falls, Minnesota. Collection of W. H. Scofield.

## Family ORTHOCERATIDÆ.

### Genus ORTHOCERAS, Breyn., 1732.

The material representing this genus is measurably abundant, but not in very favorable condition for identification, and probably represents a greater number of species than are here made out. The annulated species are more readily distinguished by their surface variations, but among the smooth forms the exterior of the shell so rarely retains the surface sculpture that little basis remains for the determination of specific traits. No attempt is here made to follow the subgeneric distinctions introduced principally by Hyatt among orthoceran shells, as in the first place, the divisions are based largely upon variation in ornament and contour, and, secondly, our material is not sufficiently complete in its representation of the young stages to justify a subdivision of this kind.

### ORTHOCERAS NICOLLETI, *sp. nov.*

PLATE LI, FIGS. 1–2.

Tube of moderately large size, very gradually tapering, slightly arcuate in the original specimen, but this appears to be, to some extent, casual. Transverse section circular or subelliptical. Surface covered with strong, distant annulations which are sharp, rather narrow at the base, elevated and quite oblique in their direction, curving downward in traversing the shell from the convex (dorsal?) side to the inner side of the specimen. This obliquity increases very considerably toward the aperture. The annulations are separated by broad and deep constrictions whose width increases toward the aperture. Sutures transverse and even; septa regularly and somewhat deeply concave, crossing the shell in such a manner as to transect the annulations and constrictions. The interval between the septa appears to be about the same as that between the annulations, but this is not distinctly shown in the specimen, the suture and septum being clearly displayed only at the lower extremity. The finer surface ornamentation, if such existed, is not retained. In a length of 145 mm. the shell bears eleven annulations, the distance between the first two on the outer or curved side being 11 mm., between the seventh and eighth, 15 mm. on the outer side, and 11 mm. on the inner. The depth of the septum exposed is 7 mm. The diameter of the shell at its first annulation is 33 mm., at the last, 36 mm.

This species is strikingly characterized by its strong, oblique annulations and slender tube. It is, perhaps, most closely allied to the *Orthoceras olorus* Hall, but its difference in the features mentioned serve to distinguish it.

*Formation and locality.*—In the Trenton limestone at Belle Creek, Minnesota. Collection of W. H. Scofield.

### ORTHOCERAS ANELLUS *Conrad*, 1843.

PLATE XLIII, FIGS. 22–23.

*Orthoceras annellus* CONRAD, 1843. Proc. Acad. Nat. Sci. Phila., vol i, p. 334.
*Orthoceras anellum* HALL, 1847. Palæontology of New York, vol. i, p. 202, pl. XLIII, figs. 6*a–f*.

To this species are assigned two fragments of small conchs characterized by their very gradually expanding sides, sharp, regular, almost imperceptibly arcuate annulations separated by furrows of equal width; sutures regular and lying in the horizontal furrows, septa deeply concave and regular, and surface markings consisting of fine, closely-set longitudinal lines slightly alternating in size.

These are characters agreeing with the early descriptions cited, and serve to distinguish the species from *Orthoceras bilineatum*, in which the shell expands more rapidly and the concentric striæ, which are here obscured or absent, are conspicuously developed.

*Formation and locality.*—In the Trenton shales at Minneapolis, Minnesota; also at McGregor, Iowa.
*Museum Register*, No. 8290.

### ORTHOCERAS PERROTI, *sp. nov.*

PLATE LIV. FIGS. 4 and 5.

Shell moderately large, very gradually expanding. Cross-section broadly subelliptical, nearly circular. Surface covered by closely-set annulations about 2 mm. in width, separated by somewhat narrower transverse furrows. Sixteen of these annulations, of equal size and at regular interspaces, occur in a length of 41 mm. These ridges and furrows are crossed by a double series of vertical elevated lines alternating in size, upon the summits of the annulations being very conspicuous and developed into lamellar expansions. This character (one secondary lamella between each two primary lamellæ) is maintained over the entire surface, apparently without the intercalation of other series. Where best preserved, the surface affords no evidence of concentric lines. Sutures regular and transverse; septa evenly concave, moderately deep; sipho small and central.

The specimen showing the above characters is a well-preserved silicified fragment retaining the exterior with unusual delicacy. Its length is 50 mm., its greatest width 30 mm., and its minor axis at the same plane 26 mm. The species is allied to *Orthoceras olorus* Hall, but its distinguishing features will be found in the closer annulations and the different composition of the ornament.

*Formation and locality.*—In the Hudson River group at Granger, Minnesota.

### ORTHOCERAS LESUEURI, *sp. nov.*

PLATE LIII. FIG. 4; PLATE LV. FIGS. 8 and 9.

Shell rather small, slender; subelliptical in cross-section. Surface covered with numerous, fine, nearly transverse or very slightly oblique annulations, which are narrow at the base, abruptly elevated, sloping equally above and below, and separated by grooves somewhat broader than the annulations themselves. The latter make a very slight backward curve on the dorsal and ventral surfaces, with a broad curvature anteriorly at the sides. They are not crossed by vertical surface lines as far as shown by internal and external casts.

Sutures regularly transverse, each lying at the bottom of one of the horizontal constrictions. These appear to follow the curvature of the constrictions and annulations, and it may hence be inferred that the latter, which are slight, are to some extent increased by, if not due to vertical compression of the shell-tube. In a length of 31 mm. there are fifteen annulations.

Septum moderately deep; position of sipho not known.

The species is sufficiently distinguished by the character of its annulations, the position of the septa with reference to the former and the absence of a lineate surface ornament. This seems to me to be the same species as that referred to by Prof. Hall as "Orthoceras (*species undermined*),"* from the Trenton limestone at Middleville, N. Y.

The length of the original specimen is 67 mm.; its diameter at the lower end, 11 mm.; at the upper end, 13 mm.

*Formation and locality.*—In the Trenton limestone, Cannon Falls, Minnesota.

### ORTHOCERAS BILINEATUM *Hall*, 1847.

PLATE XLVII, FIGS. 20 and 21; PLATE LIV, FIGS. 6 and 7.

*Orthoceras bilineatum* HALL, 1847. Palæontology of New York, vol. i, p. 199., pl. XLIII, figs. 2*a–d*.

Shell of rather small size, gradually expanding; cross-section subcircular. Surface for a considerable distance over the apical region, smooth; but concentric annulations gradually develop, those first appearing being very obscure, those succeeding of increasing strength, until they present the aspect of strong, rather oblique or undulating ridges which are not sharply elevated, but become broader and more conspicuous toward the aperture. The constricted interspaces, which are somewhat wider than the annulations, also become broader toward the body-chamber. In one example there are eighteen annulations in a length of 63 mm.; in another fifteen in a length of 50 mm. In a third example the shell is virtually free of annulations for a distance of about 50 mm., and has a diameter of 14 mm. where the annulations are first well developed. The apertural diameter of an average individual is probably not more than 20 mm. with an entire length of 150 mm. These estimates are somewhat conjectural but are based upon the best preserved of numerous examples.

* Palæontology of New York, vol. i, p. 203, pl. XLIII, fig. 8.

The surface is ornamented by coarse and fine vertical, elevated lines, reticulated by extremely fine horizontal lines. Toward the apex, over the smooth portion of the shell, the vertical lines occur in two simple series; where the shell has a diameter of 7 mm. there are twelve lines of the first order, between each two lying one of a secondary series. As growth advances these lines rapidly multiply by intercalation, and the alternation in the size of the striæ becomes decidedly less pronounced. Over the annulated and later portions of the shell the ornamentation becomes proportionally very much finer but the regularly alternating size of the lines is maintained throughout. The horizontal striæ are exceedingly fine and often not retained. Where crossing the other series they are usually elevated into slight nodes or projections.

Sipho small and nearly central. The septa are rather shallow and the sutures regularly transverse and without undulations. They bear no definite relation to the annulations. Over the early, smooth portion of the shell they appear to be relatively distant on account of the narrowness of the shell, there being seven air-chambers in a length of 17 mm., in another specimen five in a length of 12 mm. They do not greatly vary in depth with the increase in the diameter of the shell. The sutures being usually transverse, cross the more or less oblique annulations and constrictions, variously transecting, or at times lying wholly within a given furrow.

The original description of this fossil was based upon specimens showing only the adult characters of the species. The existence of specimens in the material in hand, showing in a single example the gradual change from a smooth to an annulated shell, brings out an interesting fact in regard to the morphic variation through which other annulated species are known to pass. It has, for example, been shown by Hall* that the embryonic tip of the shell of *Orthoceras crotalum*, an annulated Devonian species, is smooth, and also that the vertical striæ are well developed much before the appearance of the annulations. In that species, however, the smooth portion of the shell is very short and greatly abbreviated in comparison with that of *O. bilineatum*. The passage of the shell of *O. crotalum* through the smooth stage is highly accelerated, while its longer duration in *O. bilineatum* more forcibly suggests the phyletic as well as individual relation of the non-annulated to the annulated forms of this genus.

It is, however, to be observed that the degree to which the apical smooth shell of *O. bilineatum* is retained is in a certain sense an individual peculiarity. Some specimens develop the annulations much earlier than others, and those which retain the smooth shell to a considerably later period preserve for a longer period an infantile character.

* Palæontology of New York, vol. v, pt. ii, pl. CXIII, fig. 13.

*Formation and locality.*—In the Trenton horizon at Minneapolis (Lake Street bridge), Pleasant Grove, St. Paul, Cannon Falls and Fountain, Minnesota; in the Galena shales at Warsaw, Minnesota.

The original specimens were from the lower and middle parts of the Trenton limestone at Middleville and elsewhere, New York.

*Museum Register*, Nos. 350, 381.

## ORTHOCERAS OLORUS *Hall*, 1877.

PLATE LV, FIGS. 3 and 4.

*Orthoceras vertebrale* HALL, 1847. Palæontology of New York, vol. i, p. 201, pl. XLIII, figs. 5*a*–*c*.
*Orthoceras olorus* HALL, 1877. In Miller's American Palæozoic Fossils, p. 245.

To this species are referred a few specimens with rather distant, narrow and elevated annulations, which are slightly undulating and are traversed by alternating elevated vertical striæ and these crossed by extremely fine horizontal lines. None of the material is good and such characters as are retained by the specimens show no great dissimilarity from the original. The septum is moderately convex, the sipho subcentral and the sutures, in the only example where clearly shown, follow the annulations and lie in the bottom of the constrictions. The species has a general resemblance to *Orthoceras perroti*, but differs in its more distinct and stronger annulations. In one example there are nine annulations in a length of 45 mm.; in another, five in a length of 25 mm. The diameter of the shell in both of these is about 30 mm.

*Formation and locality.*—In the lower blue beds of the Trenton limestone, Mineral Point and Janesville, Wisconsin; St. Charles and Holden, Minnesota; Galena shales, at Wykoff, Minnesota.

*Museum Register*, Nos. 252, 379, 8291, 8292.

## ORTHOCERAS TENUISTRIATUM *Hall*, 1847.

PLATE LV, FIGS. 5 and 6.

*Endoceras proteiforme*, var. *tenuistriatum* HALL, 1847. Palæontology of New York, vol. i, p. 209, pl. XLV, figs. 1*a*–*b*; pl. XLVII, figs. 1*a*–*b*, 2*a*–*c*.

Shell long, straight, gradually expanding. Sutures direct; septum regularly concave and very slightly oblique. Sipho subcentral, small.

Surface of the shell without annulations or ridges; marked by fine, crowded horizontal lines, somewhat undulating or irregular, often running into one another, rounded on the summit and subimbricating, separated by low furrows and divided at irregular intervals by a furrow of more than average width. These horizontal lines and furrows are crossed by extremely fine vertical lines seen only under magnification. Thanks to incarceration in the siphonal cavity of *Cameroceras*, one example of this species shows the surface ornamentation in a highly satisfactory manner. It even retains a series of narrow vertical bands which do not in any way interrupt the surface sculpture, but have the appearance of opaque or dull lines upon the shining surface of the shell. These I presume to be traces of color lines.

*Formation and locality.*—In the Trenton limestone, Cannon Falls, Minnesota. Collection of W. H. Scofield.

### ORTHOCERAS SOCIALE *Hall*, 1877.

PLATE LV, FIG. 7.

*Orthoceras gregarium* HALL, 1861. Rept. Supt. Geol. Surv. Wisconsin, p. 46.
*Orthoceras sociale* HALL, 1877. In Miller's North American Palæozoic Fossils, 2d ed., p. 245.

*Original description:* "Shell of medium size, gradually expanding from the apex, transverse section circular. Septa deeply concave, not very distant, varying from six to nine in the space of an inch, according to age. Siphuncle central in young specimens, often becoming subcentral or quite excentric in old individuals."

This species which is better known from the general diffusion in collections of the fine specimens occurring in rocks of the Hudson River horizon in the Maquoketa region of Iowa than from any published accounts or illustration, is represented in the collections of the Minnesota survey by excellent representatives from Graf, Iowa. There are also a few examples from the Trenton and Galena horizons at Cannon Falls which bear very much the same proportions, symmetrical form and general aspect of *O. sociale* and hence suggest the presence of that species in these rocks.

### ORTHOCERAS BELTRAMII, *sp. nov.*

PLATE LV, FIG. 10.

Shell very small, straight, very gradually expanding; cross-section subelliptical; external surface smooth, so far as known. Sutures direct, without lobes or undulations. Air-chambers very deep. The specimen upon which the species is founded is imperfect at the apical end, but retains most of the body-chamber. Its length is 29 mm.; its lower diameter 2 mm.; its apertural diameter, 3.5 mm. It bears fourteen air-chambers in a length of 21 mm., the body-chamber being 8 mm. in length.

*Formation and locality.*—In the Galena shales at Wykoff, Minnesota. Collection of Dr. C. H. Robbins.

### ORTHOCERAS MULTICAMERATUM *Emmons*, 1842.

*Orthoceras multicameratus* EMMONS, 1842. Geology of New York, Rept. Second Dist., p. 382, fig. 93.
*Orthoceras multicameratum* HALL, 1847. Palæontology of New York, vol. i, p. 45, pl. XI, figs. 1*a*–*c*.

*Original description:* "Extremely elongate, slender, very gradually tapering to an acute point; surface apparently smooth or girt with slight undulations; septa thin, gently arched, distant from one-fourth to one-twelfth the diameter; siphuncle a cylindrical ventral tube; outer chamber very deep." (Hall, *loc. cit.*)

This species appears to be represented by various imperfect examples of somewhat smaller size than the New York specimens, but otherwise agreeing with the above description and the original figures.

*Formation and locality.*—Not uncommon in the Trenton limestone at Minneapolis; in the Trenton shales at St. Paul, Eyota, Lanesboro and Fountain, and the Galena limestone at Rockdell, Minnesota. In the lower blue beds of the Trenton at Mineral Point, Wisconsin, and in the upper buff beds at Rockton, Illinois. Also common in the Birdseye limestone at Watertown and elsewhere, New York.

*Museum Register*, Nos. 721, 4049, 4052, 5045, 5112, 5578, 7927, 8276, 8277, 8278.

### ORTHOCERAS JUNCEUM *Hall*, 1847.

*Orthoceras junceum* HALL, 1847. Palæontology of New York, vol. i, p. 204, pl. XLVII, figs. 3*a-f*.

To this species are referred a few internal casts of small shells, with circular cross-section, central sipho, regular and equidistant septa. The original description of the species is as follows: "Slender, terete-cylindrical, tapering very gradually; septa thin, distant from one-fourth to one-third the diameter; siphuncle small, central, section circular; surface finely striated transversely, but without longitudinal striæ."

*Formation and locality.*—In the Trenton shales at Minneapolis and near Fountain, Minnesota. In the lower blue beds at Janesville, Wisconsin.

*Museum Register*, Nos. 716, 8280, 8281, 8282.

### ORTHOCERAS compare AMPLICAMERATUM *Hall*, 1847.

PLATE XLVII, FIG. 19.

Cf. *Orthoceras amplicameratum* HALL, 1847. Palæontology of New York, vol. i, p. 205, pl. LI, figs. 1*a-g*.

There are a few moderately large fragments of orthoceran casts which present an agreement with this species in general aspect and depth of the air-chambers. In the original description, based on much more complete examples than are here afforded, the species is thus characterized: "Teretely cylindrical, extremely elongated, very gradually tapering; outer chamber profound; septa distant about one-third the diameter, very conve, siphuncle excentric, small; surface ?; section circular."

In one of our specimens the external surface appears to have borne fine, equidistant, longitudinal striæ.

*Formation and locality.*—From near the base of the Galena limestone at Preston, Minnesota; in the lower blue beds of the Trenton at Mineral Point, Wisconsin.

*Museum Register*, Nos. 8285, 8286, 8287.

## Family EUDOCERATIDÆ.

This group was erected by Hyatt to include orthoceran shells having a greatly compressed form, broad lobes and narrow saddles, with transverse section fusiform or subtriangular. The family was designed by its author to embrace the genera *Eudoceras*, (Hall) Hyatt, *Triptoceras*, Hyatt, *Edaphoceras*, Hyatt, and *Endolobus*, Meek and Worthen.

### Genus TRIPTOCERAS, Hyatt, 1883.

Compressed orthoceran shells with broad ventral and dorsal lobes and acute lateral saddles; sipho ventral. The shell may be slightly arcuate but is usually straight at maturity; in transverse section subtriangular.

#### TRIPTOCERAS PLANOCONVEXUM *Hall*, 1861.

PLATE LVI, FIG. 3; PLATE LVII, FIG. 1.

*Orthoceras planoconvexum* HALL, 1861. Rept. Supt. Geol. Surv. Wis., p. 47.
*Orthoceras planoconvexum* WHITFIELD, 1882. Geology of Wisconsin, vol. iv, p. 228, pl. VII, fig. 14.

*Original description:* "Shell of medium size, gradually expanding from the apex toward the outer chamber, plano-convex; transverse section semicircular or subtriangular, the diameters as five to nine. The convex side a little depressed on each side of the middle, the opposite side nearly flat, the edges abruptly rounded. Septa moderately concave, arching upwards on the sides, somewhat closely arranged, about five in half an inch. Siphuncle small, central. A specimen of the outer chamber, apparently of this species, is a little more than two and a half inches in length, one inch and an eighth in width, the short diameter being half an inch; the septa are about one-tenth of an inch distant."

A rather small but characteristic example of this species presents the convex side exposing fifteen septa in a distance of one inch, the body chamber having about the same length, so far as exposed. The curvature of the septal lobes is perfectly regular and the junction of the septa with the lateral margins distinctly acute. A fragment of a much larger individual has a body chamber measuring 60 mm. in length and 53 mm. in width near the aperture. To this fragment are attached three air-chambers the last exposing a clean septal surface and showing the ventral position of the sipho. The specimen shows that while the lateral saddles appear to be acute when viewed from the dorsal side, they are actually somewhat obtuse, the obtuseness of the angle being distinctly manifested only on the ventral surface. A line drawn from one lateral angle to the other shows that the dorsal convexity of the shell is about twice the ventral.

*Formation and locality.*—In the Trenton limestone, Cannon Falls, Minnesota; in the Galena limestone at Hader and Wykoff, Minnesota. Collection of W. H. Scofield. The original specimens were from the Trenton at Beloit and Mineral Point, Wisconsin.

*Museum Register*, No. 8288.

## TRIPTOCERAS PLANODORSATUM *Whitfield*, 1882.

PLATE LVI, FIG. 4; PLATE LVII, FIGS. 2–4.

*Cyrtoceras planodorsatum* WHITFIELD, 1882. Geology of Wisconsin, vol. iv, p. 231, pl. VII, figs. 10–12.

Shells small, compressed, slightly arcuate, the incurvature being on the dorsal side. Lateral margins tapering slowly over the mature portions of the shell; ventral side broadly flattened medially, lateral surface abruptly rounded; dorsal side depressed convex. Transverse section broadly subtriangular, the base being the ventral side. Minor and major diameters as 7 to 11.

Septa gently convex, with a broad ventral lobe which is much more decided than that of the dorsal side. Lateral saddles obtuse. Depth of the air-chambers near the aperture about 15 mm., five being preserved in a length of 7 mm. Sipho small, situated near the ventral side but not in contact with it.

This species is represented by incomplete specimens, one of which, retaining most of the body-chamber and six septa, has a length of 34 mm., a width at the apertural end of 12 mm., and at the lower end of 10 mm. Another example representing only the body-chamber, is 31 mm. long, has an upper diameter of 14 mm., and a lower diameter of 10 mm.

*Formation and locality.*—From the Trenton limestone at Minneapolis, Minnesota. The original locality is three miles above Beloit, Wisconsin.

## TRIPTOCERAS OWENI, *sp. nov.*

PLATE LVI, FIGS. 5–7.

Shell small, unequally convex, slightly arcuate, with the incurvature on the dorsal side; rapidly tapering; ventral side very depressed convex, nearly flat; dorsal side decidedly convex, sloping with more or less abrupt curvature to the rounded lateral margins. This dorsal convexity is rather more pronounced on the earlier portion of the tube. Lateral margins approximating at an angle of about 20°. The external aspect of the shell is that of some large, slightly arcuate forms of *Hyolithes.*

Septa slightly convex, the minor and major axis as 1 to 2. Dorso-ventrally the convexity is very slight. The entire marginal section of the septum is rounded subtriangular, the lateral saddles being narrowly obtuse. Sipho small, ventral and submarginal. Surface of the shell apparently smooth.

The single specimen of this very characteristic form has a length of 34 mm.

representing pretty much the entire body-chamber. Its dimensions are 21 by 9 mm. The distal extremity which exposes a septum is 10 by 5 mm.

This species is readily distinguished by its distinct arcuation, rapidly expanding shell and the great difference in the convexity of the sides.

*Formation and locality.*—In the Trenton limestone, Cannon Falls, Minnesota. W. H. Scofield.

### TRIPTOCERAS *sp.* ?

There is a single specimen, an internal cast of the deep body-chamber, bearing a septum at is distal extremity, which presents differences from any of the foregoing species. The convexity of the septa and sides is about the same as that of *T. planoconvexum* but the inclination of the lateral margins is greater, with the sides acutely angled and almost carinate. The body-chamber, also, is distinctly arcuate. It nearest relations are with this species, as it is decidedly less convex and less rapidly tapering than *T. oweni.* The single specimen is from the Galena horizon near Cannon Falls, Minnesota.

Billings described two species of this genus from the Trenton series, viz.: *Orthoceras ziphias**, and *O. hastatum*†. In the absence of illustration it is difficult, from the not very precise descriptions, to establish their specific traits. The former, *T. ziphias,* appears to have the lateral angles obtuse, in which respect it is unlike *T. planoconvexum*; its convexity is less, its size and apical angle much greater than in *T. oweni,* while its lateral margins are less blunt and its venter less flat than in *T. planodorsatum.* In *T. hastatum* the lateral angles must be even more obtuse than in *T. planodorsatum*, the shell also tapering more rapidly and the septa being more convex.

The *Orthoceras servile* Billings‡, from the Quebec group, is a *Triptoceras* with rapidly tapering margins and rather convex sides.

### TRIPTOCERAS LAMBI *Whiteaves*, 1891.

PLATE LVI, FIGS. 1 and 2.

*Gonioceras lambi* WHITEAVES, 1891. The Orthoceratidæ of the Trenton limestone of the Winnipeg Basin; Trans. Royal Soc. Canada, vol. ix, sect. iv, p. 86, pl. XI, figs. *1a–b.*

Shell large, biconvex and lenticular in transverse section. Convexity of the sides subequal, that of the dorsal side being slightly the greater. Ventral side slightly flattened medially. Dorsal and ventral lobes broad and regularly convex, deeper on the dorsum, the general convexity being more decided than in the other species here noticed. Saddles acute, more distinctly so as viewed from the ventral

* Rept. Geol. Surv. Canada, for the year 1856, p. 318. 1857.
† *Op. cit.*, p. 333.
‡ Palæozoic Fossils, vol. i, p. 252. 1865.

side. Minor and major diameters of the septa as 1 to 4. Average depth of the air-chambers toward the aperture, 6 mm.

A specimen measuring 90 mm. in length has an upper width of 95 mm., a diameter at the lower end of 80 mm. and bears thirteen septa. A much larger example has a length of 195 mm., of which 45 mm. belong to the aperture and the remainder bears seventeen septa.

The sipho is distinctly ventral and moniliform. Nothing is retained of the external ornament.

This species is readily distinguished by its great size, subequally convex sides and the deep concavity of the septa.

*Formation and locality.*—The two specimens observed are from the middle portion of the Galena limestone at Stewartsville, Minnesota. The specimens described by Whiteaves were from the Trenton series at East Selkirk, Manitoba.

*Museum Register*, No. 8293.

## Family GONIOCERATIDÆ

### Genus GONIOCERAS Hall, 1847.

Broad, flat, straight shells, extremely compressed dorso-ventrally, and with extended lateral flanges into which the septa are continued. The shells are subequally biconvex with regularly concave dorsal and ventral lobes, large moniliform siphonal beads, perforated with radiating canals.

### GONIOCERAS ANCEPS *Hall*, 1847.

PLATE LVII, FIG. 5.

*Gonioceras anceps* HALL, 1847. Palæontology of New York, vol. i, p. 54, pl. XIV, figs. 1*a*–*o*.

*Original description:* "General form elongated, somewhat rapidly tapering from the base, extremely compressed laterally toward the extremities, and extended into very acute angles; diameters as 1 to 4 or 1 to 5; septa composed of double [?] laminæ, deeply concave in the center, numerous, thin, approximate, sinuous on the longest diameter; siphuncle moniliform, ventral, consisting of a rounded tube which is exceedingly expanded between the septa, like the siphuncle of *Ormoceras*." To this may be added that the septa are moderately distant, the dorsal and ventral saddles subacute, the recurvature of the septa of the lateral expansion being in a broad curve.

*Formation and locality.*—Three specimens in the collections are referable to this species, one from the lower blue beds of the Trenton series at Mineral Point, Wisconsin, others from the upper portion of the Trenton limestone at Minneapolis, Minnesota. The New York specimens are from the Black River limestone at Watertown.

*Museum Register*, Nos. 5113, 5680, 8298.

## GONIOCERAS OCCIDENTALE *Hall*, 1861.

PLATE LVII, FIG. 6.

*Gonioceras occidentalis* HALL, 1861. Rept. Supt. Geol. Surv. Wisconsin, p. 47.

*Original description*: "Shell elongate, very compressed, extremely expanded laterally, the upper part with curved outline, beyond the middle the edges are more nearly parallel; the length (when entire) having been a little less than twice the greatest diameter. Upper and lower surfaces convex, the one twice as convex as the other; the two diameters as one to seven; lateral expansions very thin. Septa deeply concave, numerous, closely arranged, twelve to the inch in the central lobe; arching forwards on the sides with a sharp retral curve a little within the margin, and running backwards in a narrow extension to the edge at a point opposite or below their junction with the siphuncle in the central lobe. Siphuncle oblate [ventral] of medium size where passing through the septa, expanding in the chambers to more than one-half the smaller diameter of the shell, somewhat bilobate from a constriction above and below.

"Surface apparently smooth, or with only concentric lines of growth."

The principal characters distinguishing this from the foregoing species will be found in the closer septa of the former and the curvature of the septa on the lateral expansions. The latter feature is not sufficiently emphasized in the quoted description.

In *G. occidentale* these saddles are quite regular, the outer and inner slopes together making almost the arc of a circle or the extremital arc of a broad ellipse, but in *G. anceps* the saddles do not rise above their height at the junction of the lobes with the body of the shell, whence they are deflected backward in a long, broad curve. The species seem to agree in the general form of the shell and the size of the apical angle. The best preserved specimen fails of agreement with the description in the proportional dimensions of the shell, the minor and major diameters being here as 1 to 5, rather than as 1 to 7. The latter ratio would make a much more expanded form than that presented by our specimens.

*Formation and locality.*—One considerable fragment and two quite imperfect examples are from the Trenton limestone at Dixon, Illinois (collected by E. O. Ulrich). The original locality is in the Trenton at Platteville, Wisconsin.

# Family GOMPHOCERATIDÆ.

## Genus POTERIOCERAS, McCoy.

### POTERIOCERAS APERTUM *Whiteaves*, 1889.

PLATE LVII, FIG. 11.

*Poterioceras apertum* WHITEAVES, 1889. Description of eight new species of fossils from the Cambro-Silurian rocks of Manitoba; Trans. Roy. Soc. Canada, vol. vii, sect. iv, p. 78, pl. XIV, figs. 2—4.

Of three imperfect specimens the best preserved is a fairly satisfactory representative of Whiteaves' species, exhibiting the internal cast of the shell from the aperture to the eleventh septum (counting from the aperture) and conforming in size and other specific details with the originals. Though this specimen is considerably worn on one side, it shows very clearly that the venter is somewhat narrower than the dorsum and the aperture, narrowed by the contraction of the body-chamber, broad on the dorsum and sinused on the venter. These are both features which are more sharply developed in species of *Oncoceras* and some of the forms here referred to *Cyrtoceras*. Nevertheless the aspect of the shell is not that of either of these genera, and though recognizing the close relations in form of all these genera, we appreciate the usefulness of McCoy's generic term, notwithstanding the fact that, as observed by Dr. Whiteaves, it has usually been assigned to the synonyms of *Gomphoceras*.

The position of the sipho in all of our specimens is just within the margins of the right dorso-lateral surface (the shell being oriented with the venter toward the observer). Whiteaves describes its position as "a little nearer to the dorsal than to the ventral side," but expresses at the same time a degree of uncertainty as to its proper place.

The most complete of our examples measures 73 mm. in length; 24 mm. in dorso-ventral diameter at the first septum preserved (the eleventh from the aperture); 43 mm. in the same dimension at the second septum from the aperture and this is the greatest width of the shell. The aperture is 36 mm. across. The body-chamber measures 30 mm. in length, and the eleven air-chambers cover 43 mm. One of the other fragments is larger, though less complete; the fifth septum has a dorso-ventral diameter of 44 mm., and here the diameter of the siphuncle is 8 mm.

This shell has essentially the same proportions as the *Gomphoceras* [*Poterioceras*] *cassinense* Whitfield, from the Calciferous fauna at Fort Cassin, Vermont, but will be found to differ therefrom in its much shorter body-chamber*.

*Formation and locality.*—In the lower blue beds of the Trenton limestone at Mineral Point, Wisconsin, and the Galena shales at St. Paul and Cannon Falls, Minnesota.

*Museum Register*, No. 5837.

* See Whitfield, Bull. Amer. Mus. Nat. Hist., vol. i, no. 8, p. 329, pl. XXIX, figs. 1—3.

## Family ONCOCERATIDÆ.

### Genus CLINOCERAS, Mascke, 1876.

### CLINOCERAS MUMIÆFORME *Whitfield*, 1878.

PLATE LVII, FIGS. 7–10.

*Oncoceras mumiaforme* WHITFIELD, 1878. Ann. Rept. Geol. Surv, Wisconsin, p. 58.
*Oncoceras mumiaforme* WHITFIELD, 1882. Geology of Wisconsin, vol. iv., p. 232, pl. VII, figs. 3–5.

Mascke founded this genus* upon a shell, *C. dens*, from the Silurian boulders of North Prussia, characterized by its gently arcuate form, the slender proportions of its early parts, the expansion of the body-chamber, and broad, rather deep constriction near the aperture. The aperture itself is regular and not contracted. The sutures are slightly undulating and are stated to form a minute dorsal lobe although the sipho is not marginal but lies between the center and the ventral side in the adult chambers.

The species which is herewith referred to this genus was described from rather imperfect material, virtually internal casts of but parts of the shell. Similarly preserved specimens of the species occur in the Minnesota collections, and after an examination of the original material, I refer to the species an unusually fine example which, in form and proportions, is almost a replica of Mascke's type. This shell, as preserved, is nearly complete, the aperture and external surface being retained and nothing wanting but a small portion at the apex. Its length is 66 mm.; its original length was probably about 70 mm. Its aperture which is essentially circular has a diameter of 10 mm., and at a distance of 8 mm. below the aperture the broad constriction is deepest. From the aperture to the greatest elevation of the swelling below it is 16 mm. and at this point the diameter of the shell is 10 mm. The distal extremity of the shell measures 3.5 mm. in diameter. The cross-section of the shell is circular at every point. The arcuation of the shell or divergence from the vertical let fall from the center of either extremity is 12 mm. The shell is not equiconvex; the swelling just below the constriction is much more considerable on the outer or convex curve of the shell, and this difference is perceptible though not so distinct over other portions of the body-chamber.

No septa are exposed except the terminal one, and that is evenly convex in all directions and bears a central sipho. This, however, is a very early septum, and though the maturer septa are unexposed, their siphonal punctures may prove to more nearly agree in position with those of the type-species of the genus. In some of the internal casts the position of the sipho is somewhat excentric and is dis-

* Zeitschr. der deutsch. geolog. Gesellsch. vol. xxviii, p. 49, pl. I. 1876.

tinctly moniliform. The external surface of the shell is covered with very fine, slightly undulating concentric lines.

*Formation and locality.*—The most perfect of the single specimens, is in a block of buff limestone of Trenton age, but without precise locality. In association with it are *Orthis flabellites* Hall, *O. testudinaria* Dalman, and *Plectambonites sericea* Sowerby. (Collection of Dr. Robbins). Others are from the lower blue beds of the Trenton limestone, at Janesville and near Beloit, Wisconsin.

## Genus ONCOCERAS, Hall, 1847.

### Oncoceras exiguum *Billings*, 1860.

PLATE LVIII, FIGS. 10 and 11.

*Cyrtoceras exiguum* Billings, 1860. Canadian Naturalist and Geologist, vol. v., no. 3, p. 172, figs. 17—18.

Shell small, short, gently arcuate, gradually expanding toward the aperture and somewhat abruptly constricted. Air-chambers relatively deep, septa evenly convex, with regular sutures and central sipho. Exterior smooth.

Of six incomplete examples of this little species, some show that the body-chamber occupied from one-half to one-third the length of the shell. Probably none of the shells were more than 30 mm. in length when entire, and the depth of the air-chambers is from $1\frac{1}{2}$ to 2 mm. The species is distinguished by its small size, distant septa and gradual inflation.

*Formation and locality.*—In the Galena shales near Fountain, Minn. The original specimens were from the Trenton limestone near L'Orignal, Canada.

*Museum Register*, No. 8281.

### Oncoceras minnesotense, *sp. nov.*

PLATE LVIII. FIGS. 16–18.

Shell moderately large, rapidly expanding, very faintly arcuate, cross-section strictly oval, the major or dorso-ventral, and minor or lateral axes being as 3 to $2\frac{1}{2}$. Septa concave, much more so dorso-ventrally than laterally. Air-chambers moderately deep, there being about eight in a distance of 32 mm. The longest example observed has fifteen air-chambers in a length of 45 mm. Sutures regular, with broad, evenly convex lateral, and a rather broad dorsal saddle. The ventral saddle is much the narrower and subacute, the summit of its angle higher than that of the dorsal saddle. Sipho ventral, submarginal, large and moniliform. The siphonal beads are large subrhombic chambers (in section), with thin walls. The opening of the sipho through the septa has about one-half of the diameter of the beads. The siphonal margins of the septa are distinctly calloused. The diameter of the beads equals about one-sixth of the major axis of the septum. Many specimens show indications of a linear or thickened oval scar extending from the inner margin of the siphonal beads along the major diameter of the septum to near the inner dorsal margin.

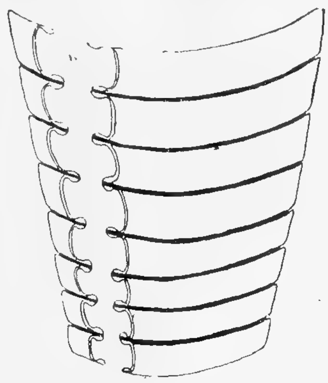


Fig. 10.—Vertical median section of *O. minnesotense* showing the form of the siphonal beads. × 1.5.

The external surface is covered with numerous low longitudinal ribs, thirty-five or forty in number on the later portions of the shell. Among a number of specimens representing this species there are none of the body chamber. The septate portions afford no satisfactory indication of the expansion which characterizes the genus *Oncoceras;* still the material presents many similarities to the species described by Whiteaves* as *Cyrtoceras manitobense,* from the Lower Silurian at many localities in Manitoba. The latter possesses a somewhat similar curvature of the septa, though a deeper concavity and a greater obliquity; and it also has a similar external ornamentation. Whiteaves' figures indicate a species with very slight arcuation and a decided expansion of the tube toward the aperture, and nearly the entire extent of the swelling is septate, the body-chamber occupying but a small part of it. It would seem wiser for the present to refer such shells to *Oncoceras* as they must be regarded as differing notably from typical forms of *Cyrtoceras.* The Minnesota specimens are hence thus referred, though they all lack the body-chamber.

*Formation and locality.*—In the Galena limestone at Hader, Stewartsville, Mantorville, Pleasant Grove and Lime City, Minn. A single fragment of the apical portion of a shell having the aspect of the other but with the septa closer together is from the Hudson River horizon at Granger, Minn.

*Museum Register*, Nos. 258, 4106, 8294, 8295, 8296.

## ONCOCERAS LYCUS, *Hall*, 1861.

PLATE LVIII, FIGS. 1—3.

*Orthoceras lycum* HALL. Rept. Supt. Geol. Surv. Wisconsin, p. 45.

Shell arcuate, with an arc of short radius on the ventral curve and a much

*Trans. Royal Soc. Canada, vol. vii, sect. iv, p. 80. pl. xiii, figs. 3, 4; pl. xv, fig. 4. 1889.

broader curvature on the dorsal margin; expanding rapidly to its greatest diameter near or at the base of the body-chamber. About the aperture it is broadly and rather deeply constricted and the margin slightly expanded and reflected. This apertural contraction is greatest on the ventral side where it is pinched out to a very narrow, subacute angle and the outline thus given to the aperture is that of an acute oval. The transverse diameter of the aperture is less than that of the body-chamber below the constriction. Its lateral margins form low convex curves bending into slight concavities on the dorsal and ventral sides. Transverse section of the septate portion of the shell broadly oval, the dorso-ventral and lateral diameters being about as 9 to 10. The greatest breadth of the section is somewhat within or toward the dorsal side of the center of the septum. Thus the surface of the shell-tube, which is quite broad on the dorsal curve, increases in breadth for about one-third of its lateral extent, thence decidedly narrows to the venter which is subacute. The septa are gently and regularly convex over the earlier part of the shell but increase in this respect near the body-chamber. The greatest depth of the septa is within the center. The sutures make broad and low, scarcely perceptible lateral lobes and dorsal saddle, but their anterior curvature is decidedly marked upon the venter. The depth of the air-chambers varies somewhat in different specimens and in the same individual, those near the body-chamber being as a rule the shallower. In a distance equal to the greatest diameter of the shell there are eight air-chambers in one example, and nine in another. In all of these the depth on the dorsal curve is scarcely more than one-half that on the venter. Sipho ventral, situated just within the margin, somewhat expanded between the septa. Some of the internal casts indicate that the external surface was smooth and covered with concentric growth lines which were strongly reflected over the venter in a direction just the reverse of that of the septa. Some of the casts bear very obscure traces of longitudinal ridges which may be altogether of muscular origin.

*Dimensions.* A well preserved example lacking a portion of the apex, measures 60 mm. on the ventral curve and 31 mm. on the dorsal curve. The body-chamber is 21 mm. in length and lacks a portion near the aperture. In 35 mm. on the ventral curve there are twelve air-chambers. The transverse lateral diameter of the shell where thickest is 19 mm. and the dorso-ventral diameter 24 mm. In another specimen which has a dorso-ventral diameter of 18 mm. at the third septum and retains the body-chamber and aperture in their entirety, the length of the body-chamber is 20 mm.; of this, 11 mm. occur below the constriction. The major and minor diameters of the body-chamber at its base are 24 and 20 mm., the major axis of the aperture is 23 mm. and its greatest lateral axis 15 mm.

This species is distinguished by its subacute venter, broad but not ventricose dorsal surface and the very slight decrease in the diameter of the body-chamber from its base to the constriction.

*Formation and locality.*—The species appears to be quite common in the lower blue beds of the Trenton limestone at Janesville, Wisconsin. It also occurs in the Trenton at Preston and Minneapolis, Minnesota.

*Museum Register*, No. 8300.

## ONCOCERAS CARVERI, *sp. nov.*

PLATE LVIII, FIGS. 7–9.

An entire body-chamber, with three air-chambers attached, is characterized by its broad sides, narrow dorsum and compressed, subangular venter. The cross-section of the shell is, thus, elongate-ovate, its major and minor diameters being as 3 to 2. Above the third septum (counting from the aperture) the shell expands somewhat to within the base of the body-chamber and is, thence, gently contracted to the aperture. The latter is more narrowly ovate than the rest of the shell, its lateral margins convex, making a narrow emargination on the venter. The suture is transverse on the sides and dorsum, without curvature, but is curved forward over the venter to such a degree that the depth of the air-chambers at the ventral surface is about twice that on the dorsal surface.

The sipho is ventral and is situated within the margin of the septa.

The shell is but slightly arcuate, being suberect except in the vicinity of the aperture where it is curved inward making the aperture somewhat oblique. Surface covered with fine concentric striæ which are strongly recurved over the venter, concentric to the outline of the aperture. The length of the body-chamber in the specimen is 20 mm.; the entire length of the body-chamber with three air-chambers, 26 mm.; the major diameter of the third septum, 21 mm., the minor diameter, 14 mm.

*Formation and locality.*—In the Trenton limestone at Minneapolis, Minnesota. A fragment of a larger shell has also been observed in the upper buff beds at Rockton, Illinois.

*Museum Register*, No. 2193.

## ONCOCERAS DOUGLASSI, *sp. nov.*

PLATE LXI, FIGS. 13–15.

Shell arcuate over the earlier portion, suberect for the greater part of its length. From the eighth air-chamber (counting from the aperture) upward, the shell expands rapidly to the last septum, thence contracts more rapidly, forming a broad and rather deep constriction just within the aperture. The expansion is more rapid on the ventral than the dorsal surface and hence the curvature is greater on the outer than on the inner margin of the shell. Dorsal and lateral surfaces very broad; ventral surface narrow and somewhat compressed laterally. The transverse section of the shell is therefore very broadly ovate, almost circular, the dorso-ventral and lateral diameters being to each other as 13 to 12 at the last septum; as 12 to 11 at the first septum exposed (the eighth from the aperture). The septa are regularly and not deeply concave; the sutures regularly transverse and simple, without lobes or saddles and the air-chambers comparatively broad and of subequal depth on ventral and dorsal margins alike. The average depth of these chambers is 3 to 4 mm., eight of them occuping a length of 32 mm. Surface smooth, covered with obscure concentric lines which follow the outline of the apertural margin and are, hence, bent backward over the venter. The lateral length of the specimen described, from the aperture to the eighth or terminal air-chamber, is 59 mm., its dorsal length 51 mm. and the ventral length 57 mm. The lateral length of the body-chamber is 20 mm. The transverse section at the eighth septum measures 12 by 11 mm.; at the base of the body-chamber 26x24 mm.; at the bottom of the subapertural constriction 28x34 mm. This species is charaterized by its very broad dorsum, rapid expansion over the later air-chambers, the regularity and considerable depth of the latter. It is most nearly allied to *Oncoceras constrictum* Hall, of the Trenton limestone of Middleville, N. Y., but is less arcuate than that species, and the expansion of the tube is less abrupt and less ventricose on the dorsal surface.

*Formation and locality.*—In the Galena limestone at Hader, Goodhue county, Minnesota.
*Museum Register*, No. 243.

## ONCOCERAS PANDION *Hall*, 1861.

PLATE LVIII, FIGS. 4—6.

*Oncoceras pandion* HALL, 1861. Rept. Supt. Geol. Surv. Wisconsin, p. 45.

*Original Description:* "Shell robust, strongly curved, very rapidly expanding to near the outer chamber which gently decreases in size for nearly two-thirds of its length and then becomes suddenly constricted to nearly one-half its former dimensions; broadly ovate or subcircular, the [greatest] diameter in the dorso-ventral direction. Septa moderately distant, strongly curved forwards on the dorsal side, the greatest concavity on the ventral side. Siphuncle large, dorsal. Surface unknown."

To this species I refer a few specimens characterized by the great inequality in the curves of the ventral and dorsal surfaces, the latter being very gentle, while the former are more abrupt than in any other species of the genus here noticed. None of the specimens are very well preserved, but the best of them retains nearly all of the body-chamber and seven air-chambers. The dorsum is very broad and but slightly arched. The seven air-chambers occupy a length of 19 mm. on the venter and 10 mm. on the dorsum. The body-chamber is 23 mm. in length, 23.5 mm. in major diameter at the base, and 22 mm. in minor diameter. The great difference in the outer and inner curves gives the shell a decided ventricose aspect about the base of the body-chamber.

The specimens here described are in very close agreement with those upon which Whitfield based his species *Oncoceras brevicameratum** from the Trenton beds at Beloit, Wisconsin. This is especially noticeable in the subcircular form of the septum. This species is, however, much less ventricose on the body-chamber than those which we here regard as representing *O. pandion.*

*Formation and locality.*– In the Trenton limestone at Janesville, Wisconsin, and in the vicinity of Cannon Falls, Minnesota.

*Museum Register*, No. 8303.

## Family CYRTOCERATIDÆ.

### Genus CYRTOCERAS, Goldfuss, 1832.

Though fully alive to the fact that the multitude of middle and late Silurian and early Devonian species which have been referred to *Cyrtoceras*, must eventually prove to be an association of phyletic inequalities, we still feel constrained to employ the term for a considerable number of the species here under consideration. These forms have been studied with care by Hyatt and most, if not all of the species here discussed will probably take their places within the genera introduced by him, namely; *Mœlonoceras, Oonoceras, Cranoceras* and *Eremoceras*†, but it is difficult in many cases to employ these terms with precision. In this author's work *Cyrtoceras* does not appear as one of the "Genera of Fossil Cephalopoda," but the type of this old genus, *C. depressum,* is assumed as the type of *Cranoceras.* This type-species is a middle Devonian shell, occurring in those later faunas of the Paleozoic where such forms ususully lack any evidence of a swollen body-chamber, but are likely to possess extended and more completely coiled tubes than in the Silurian faunas. It is among these later forms that the distinction between the genera *Cyrtoceras* and *Gyroceras* becomes very obscure,‡ while in the Silurian shells the presence of an inflated tube is common and the

*Geology of Wisconsin, vol. iv, p. 234, pl. vii, fig. 2.

†Proc. Boston Soc. Nat. Hist., vol. xxii, pp. 280–282.

‡See the remarks by James Hall upon the impossibility of referring a large number of Devonian species with accuracy to either genus: Palæontology of New York, vol. v, pt. ii.

affinities of these species are with *Oncoceras* and *Clinoceras*. Some light is thrown upon these facts by observations recently made upon the early stages of the shell in the genus *Bactrites** where it appears that in late Devonian represenatives of this genus the swollen tube is a growth-stage immediately succeeding the protoconch. It is hence a primitive condition, or at least it may be regarded as indicating such a condition in such nautiloids as reveal it at any growth-stage. We find that this inflation of the tube is a normal mature character in many early Silurian genera, but is continued into the Devonian only in the genus *Gomphoceras.*

### CYRTOCERAS NELEUS *Hall*, 1861.

PLATE LIX, FIGS. 17—20.

*Cyrtoceras neleum* HALL, 1861. Rept. Supt. Geol. Surv. Wisconsin p. 40.

*Original description;* "Shell of small or medium size, very gradually expanding from the apex and strongly curved, transverse section circular or subcircular, very obtusely subangular on the back in casts, most ventricose on the ventro-lateral region. Septa closely but not evenly arranged, averaging about nine in a space equal to the transverse diameter of the shell, curving forward to the dorsal sides, their margins undulated especially toward the outer chamber where they become crowded. On the ventral side the septa have a broad advancing curve. The exposed surface of the septa shows the greatest concavity a little on the ventral side of the center. Siphuncle dorsal, comparatively large. Surface marked by transverse, slightly undulating annulations, which are strongly and abruptly curved backwards on the dorsum. Diameter of the large specimens five-eighths of an inch."

To this species I have referred a number of specimens which conform to the above description, though the surface markings in the specimens are not distinctly annulations but rather strong concentric striæ grouped in bundles and presenting the appearance of low and obscure annulations. Some of this material is of good quality, one specimen in particular retaining nearly the entire extent of the shell, showing its slender and graceful form, and making a little less than one volution. The broad, simple aperture (dorso-ventral diameter 18 mm., lateral diameter 21 mm.), rather shallow body-chamber (15 mm. on the dorsal surface) and the numerous septa, which number forty in the entire length, serve to characterize it. This specimen is an internal cast and along the venter the comparatively large siphonal beads are clearly exposed. Other examples, in which there has been no abrasion of the ventral surface, show the strong upward curvature of the septa and

* The writer in the American Geologist, vol. xiv, p. 37, 1894; "The Early Stages of Bactrites."

the slight deepening of the air-chambers on the ventral surface and also the recurved surface striæ which have a direction nearly the reverse of that of the septa.

*Formation and locality.*—In the Trenton limestone at Cannon Falls, Minneapolis and near Fountain, Minnesota, and Beloit, Wisconsin; in the Galena shales at Wykoff, Minnesota.

*Museum Register*, Nos. 6554, 7926.

### Cyrtoceras camurum *Hall*, 1847.

PLATE LX, FIGS. 5, 6.

*Cyrtoceras camurum* Hall, 1847. Palæontology of New York, vol. i, p. 196, pl. xlii, fig. 6.
*Cyrtoceras camurum* Whitfield, 1882. Geology of Wisconsin, vol. iv, p. 231, pl. vii, figs. 7, 8, 9.

The very gradual expansion, slight arcuation and extreme lateral compression of this species afford a ready distinction from associated forms. The original specimen, from Middleville, N. Y., is not very favorably preserved, but that figured by Whitfield serves to establish the characters of the species and with the latter I find a close agreement in the case of a single specimen in the collections in hand. This retains the entire body-chamber and sixteen air-chambers, and also shows the bead-like divisions of the submarginal sipho.

*Formation and locality.*—In the upper buff beds of the Trenton limestone, Samp's quarry, Beloit, Wisconsin,

### Cyrtoceras hallianum *D'Orbigny*, 1850.

PLATE LX, FIGS. 11, 12.

*Cyrtoceras lamellosum* Hall, 1847. Palæontology of N. Y., vol. i, p. 93, pl. xli, figs. 2*a–c*.
*Cyrtoceras hallianum* D'Orbigny, 1850. Prod. de paléontol. stratigraph., vol. i, p. 1.
*Cyrtoceras billingsi* Salter, 1859. Figures and Descr. Canad. Org. Rem. Decade 1, p. 33, pl. vii, fig. 5 (*non* 6).

The original of this species was a small, badly crushed specimen distinguished by its surface ornamentation, consisting of "undulating squamose lamellæ which are abruptly bent backward on the dorsal line." There are two specimens before me in which this peculiar ornament is retained; one a mere fragment of the shell with these surface markings very sharply defined, the other a considerable portion of a large and more complete example in which the surface is less clearly preserved. The latter shows an arcuate and broad shell with ovate cross-section, the dorso-ventral diameter diminishing, in a length along the ventral periphery of 60 mm. (and dorsal of 37 mm.), from 25 mm. to 16 mm.

Septa rather closely crowded, eight or ten on the dorsal surface of 37 mm., inclining somewhat to the venter. Sutures with low, scarcely perceptible lateral lobes. Sipho ventral, submarginal.

The undulations of the surface lamellæ consist of numerous small festoons caught up at regular intervals on the successive growth-lines. Over the dorsal and ventral surfaces are traces of low revolving ridges.

*Formation and locality.*—In the Trenton limestone at Janesville, Wisconsin, and in the shales at St. Anthony Park, Minneapolis.

### CYRTOCERAS BILLINGSI *Salter*, 1859.

PLATE LX, FIG. 10.

*Cyrtoceras billingsi* SALTER, 1859. Figures and Descr. Canad. Organ. Rem. Decade 1, p. 33, pl. VII, fig. 6 (*non* 5).

Salter, in proposing, in the work cited, to rechristen the species *C. lamellosum* Hall, with the name *C. billingsi*, overlooked the fact that d'Orbigny had recognized the preoccupancy of that term, and in 1850 had introduced the name *C. hallianum* therefor. Mr. Salter also figured as *C. billingsi* two specimens, one of which shows the form and rate of expansion of the shell as we have above given it, and also the peculiar festooned, squamous growth-lines and faint longitudinal ridges of the surface. The other of his figures (fig. 6) represents a more rapidly expanding shell, with lamellose growth-lines which are simple and not festooned, and are strongly retrose on the venter. By finding both forms represented in the Silurian rocks of Minnesota, retaining all the features exemplified in each of Salter's figures, we are convinced that there are here two quite distinct species. As Salter's name, so far as it is based on the first of his figures (fig. 5) is a synonym for *C. hallianum* the term *C. billingsi* may properly be employed for shells conforming to the type of the second of his figures.

One excellent specimen and fragments of others permit the following description of this species.

Shell very arcuate and rapidly expanding. A specimen measuring 57 mm. in length on the ventral periphery and 32 mm. on the dorsal, has an apertural diameter of 23 mm. dorso-ventrally and a posterior diameter of 8 mm. The arc traversed in this length is approximately one-third of a volution. Transverse section nearly circular, venter very broad. Surface covered with fine, crowded, subequidistant lamellæ, from .3 to .5 mm. apart; these are projected forward or toward the aperture and may be sufficiently long to overlap each other. The interspaces become somewhat greater toward the aperture. On the venter these lamellæ make a short, decided curve backward. The form of the septa and course of the sutures are not known.

The external characters of this species are such as to readily distinguish it. The single respect in which a difference from the specimen described by Salter can be suggested is the somewhat greater interval between the lamellæ and their stronger ventral curvature in the Canadian example.

*Formation and locality.*—Trenton limestone, in the vicinity of Cannon Falls, Minnesota. Collection of W. H. Scofield.

### Cyrtoceras houghtoni, *sp. nov.*

PLATE LIX, FIGS. 12–15.

Shell small, short, slightly arcuate, very compressed laterally, the dorso-ventral diameter being from one and a half to twice the lateral diameter. Dorsal surface obtusely rounded, ventral margin subacutely convex. Transverse section narrowly and rather acutely ovate. Greatest diameter of the tube, just behind the aperture, about twice that at the 16th septum. Body-chamber moderately deep, not direct but sharing in the general arcuation of the shell. Septa moderately, somewhat irregularly distant. Sixteen of the air-chambers have a length of 16 mm. on the sides, with a scarcely perceptible upward curve on the dorsum, and a broad ventral saddle which may be subacutely angled. Greatest convexity at the base of the body-chamber which is somewhat contracted toward the aperture. Sipho dorsal, submarginal. Surface covered with fine striæ which over the body-chamber, are curved backward. A specimen 39 mm. in length on the venter has a body-chamber 15 mm. deep. In one 45 mm. in the same dimension, the body-chamber is 20 mm. long. This specimen has the body-chamber entire.

In this species the great lateral compression of the shell is the primary distinguishing character. This added to the arcuation of the body-chamber and the very slight convexity of the septa renders the species readily separable from other described forms.

*Formation and locality.*—Four specimens of this shell from the Trenton limestone of Cannon Falls, Minnesota, occur in the material loaned by the late W. H. Scofield.

### Cyrtoceras featherstonhaughi, *sp. nov.*

PLATE LVIII, FIGS. 12–15.

Shell small, slightly arcuate, gently contracted at the aperture, expanded a little on the body-whorl and tapering toward the apex in low, convex curves. Dorsal or inner surface very depressed convex, rounding rather abruptly at the sides to a somewhat elevated venter. Transverse section broadest laterally. The greatest lateral diameter of the septum divides the major axis into parts which are as 2 to 3, the greater being ventral. Each septum is gently concave, the concavity being the most pronounced on the ventral slope. Air-chambers closely appressed, thirteen of them measuring 15 mm. on the dorsal side and 23 mm. on the ventral side. This implies that the depth of each chamber on the venter is very much greater than on the dorsum. Each suture makes a low, broad and very obscure saddle on the dorsum, scarcely perceptible lateral lobes, thence sloping forward and making a strong ventral saddle.

Sipho ventral and submarginal. Body-chamber large and deep on the dorsum, equalling ten air-chambers in length, and on the venter six. Surface smooth.

*Dimensions.* The specimen upon which this species is based retains the body-chamber nearly intact, and thirteen air-chambers. It has a length of 36 mm. on the outer curve, 11 of which belong to the body-chamber; on the inner curve it measures 28 mm., of which 11 belong to the body-chamber. Its transverse diameter near the aperture is 14 mm.; at the last septum 13 mm., and at the thirteenth septum 7 mm. Its dorso-ventral diameter near the aperture is 12 mm., at the last septum 11 mm., and at the thirteenth septum 6 mm.

This species is well characterized by the peculiar transverse form the shell.

*Formation and locality.*—The type specimen is from the Trenton limestone, and is believed to have been obtained from Madison, Wisconsin. Collection of W. H. Scofield.

### CYRTOCERAS MINNEAPOLIS, *sp. nov.*

PLATE LIX, FIGS. 1–8.

Shell arcuate, rapidly expanding to the aperture. Body-chamber without constriction; apical curvature not known. Surface laterally compressed; sides broad; dorsum narrow, venter still narrower and more arcuate. Transverse section subelliptical, the major and minor diameters being as 11 to 9 at the next to the last septum, and as 16 to 11 at the aperture. The lateral margins of the aperture are convex, the dorsal and ventral margins broadly and narrowly concave or re-entrant, respectively. The septa are regularly and evenly, though not deeply concave, the deepest concavity being at about the center. The sutures are transverse and simple, without lobes or saddles save for a slight upward inclination on the venter, which gives to the air-chambers a greater depth on the ventral than on the dorsal side. Sipho ventral, submarginal, expanded in each air-chamber.

Surface covered with closely crowded concentric lines, conforming in curvature to the aperture. On the internal cast are traces of longitudinal ridges over the body-chamber.

A small and typical example has the aperture 16 mm. in major, and 11 mm. in minor diameter. At the next septum to the last these dimensions are 11 and 9 mm. In a large specimen the aperture is 21.5x15 mm. and at the third septum from the aperture 15x12 mm. This species has some similarity to *Cyrtoceras camurum*

Hall, as figured by Whitfield,* but is distinguished from that as from other species by the rapid expansion and absence of constriction in the body-chamber.

*Formation and locality.*—In the Trenton limestone at Minneapolis.

*Museum Register,* No. 5048.

### Cyrtoceras corniculum *Hall*, 1862.

PLATE LIX, FIG. 16.

*Cyrtoceras corniculum* Hall, 1862. Rept. Geol. Surv. Wisconsin, p. 41, figs. 1, 2.

Shell small, slender, with graceful curvature, making less than one volution.

Surface nearly equally rounded, somewhat broader on the dorsum. Transverse section nearly circular. Septa very gently and regularly concave. Sipho ventral, intra-marginal, minute, distant by twice its diameter from the margin.

There are two specimens of this little species, both preserved as internal casts in crystalline calcite. But one shows the character of septum and sipho and neither indicates the distance between the air-chambers. Enough, however, is retained of the form of the shell and its curvature to show its agreement with this species.

The larger of the two incomplete examples measures, along the ventral curve, 30 mm.; along the dorsal curve, 21 mm. At the distal extremity of the specimen which is not far from the apex of the shell, the diameters are 2.5 and 2 mm., while at the proximal extremity the dorso-ventral diameter is 8 mm. and the lateral diameter 9 mm.

*Formation and locality.*—In the Galena shales, Warsaw, Minnesota. Collection of W. H. Scofield.

### Cyrtoceras norwoodi, *sp. nov.*

PLATE LX, FIGS. 7–9.

The specimen upon which this species is based retains the entire body-chamber and six air-chambers. The form of the shell is suberect, gently increasing in convexity from the base of the specimen to the base of the body-chamber, thence gradually contracting to the aperture but forming no distinct constriction. The shell is stout, with broad dorsum, broad sides and a somewhat narrowed or laterally compressed venter. The transverse section is oval, with diameters as 5 to 6, the greater dimension being dorso-ventrally. This diameter at the 7th septum is 26 mm.; at the aperture 22.5 mm. The sutures are nearly transverse with very low and broad lateral lobes, an indistinct dorsal saddle and more conspicuous and subacute ventral saddle. Throughout their extent the sutures are minutely undulated, these undulations being most clearly shown on the sides where the upward curves of each seem to coincide with obscure longitudinal ridges on the surface.

* Geology of Wisconsin, vol. iv, pl. vii, figs. 7—9.

The septa are very gently concave and closely appressed, the air-chambers being somewhat deeper on the venter than on the dorsum. Six of these septa occupy a length of 9 mm. Sipho ventral and submarginal.

The entire length of the specimen on both ventral and dorsal surfaces is 26 mm. of which 17 mm. belong to the body-chamber.

*Formation and locality.*—In the upper buff beds of the Trenton series at Rockton, Illinois.

### CYRTOCERAS SHUMARDI, *sp. nov.*

PLATE LX, FIGS. 1–4.

The body-chamber and last air-chamber of a single specimen indicate the presence of another undescribed species of this genus, distinctly characterized by the very broad, somewhat flattened venter, narrow sides and broad, concave dorsum. This shape gives to the cross-section of the shell the form of a transverse oval somewhat flattened on one (the ventral) side. Another leading feature is the regularity of the suture which is without evidence of lobe or saddle even on the ventral side. The septum is deeply concave, its point of greatest convexity being on the dorsal side of the center. The aperture is slightly expanded, oblique and highest on the ventral side. The length of the body-chamber in this specimen is 25 mm. The major and minor diameters of the aperture are 25 and 23 mm.; the major and minor axes of the last septum, 19 and 15 mm.; the depth or concavity of the last septum, 4.5 mm. There is also a second specimen from near the apex of the shell, which retains the proportions of that described but has a greater arcuation of the conch.

*Formation and locality.*—In the Trenton limestone at Cannon Falls, Minnesota. Collection of W. H. Scofield.

### CYRTOCERAS SCOFIELDI, *sp. nov.*

PLATE LIX, FIGS. 9–11.

A very sharply defined internal cast, which resembles in some respects *Cyrtoceras camurum* Hall, though with a more arcuate shell and more oval cross-section, retains a portion of the body-chamber with eleven air-chambers attached. From *C. camurum* it differs in the sharper venter, in the presence of a low and obscure median ridge on the dorsum and in the form of the septal sutures, which may be described as follows:

At the median ridge on the dorsum they make a small but distinct saddle; thence they slope laterally in a very low lobe, again making a slight forward curve at about one-third the distance across the shell. From this point they make a broad and gentle lobe which covers the remaining portion of the side. Toward the venter they are curved forward into a broadly angled saddle, which is not acute, but is sharper on the septa nearest the aperture. The depth of the air-chambers on this side is about one-half greater than on the dorsum. The form of the suture is so characteristic that, taken in conjunction with the form of the shell, I have ventured to regard the specimen as representing a new specific form.

*Dimensions.* Length, 30 mm.; major axis of apertural end, 16 mm.; minor axis 12-5 mm.; major axis of distal end 12 mm.; minor axis, 10 mm. Average depth of air-chamber on venter, 2 mm.; on dorsum, $1\frac{1}{4}$mm.

*Formation and locality.*—In the lower blue beds of the Trenton limestone at Janesville, Wisconsin.

*Museum Register*, No. 62.

### Genus GYROCERAS, DeKoninck, 1841.

#### GYROCERAS DUPLICICOSTATUM *Whitfield*, 1878.

*Gyroceras duplicicostatum* WHITFIELD, 1878. Ann. Rept. Geol. Surv. Wisconsin for 1877, p. 78.
*Gyroceras duplicicostatum* WHITFIELD, 1882. Geology of Wisconsin, vol. iv, p. 235, pl. VII, fig. 1.

Fragments of this species occur in specimens in the state museum, collected from the lower blue beds of the Trenton limestone at Janesville, Wisconsin. The original specimens were from the Trenton at Bristol and Beloit, in that state.

## Family TÆNOCERATIDÆ.

### Genus EURYSTOMITES, Schroeder, 1891.

#### EURYSTOMITES UNDATUS *Emmons*, 1842, var. OCCIDENTALIS *Hall*, 1861.

*Lituites undatus*, var. *occidentalis* HALL, 1861. Rept. Supt. Geol. Surv. Wisconsin, p. 38.

This well known form is represented by several specimens in the collections before me, some of them of large size, all possessing the broad whorls with flattened dorsum and the simple concave septa characterizing the western variety of this species. The New York specimens upon which the species was founded, seem to be restricted in range to narrow limits within the Black River limestone formation but the specimens from Minnesota indicate a more general distribution. Two large examples have a diameter of about 140 mm.; smaller specimens show the extreme ventral but submarginal position of the sipho and the dorsal depression or groove on each whorl made by contact with that next within.

The species has usually been referred to the genus *Lituites*, Breyn, the type of which is *Lituites lituus*. It is evident however that the species is not a *Lituites*, and and I have here followed the recent suggestion of Hyatt* that it be placed with *Eurystomites*.

*Formation and locality.*—In the Trenton limestone at Minneapolis, Spring Valley, Northfield, Pine Island, Minnesota; Dixon and Rockton, Illinois.

*Museum Register*, Nos. 5066, 5714.

* Proc. Amer. Philos. Soc., vol. xxxii. p. 445. 1894.

## LIST OF SPECIES OF CEPHALOPODA HERE DESCRIBED.



NOTE TO PAGE 769.—Since recording the observations given upon the structure of *Nanno aulema*, the original material has been placed in the hands of Professor Alpheus Hyatt for further elucidation. Prof. Hyatt's conclusions, not wholly confirmatory of my inferences, will be published in the "American Geologist" for July, 1895.

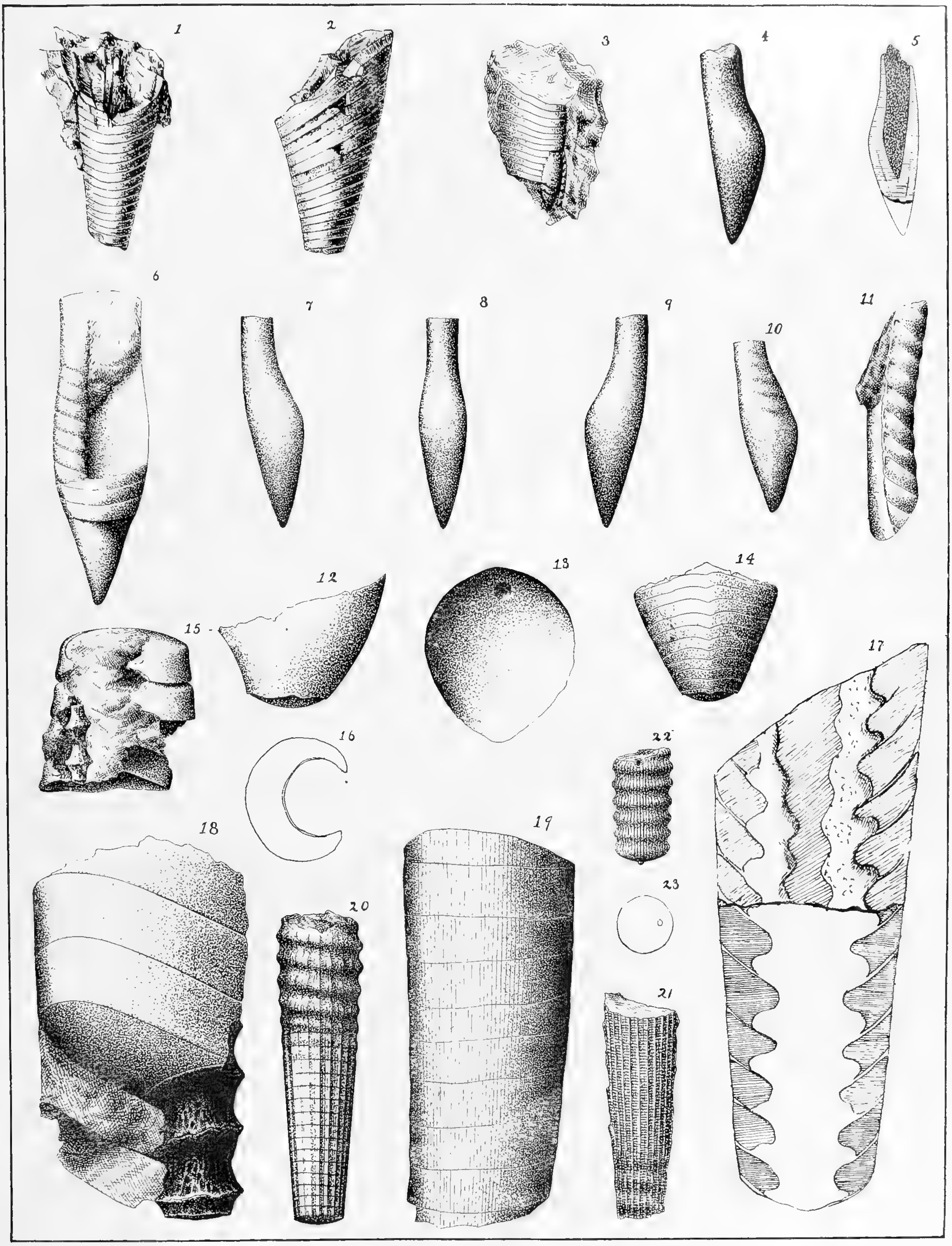
NOTE TO PAGE 774.—The *Endoceras*-affinities of the genus *Cyrtocerina* have been confirmed by Holm's discovery by of large species of this genus with dorsal siphones of great size and typical structure. (Om tvenne Gyroceras-formight böjda Endoceras-arter; Geol. Fören. i Stockh. Förhandl. vol. 14, 1892).

*Errata for the Chapter on Cephalopoda.*

Page 766, line 14, after *filaments*, insert *or canals*.
Page 774; the application of the terms *dorsal* and *ventral* on this page should be reversed.
Page 777, reference to plates, second line omit *4*.
Page 784, reference to plates; for *LI* read *LV*; for *XLIII* read *XLVII*.

# PLATE XLVII.

| | | Page. |
|---|---|---|
| Figs. 1 to 3 | PILOCERAS NEWTON-WINCHELLI, sp. nov...................................... | 767 |
| 1 and 2 | Inner and profile views of the more complete specimen; showing the form of the shell, the direction of the septa and, in fig. 1, the large size of the sipho. x 1 1-6. | |
| 3 | A fragment showing a portion of the filling of the sipho with traces of two siphonal sheaths. Shakopee chert, Union township, Houston county, Minn. | |
| Figs. 4 to 11 | NANNO AULEMA, sp. nov...................................... | 770 |
| 4 | Lateral view of a sipho with the aperture completed, indicating its freedom from the septal funnels | |
| 5 | Longitudinal section of a specimen broken at the top; showing the thickness of the preseptal cone, the convergent lines representing organic deposits. | |
| 6 | The most complete example observed; showing the form of the shell, the position of the sipho, three of the distal air-chambers and the relations of the preseptal cone to the rest of the shell. | |
| 7 to 9 | Lateral and antisiphonal views of an average sipho, broken at the upper margin. Figs. 4—9 from the Trenton shales, Minneapolis, Minn. | |
| 10 | Lateral view of a sipho bearing traces of annulations produced by the septa. From the Galena formation, Chatfield, Minn. | |
| 11 | A portion of a sipho above the preseptal cone, showing very strong annulations produced by the septal funnels, and retaining a portion of the conch. Probably from near Cannon Falls, Minn. | |
| Figs. 12 to 14 | CYRTOCERINA (?) SCHOOLCRAFTI, sp. nov...................................... | 774 |
| | Lateral, septal and ventral (anti-siphonal) views of the original specimen. ×3. The sutures are shown on one side of the specimen, and in fig. 14 they have been somewhat conventionally extended over the entire surface. Trenton shales near Cannon Falls, Minn. | |
| Figs. 15 to 17 | ACTINOCERAS BIGSBYI Stokes...................................... | 781 |
| 15 | View of the siphonal side of an internal cast of four air-chambers; showing the great size of the sipho and the filling of a portion of the endosiphon which is somewhat displaced from its normal position. | |
| 16 | Outline of the distal septum of the same specimen. Trenton horizon, Minneapolis. | |
| 17 | Longitudinal section of a longer specimen, the upper part through the endosiphon, and showing the thickness of the siphonal wall; the lower part through the substance of the sipho. From the Trenton group near Rochester, Minn. | |
| Fig. 18 | ACTINOCERAS BELOITENSE Whitfield...................................... | 782 |
| | A portion of an internal cast showing the filling of the endosiphon. In the Trenton limestone at Janesville, Wisconsin. | |
| Fig. 19 | ORTHOCERAS compare AMPLICAMERATUM Hall...................................... | 790 |
| | A fragment which retains traces of a fine longitudinal surface striation. Galena limestone, Preston, Minn. | |
| Figs. 20 and 21 | ORTHOCERAS BILINEATUM Hall...................................... | 786 |
| 20 | The apical part of a shell which shows very distinctly the gradual development of the annulations. ×2. | |
| 21 | A fragment of a small shell with the characteristic exterior. This specimen is not very well preserved and the apparent absence of annulations on the upper part of the shell is essentially due to imperfect retention. ×2. Trenton shales, Minneapolis. | |
| Figs. 22 and 23 | ORTHOCERAS ANELLUS Conrad...................................... | 784 |
| 22 | A portion of a small shell showing the characteristic annulation and surface ornamentation. | |
| 23 | Outline of the distal septum. Trenton shales, Minneapolis. | |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## PLATE XLVIII.



(See also plates XLIX, L, LI, LII.)

An internal cast of a very long siphon, viewed from the siphonal side of the shell; showing the oblique marks of the septal funnels and the outline of the continuous apical sheath. From the Trenton limestone, Wykoff, Minn.

## PLATE XLIX.

Page.

Fig. 1 Cameroceras, sp .......................................................... 777

A long cylindrical sipho, with very broad septal funnels; representing a distinct but otherwise unknown species.

From the Trenton limestone, Cannon Falls, Minn.

This specimen may be advantageously compared with the figures of *Orthoceras simpsoni* Billings, given by Whiteaves. (Orthoceratidæ of the Trenton limestone of the Winnipeg basin; Trans. Roy. Soc. Canada, vol. ix, sect. iv, p. 80, pl. vii, figs. 2, 2*a*, 3; pl. viii, fig. 1, 1891).

Fig. 2 Cameroceras proteiforme Hall.......................................................... 777

(See also plates lviii, xl, xli, xlii.)

A portion of a large individual, showing the extent of the solid apical end of the sipho, and the abrupt increase in the depth of the air-chambers above the distal extremity of the body. Where the apical sheath is broken, at the lower extremity of the specimen the cast of the internal cavity and the thickness of the sipho are exposed. Cannon Falls, Minn.

(Cephalopoda.)

 

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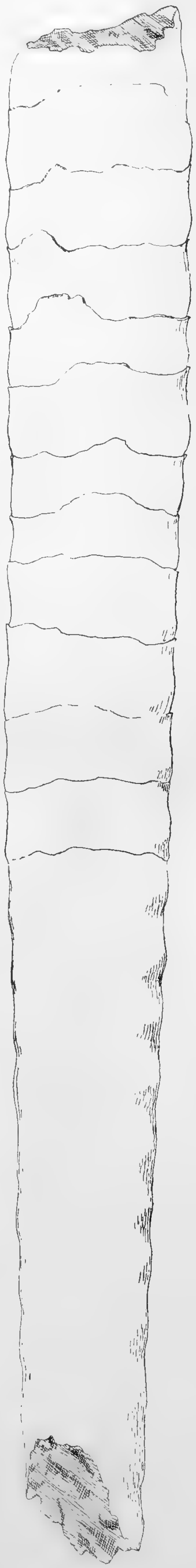

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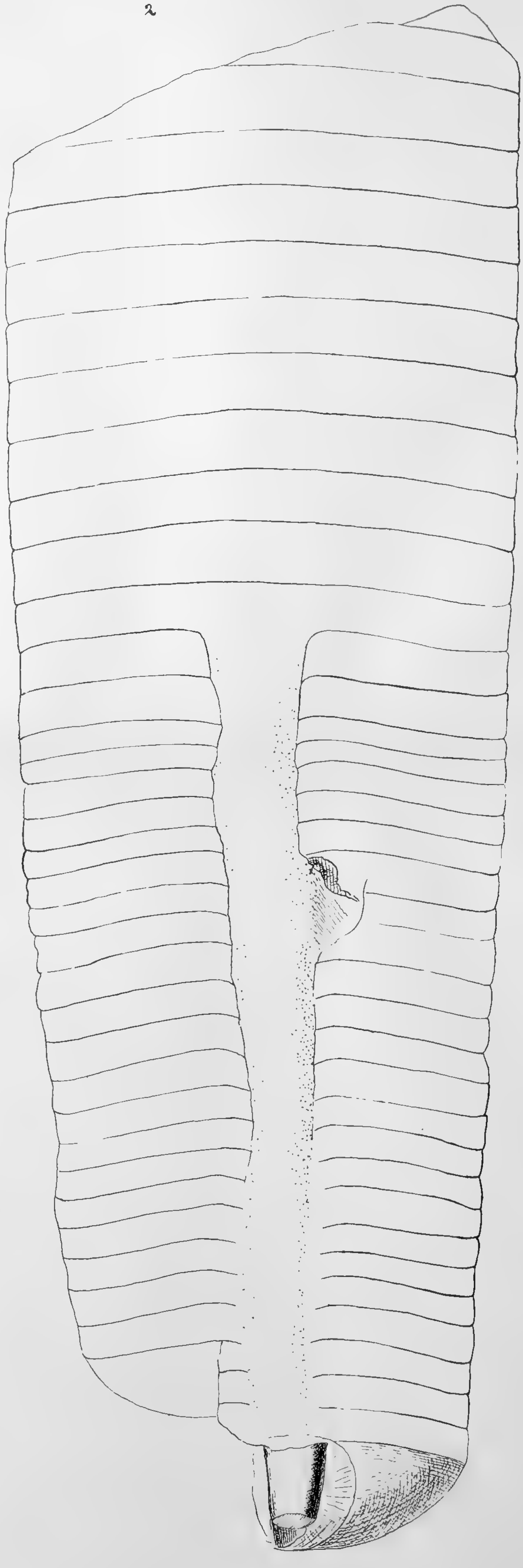

## PLATE L.

| | | | Page. |
|---|---|---|---|
| Figs. 1 and 2 | CAMEROCERAS PROTEIFORME Hall.... | ........................................ | 777 |

(See also plates LVIII, LIX, LXI, LXII.)

1 Cross-section of the continuous apical sheath (E) in the filling (e) of which are three small orthoceran shells (x). Trenton limestone, Cannon Falls, Minn.

2 Fragment of a large internal cast with the filling of the air-chambers embracing the cast of the continuous apical sheath. Cannon Falls, Minn.

| | | | |
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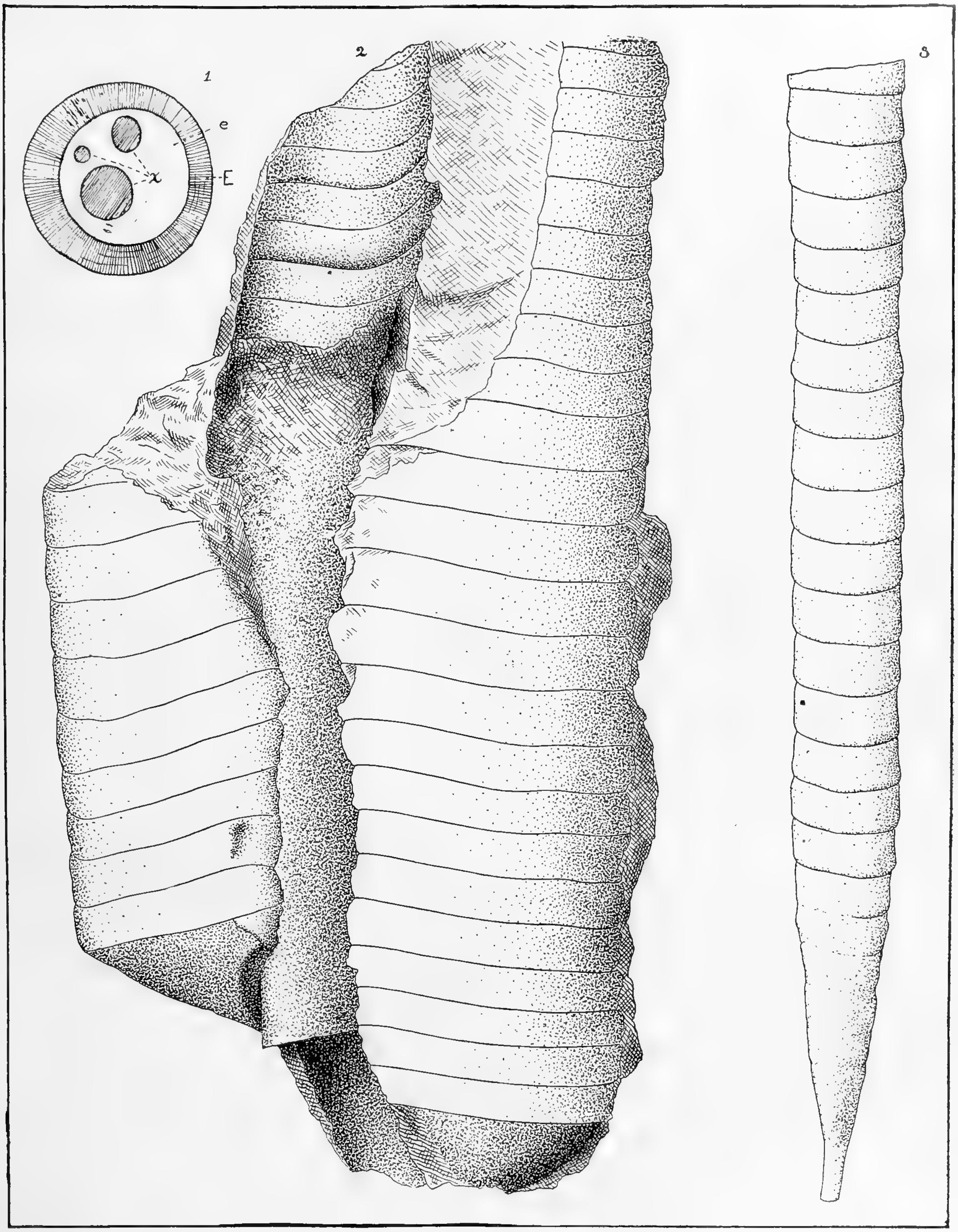
| Fig. 3 | CAMEROCERAS, sp. | ........................................ | 777 |

Cast of a slender *Colpoceras*-like sipho, with broad septal funnels and a narrow acuminate extremity which may indicate the filling of the endosiphon. From the Trenton limestone, probably at Cannon Falls, Minn.

(Cephalopoda.)



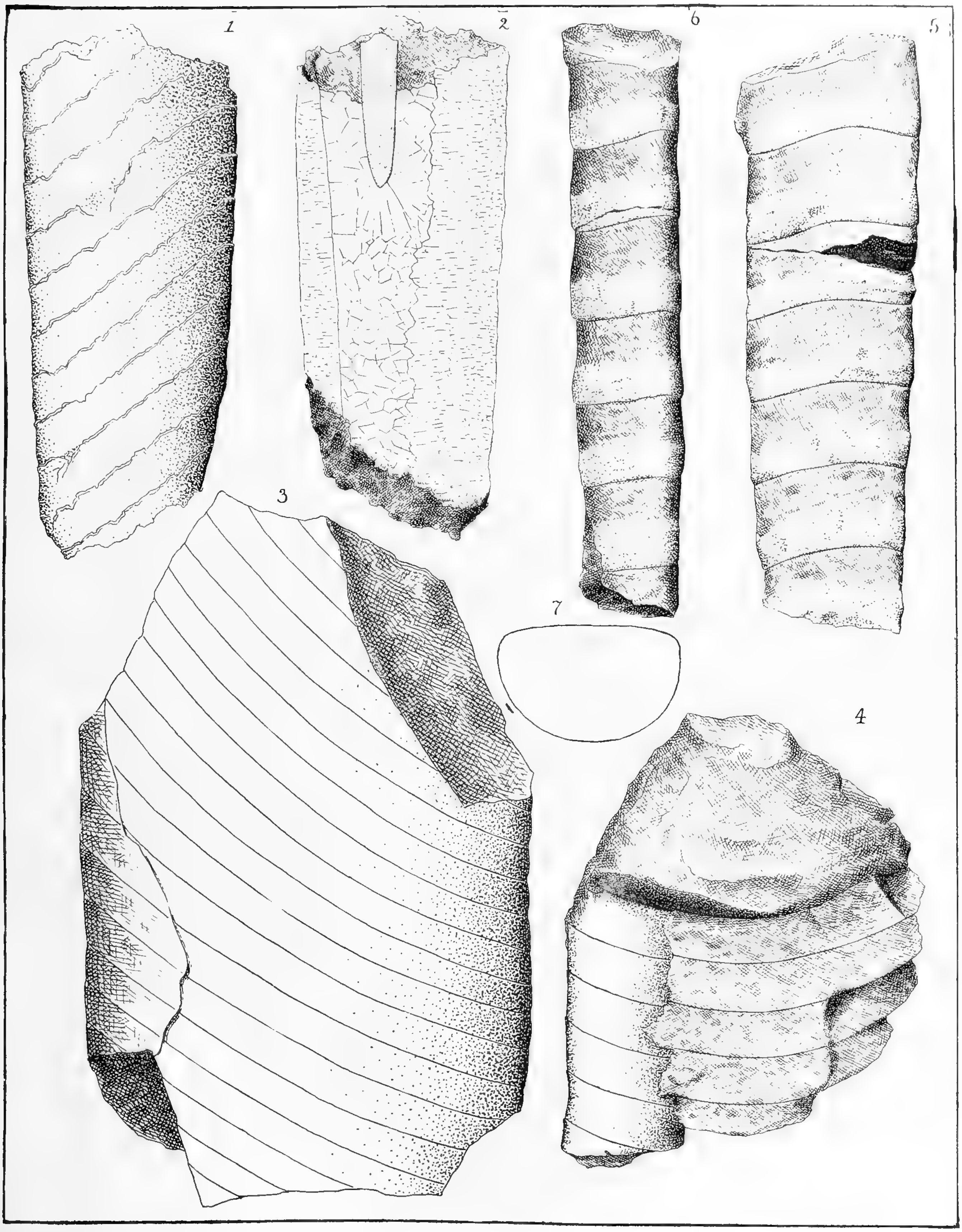


## PLATE LI.

| | | PAGE. |
|---|---|---|
| Figs. 1 to 3 | CAMEROCERAS PROTEIFORME Hall | 777 |
| | (See also plates LVIII, LIX, LX, LXI, LXII.) | |
| 1 | The exterior of a sipho, showing the short septal funnels. | |
| 2 | The same specimen longitudinally sectioned and showing one, and traces of a second siphonal sheath. | |
| 3 | Portion of a larger siphon; showing more distinctly the septal funnels. Trenton limestone, Cannon Falls, Minn. | |
| Fig. 4 | CAMEROCERAS, sp? | 777 |
| 4 | A specimen whose specific relations are uncertain, having a narrow, cylindrical sipho and relatively short septal funnels. Cannon Falls, Minn. | |
| Figs. 5 to 7 | CAMEROCERAS, sp | 780 |
| 5 and 6 | Two views of a subtriangular sipho with broad septal funnels. Its specific relations are not known. | |
| 7 | Outline section of the same. From the Trenton limestone, Zumbrota, Minn. | |

(Cephalopoda.)





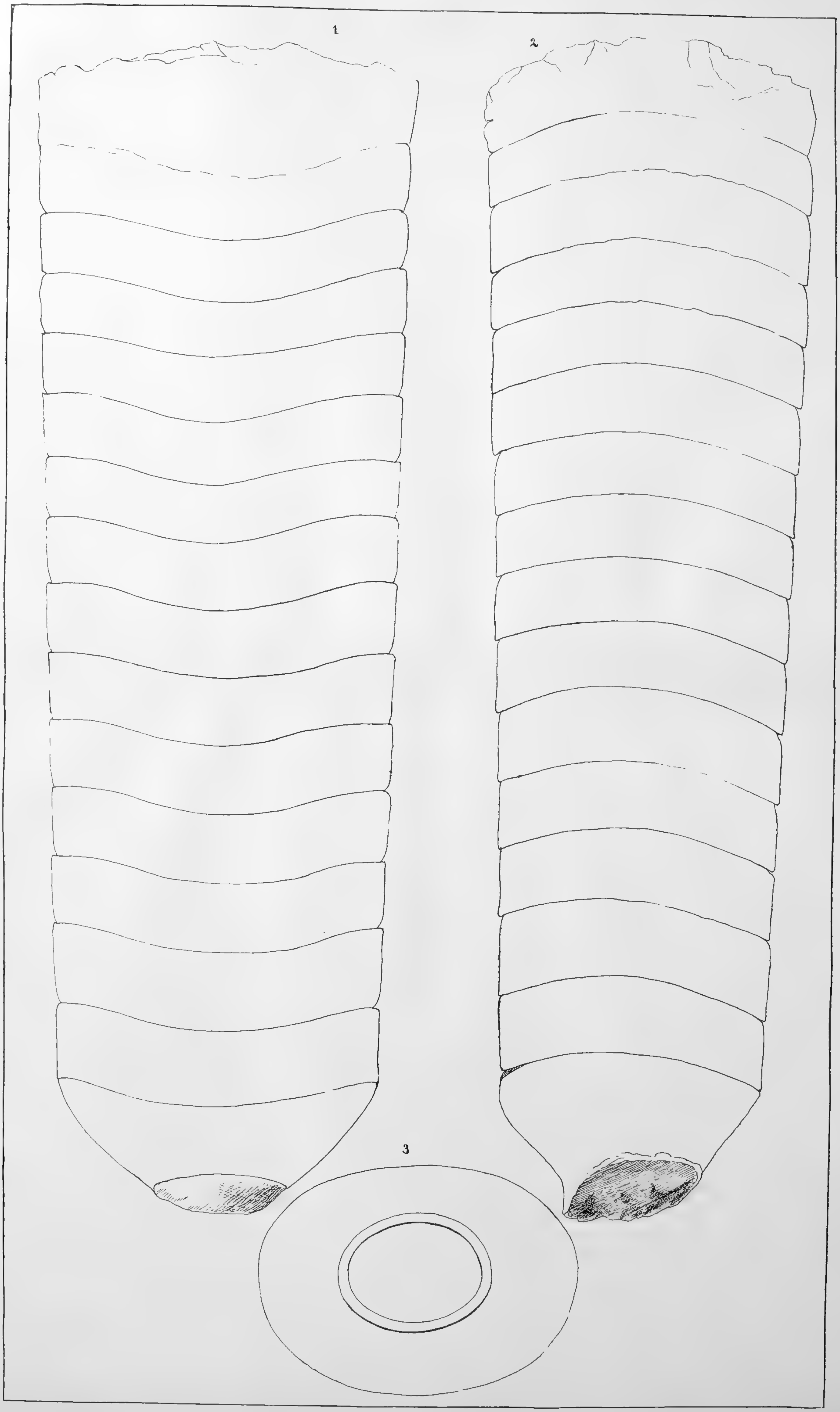
## PLATE LII.

| | | | Page. |
|---|---|---|---|
| Figs. | 1 to 3 | Cameroceras hennepini, sp. nov. | 779 |
| | 1 and 2 | Two views in outline of a very large fragment. | |
| | 3 | The form of the terminal septum, showing the size of the sipho. | |
| | | From the Galena limestone, near Spring Valley, Minn. | |

(Cephalopoda.)



PLATE LII.

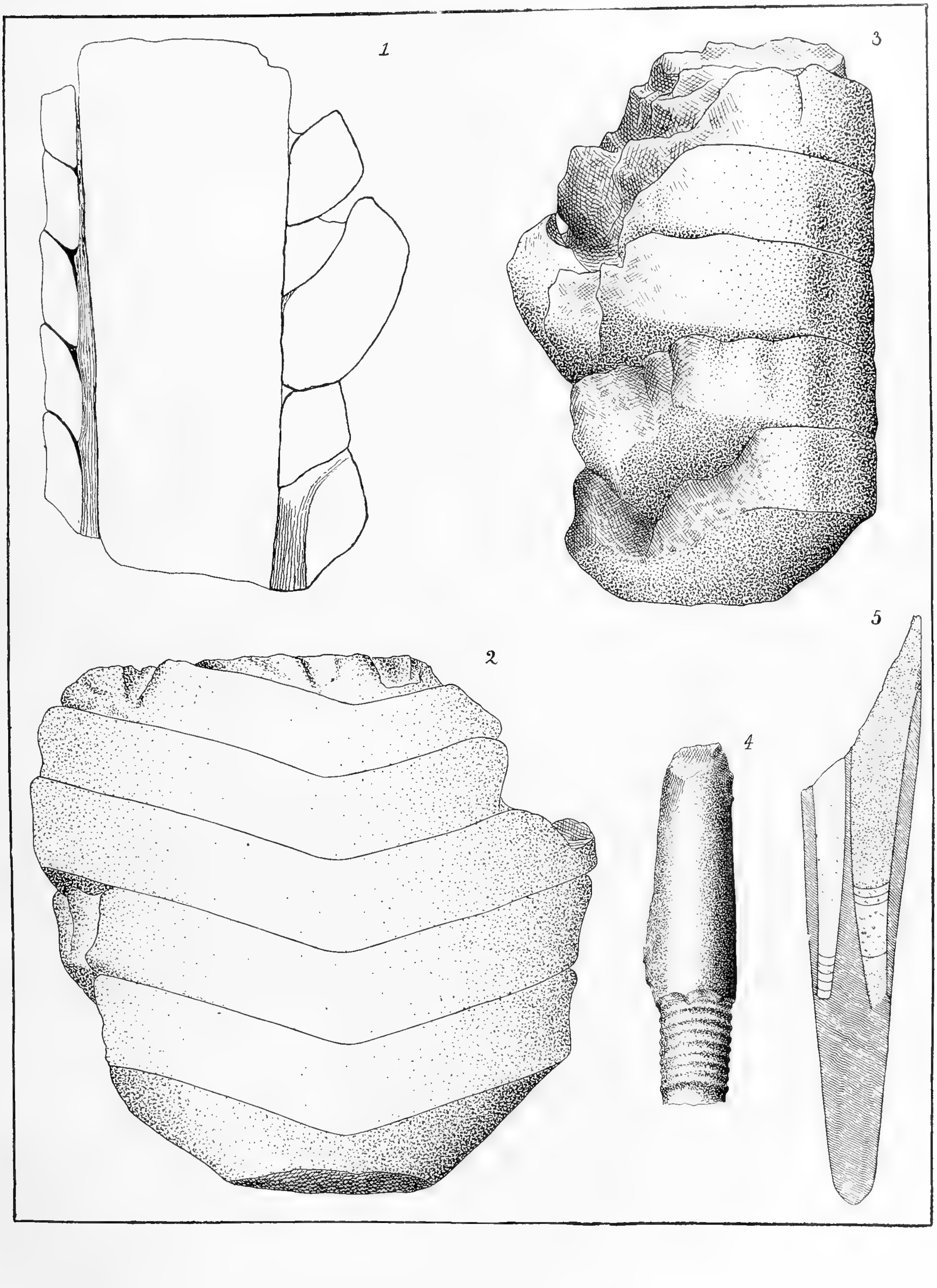


## PLATE LIII.

| | | Page. |
|---|---|---|
| Figs. 1 to 3 | Cameroceras hennepini, sp. nov. (See also plate lii.) | 779 |
| 1 | Longitudinal section of a small fragment through the sipho; showing a portion of the thick continuous wall of the tube and the annulations formed at the junction therewith of the septa. On one side the siphonal wall is but partially retained. | |
| 2 and 3 | Two views of the same specimen. | |
| Fig. 4 | Orthoceras lesueuri, sp. nov. (See also plates xlvii and lv.) A portion of a shell protruding from an internal cast of the siphon of *Cameroceras proteiforme*. From the Trenton limestone at Cannon Falls, Minn. | 779 |
| Fig. 5 | Cameroceras proteiforme Hall (See also plates xlviii, xlix, l, li.) Longitudinal section of a siphonal cast enclosing two individuals of *Orthoceras* or *Clinoceras*. Trenton limestone, Cannon Falls, Minn. | 777 |

(Cephalopoda)



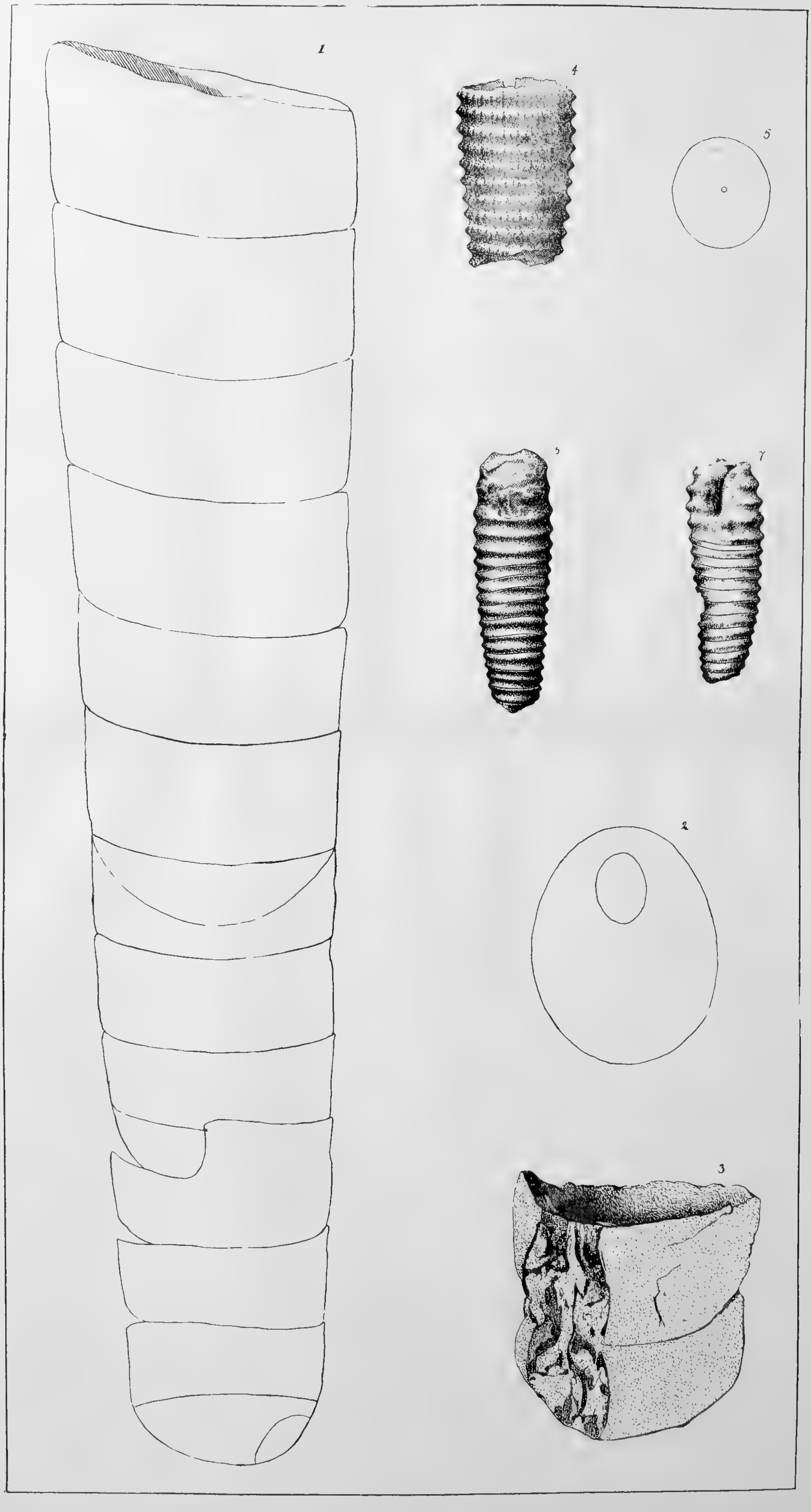


## PLATE LIV.

| | | PAGE. |
|---|---|---|
| Figs. 1 to 3 | ACTINOCERAS REMOTISEPTUM Hall | 782 |
| 1 | Outline of a large example. | |
| 2 | The form of the transverse section. | |
| 3 | The first two air-chambers, longitudinally sectioned; showing the bulbs of the sipho, their thickened walls and endosiphon with its ramifying branches. ×1 1-6. From the Trenton limestone at Cannon Falls, Minn. | |
| Figs. 4 and 5 | ORTHOCERAS PERROTI, sp. nov | 785 |
| 4 | A view of a silicified shell, showing the closely annulated exterior and the strong alternating vertical striæ. | |
| 5 | Transverse section at the terminal septum. | |
| Figs. 6 and 7 | ORTHOCERAS BILINEATUM Hall (See also plate XLVII.) | 786 |
| 6 | View of an internal cast showing the relations of annulations and septa. | |
| 7 | Another specimen illustrating the same features. From the Trenton shales at Minneapolis. | |

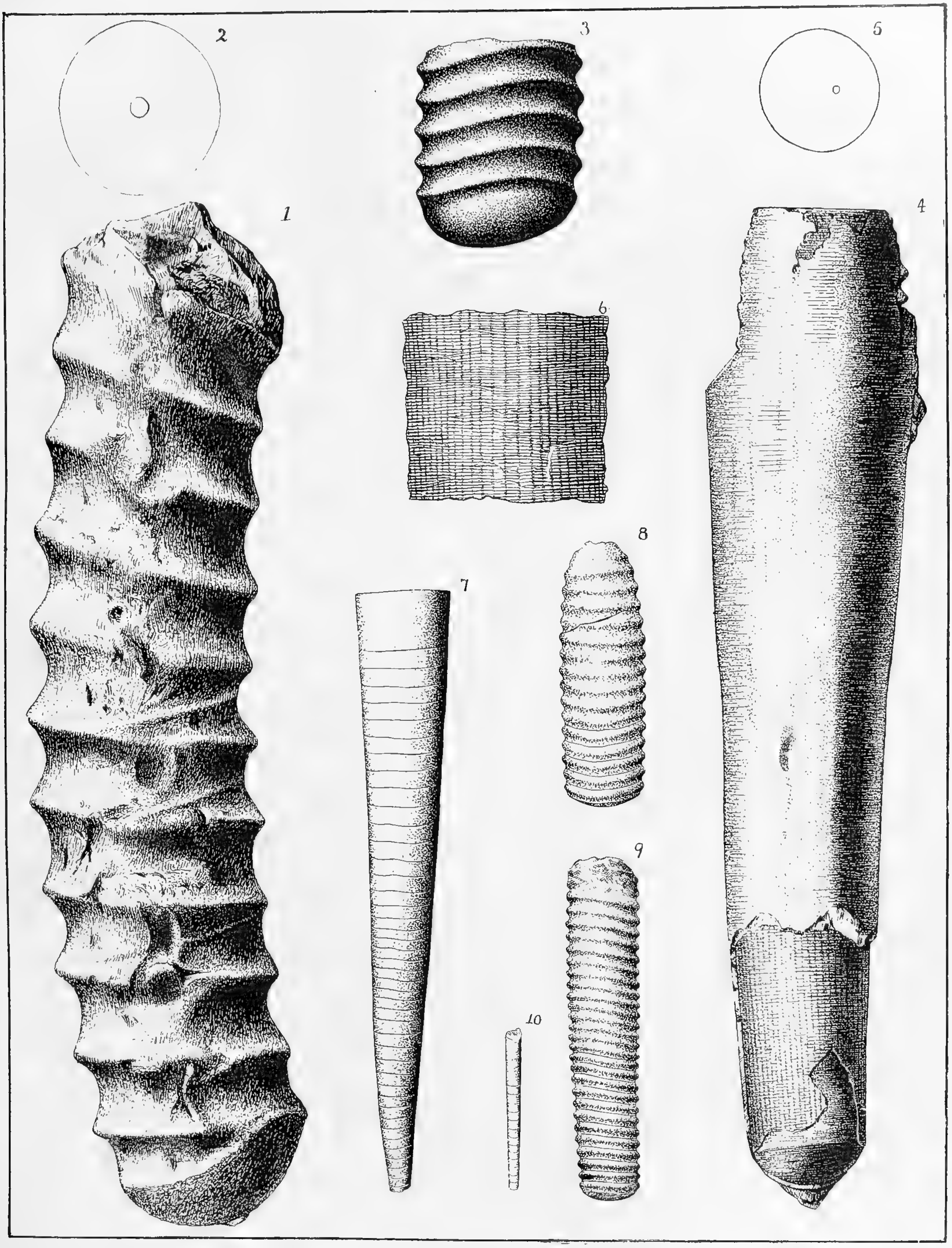
(Cephalopoda.)





## PLATE LV.

| | | PAGE. |
|---|---|---|
| Figs. 1 and 2 | ORTHOCERAS NICOLLETI, sp. nov. | 784 |
| 1 | View of the portion of the conch of the original specimen; showing the strong, distant annulations and the obliquity of the septa. × 1 1-6. | |
| 2 | Outline of a septum; showing the position of the sipho. From the Trenton limestone at Belle Creek, Minn. | |
| Figs. 3 and 5 | ORTHOCERAS OLORUS Hall | 788 |
| 3 | A portion of an internal cast referred to this species. | |
| 5 | Outline of septum, showing position of sipho. From the Trenton limestone, Minneapolis, Minn. | |
| Figs. 4 and 6 | ORTHOCERAS TENUISTRIATUM Hall | 788 |
| 4 | A portion of a conch protruding from an internal cast of a *Cameroceras*-sipho, and retaining the surface ornament. × 1 1-6. | |
| 6 | An enlargement of the surface; showing the fine concentric lines crossed by longitudinal bands which appear to be traces of color-streaks. Cannon Falls, Minn. | |
| Fig. 7 | ORTHOCERAS SOCIALE Hall | 789 |
| | An internal cast apparently entire at the aperture; showing the form of the shell, length of the body-chamber and the distances between the septa. From the Maquoketa or Hudson River shales at Graf, Iowa. | |
| Figs. 8 and 9 | ORTHOCERAS LESUEURI, sp. nov. (See also plate LIII.) | 785 |
| 8 | An internal cast with very regular annulations. Trenton limestone, Dixon, Ill. | |
| 9 | An internal cast having the annulations slightly undulating and the septa lying regularly in the intervening furrows. Trenton limestone, Cannon Falls, Minn. | |
| Fig. 10 | ORTHOCERAS BELTRAMI, sp. nov. | 789 |
| | The original specimen, natural size; showing the body-chamber and thirteen septa. Galena limestone, Wykoff, Minn. | |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## PLATE LVI.

| | | Page. |
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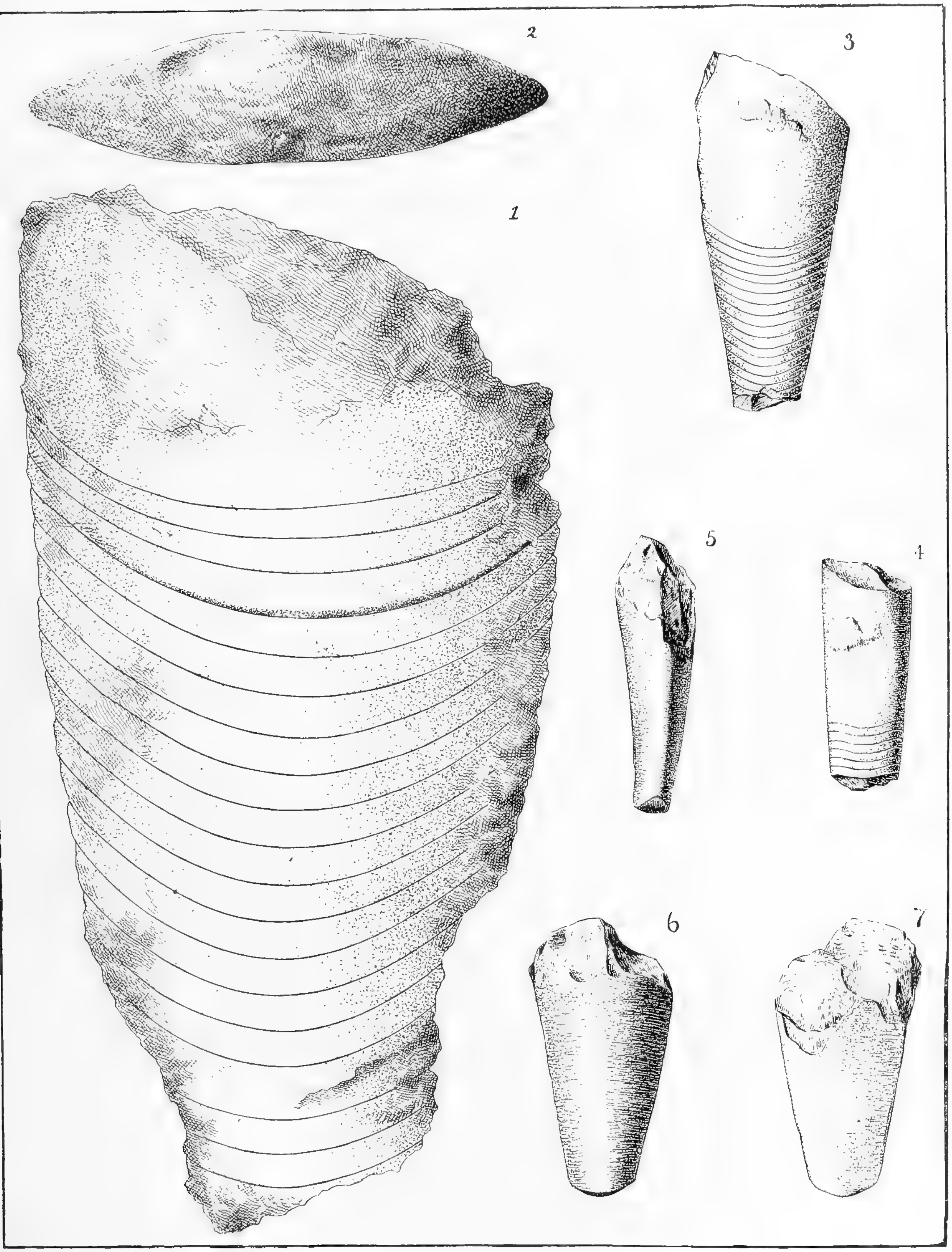
| Figs. 1 and 2 | Triptoceras lambi Whiteaves........................................ | ~~937~~ 753 |
| 1 | View of a large specimen. | |
| 2 | One of the septa; showing the form of the shell in cross-section and the position of the sipho. From the Galena limestone, Stewartville, Minn. | |
| Fig. 3 | Triptoceras planoconvexum Hall........................................ (See also plate lvii.) | 791 |
| | View of an internal cast. Trenton limestone, Cannon Falls, Minn. | |
| Fig. 4 | Triptoceras planodorsatum Whitfield........................................ (See also plate lvii.) | 792 |
| | View of the flatter side of an internal cast; showing the curvature of the septa. Trenton limestone, Minneapolis. | |
| Figs. 5 to 7 | Triptoceras oweni, sp. nov........................................ | 792 |
| | Three views of the typical specimen, showing the contour of its surfaces. Trenton limestone, Cannon Falls. | |

(Cephalopoda.)





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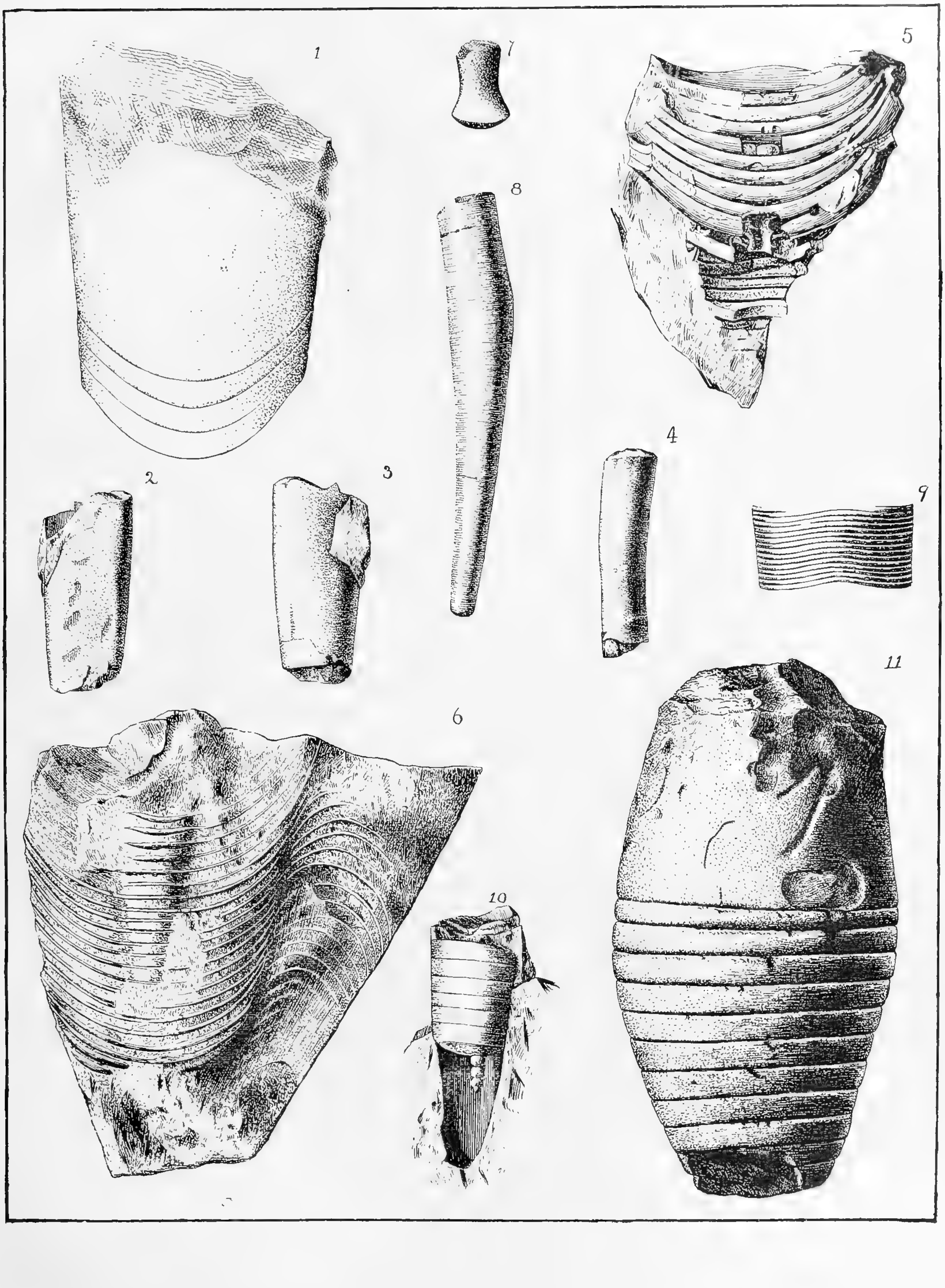
## PLATE LVII.

| | | | PAGE. |
|---|---|---|---|
| Fig. | 1 | TRIPTOCERAS PLANOCONVEXUM Hall.. (See also plate LVI.) A partial internal cast of a large shell. Galena limestone, Hader, Minn. | 791 |
| Figs. | 2 to 4 | TRIPTOCERAS PLANODORSATUM Whitfield (See also plate LVI.) Three views of an internal cast of the body-chamber. Trenton horizon, Minneapolis. | 792 |
| Fig. | 5 | GONIOCERAS ANCEPS Hall. A partial internal cast; showing the form and depth of the air-chambers, the size of the sipho and the filling of the branches of its internal canal. Trenton horizon, Minneapolis. | 794 |
| Fig. | 6 | GONIOCERAS OCCIDENTALE Hall. A weathered specimen, showing the double curvature of the septa, the size of the lateral flange and of the sipho. Trenton limestone, Dixon, Illinois. | 795 |
| Figs. | 7 to 10 | CLINOCERAS MUMIÆFORME Whitfield | 797 |
| | 7 | An internal cast of the body-chamber. | |
| | 8 | A nearly entire individual retaining the shell. | |
| | 9 | An enlargement of its surface. From the Trenton horizon, locality uncertain. | |
| | 10 | An internal cast of a portion of the conch; showing the depth of the air-chambers, the position and form of the sipho. × 1 1-6. | |
| Fig. | 11 | POTERIOCERAS APERTUM Whiteaves. A view of the best specimen observed, retaining most of the body-chamber and eleven air-chambers. Galena limestone, St. Paul, Minn. | 796 |

(Cephalopoda.)

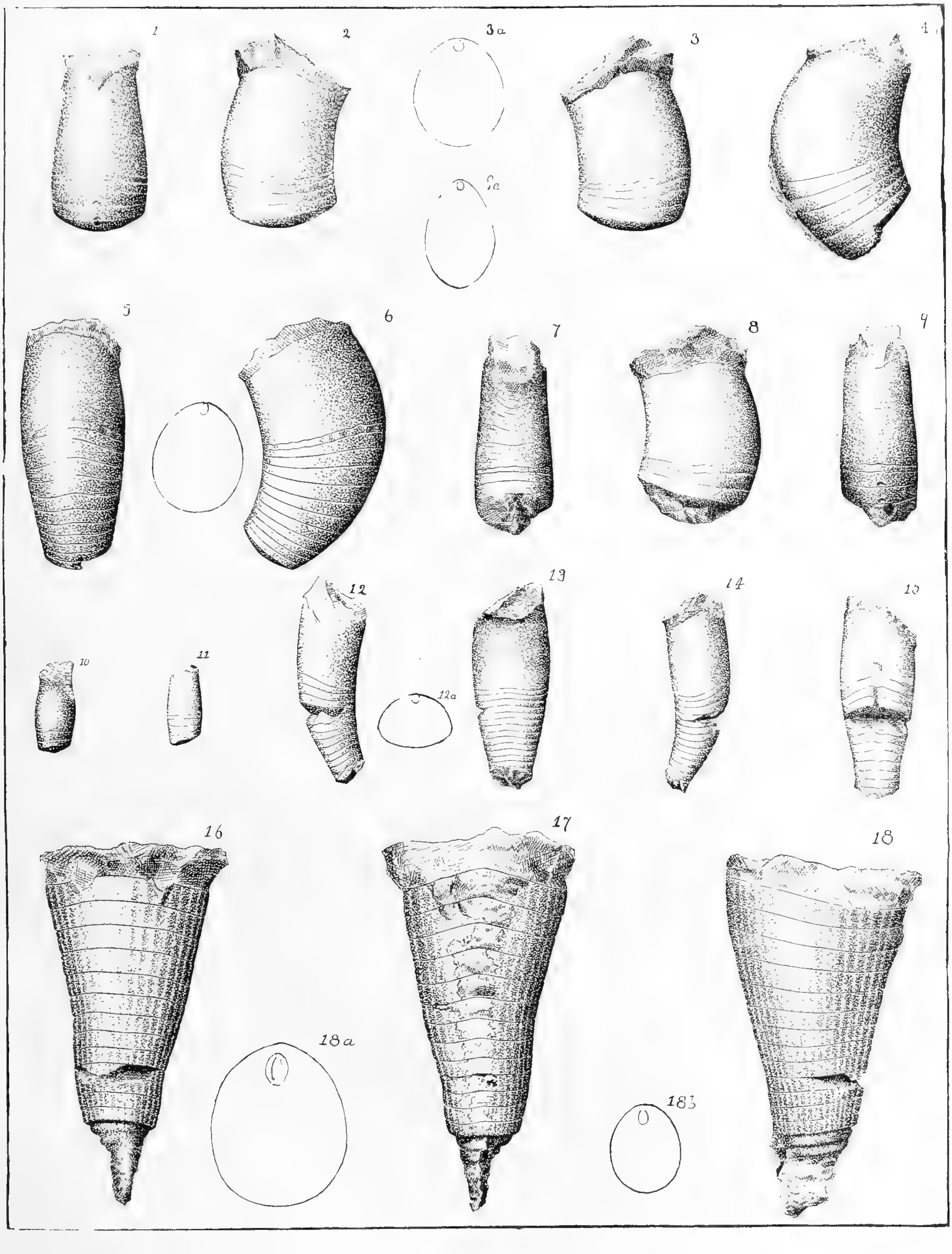




# PLATE LVIII.

{Cephalopoda.}





## PLATE LIX.

| | | Page. |
|---|---|---|
| Figs. 1 to 8 | CYRTOCERAS MINNEAPOLIS, sp. nov. | 808 |
| 1, 2, 3, 4 | Lateral, dorsal and ventral views of a small specimen retaining the shell and preserving the apertural margin. | |
| 5, 6 | Ventral and lateral views of another small example with the aperture entire. | |
| 7, 8 | Lateral and ventral views of a larger specimen which is a partial internal cast; showing faint revolving bands interrupting the concentric striæ, and the position of the sipho. | |
| 7*a* | Outline of a septum. From the Trenton shales at Minneapolis. | |
| Figs. 9 to 11 | CYRTOCERAS SCOFIELDI, sp. nov. | 810 |
| | Dorsal, ventral and lateral views of the typical specimen. From the Trenton horizon at Janesville, Wisconsin. | |
| Figs. 12 to 15 | CYRTOCERAS HOUGHTONI, sp. nov. | 807 |
| 12 | Lateral view of an internal cast of large size. | |
| 13, 14, 15 | Lateral and ventral views of an average specimen. | |
| 14*a* | Outline of a septum, showing the position of the sipho and the great lateral compression of the conch. From the Trenton limestone, Cannon Falls, Minn. | |
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(Cephalopoda)

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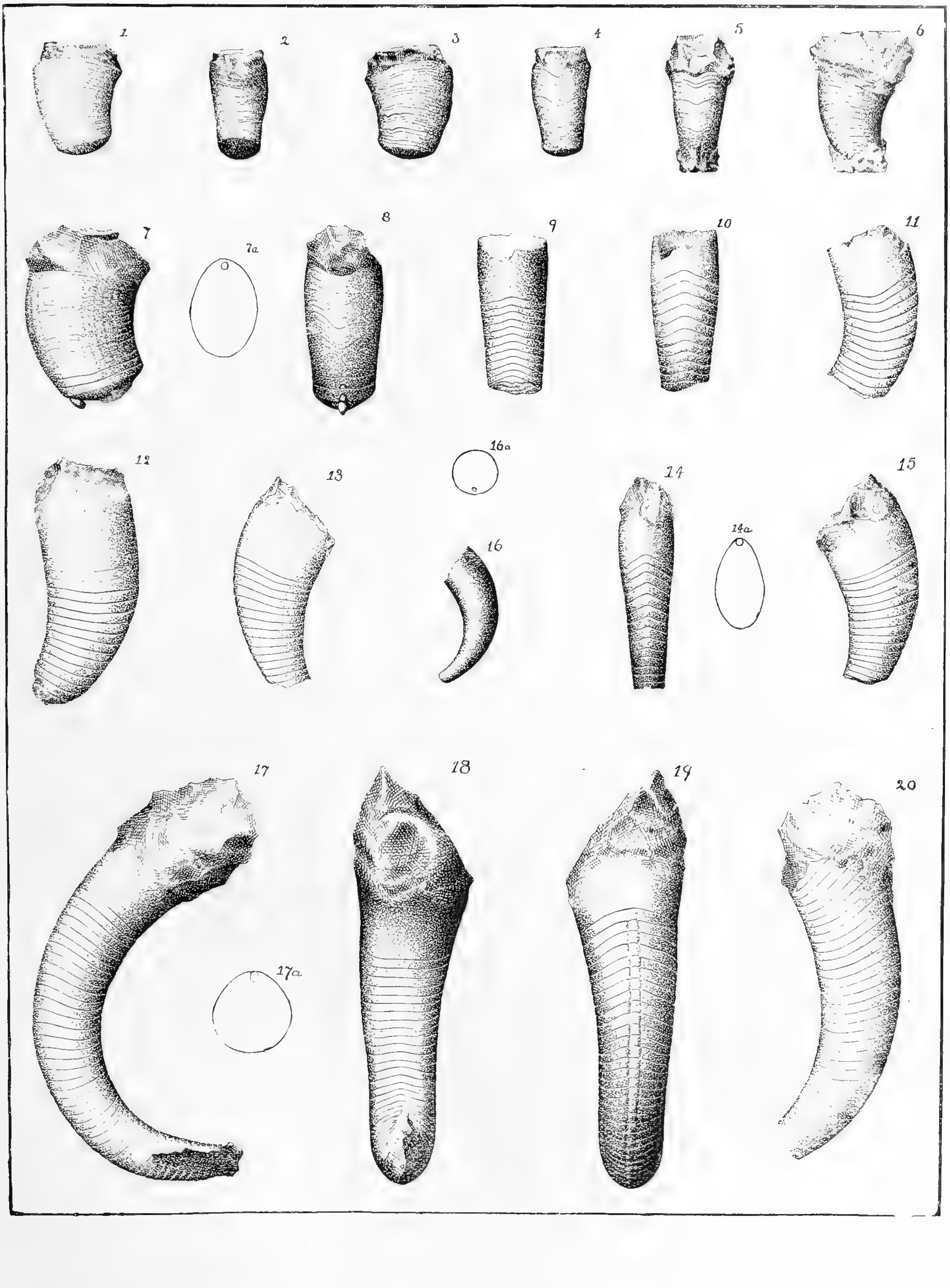

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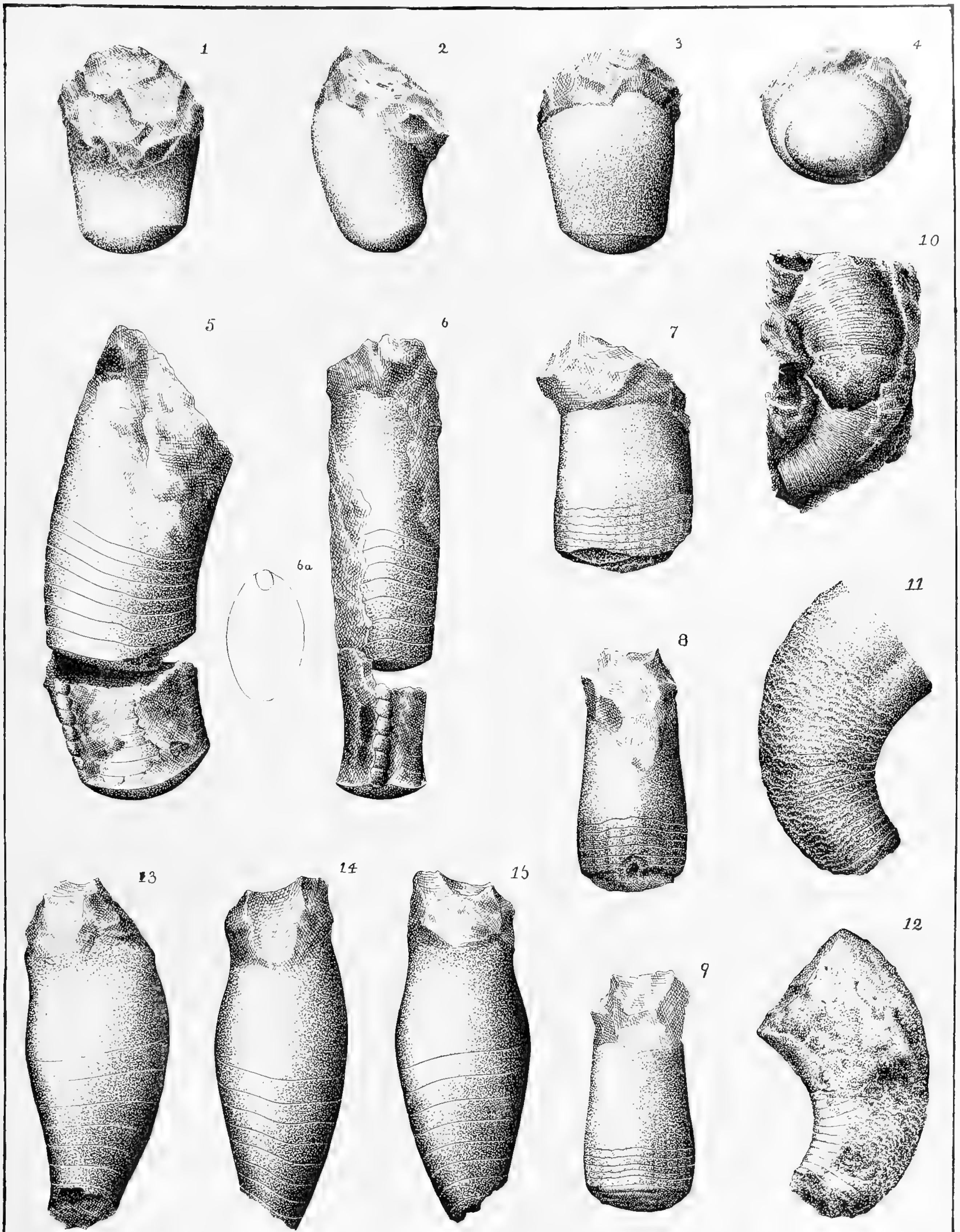
(Cephalopoda)





# CHAPTER X.

# THE LOWER SILURIAN GASTROPODA OF MINNESOTA.

BY E. O. ULRICH AND W. H. SCOFIELD.*

## INTRODUCTION.

The *Gastropoda* are *Mollusca* with a more or less distinct head and a well developed tongue which as a rule is armed with a plate or band set with teeth. The body is nearly always more or less unsymmetrical, the mantle never divided into two lobes, and the shell, when one is present, is univalve, except in the chitons in which it consists of numerous pieces. The "foot" is generally well developed, broad and horizontally expanded, being used by the animal in creeping about; or it may be variously modified to adapt it for swimming or burrowing purposes. The eyes and organs of feeling and hearing are contained in the head, while the viscera (organs of alimentation, reproduction, etc.) are found in the posterior portion of the body.

Three principal portions are distinguishable in the body,—head, foot and visceral sac,—the last of these being protected by a fold of the dorsal integument called the "mantle." Typically, the foot is in the form of a flattened muscular disk, developed upon the ventral side of the body, and not divided into distinct parts. In certain types, however, the *Heteropoda* especially, the foot exhibits a division into three portions,—an anterior, a middle and a posterior lobe,—and besides forms either a ventral fin, or a fin-like tail, by means of which the animal swims, the back down wards.

The head is usually very distinct and is generally provided with tentacles and eyes. Within the pharynx is found the singular dental apparatus known as the

*Before my part of the work on the Lower Silurian Gastropoda of Minnesota could be finished, my friend and colaborer, Mr. W. H. Scofield, died. In his death science has lost an earnest and able, though too modest, worker, the Geological and Natural History Survey of Minnesota one of its best friends, and the world a true man. In finishing the work without his assistance, I may here and there have taken a stand that he might not have sanctioned. Some of the material which is described as new, he never saw, and, as it would be unjust to make him bear half the responsibility in these cases, I have thought it right to distinguish such species by placing my own name in parenthesis after the proposed names. Further, I wish it to be understood that whatever credit may attach to the following work Mr. Scofield has every right to share it with me. On the other hand, permit me alone to bear the blame for the errors. E. O. ULRICH.

"odontophore." The principal portion of this is a chitinous band called the "radula" or "lingual ribbon." This is beset with minute, regularly arranged teeth, and, as it is supported on a cartilaginous cushion, which can be given a rotary motion by a special set of muscles, the ribbon is made to act as a file or saw. The arrangement of the teeth in the radula, taking the whole class into consideration, is subject to considerable variation; yet, within narrower limits, their form and disposition are so constant that they afford one of the most reliable aids to classification. As a rule they are disposed in a medium series, flanked by two or more lateral rows.

Two principal modes of respiration pertain to the *Gastropoda*, the first by means of gills variously constructed and adapted to breathe air dissolved in water, and the second by means of a pulmonary chamber which is adapted for aerial respiration.

The alimentary canal, nervous and vascular systems, and some of the senses (seeing, feeling and hearing) are well developed. The sexes may be separate or united in one individual. Generally the young are developed in eggs laid in horny capsules or in the form of a string or band. With very few exceptions the young when first hatched are provided with a shell, which in some cases may subsequently entirely disappear through resorption. Very commonly the embryonic shell forms a nucleus at the apex of the fully-grown shell which is often very different from the following portions.

Most of the *Gastropoda* are water animals and a large proportion of them are inhabitants of the sea. Only the *Pulmonata* and certain groups of the *Prosobranchiata* are terrestrial in habit or live in fresh waters. The pteropods and heteropods of the present day are oceanic in habit and are found swimming in the open sea, near the surface and far from land; but the majority of the marine prosobranchs and the opisthobranchs live in shallow seas, many of them between tide-marks. In depths exceeding five hundred fathoms the number of *Gastropoda* is greatly reduced; still a few forms are found to inhabit depths of two or three thousand fathoms, or even more.

The *shell*, with which, for manifest reasons, the paleontologist is chiefly concerned, is a secretion of the mantle. It is wanting in the adult stages of the nudibranchs, while in other cases, notably the slugs, it is very minute and hidden in the mantle. In its chemical composition carbonate of lime, either in the form of calcite or aragonite, constitutes 95 per cent. or more of the whole. The inner layer is often nacreous (*Pleurotomariidæ*), but as a rule the whole shell, aside from the horny epidermis, consists of an apparently homogeneous porcellaneous mass, which when carefully examined is seen to be made up of three layers composed of parallel lamellæ, those in the outer and inner layers having the same direction, i. e. perpendicular to the surface and mostly at right angles to the external lines of growth. The lamellæ of the inner layer, which is commonly the strongest of the three, are also perpendicular but their direction is opposite. Tertiary *Gastropoda* often retain the microscopic structure of the shell in a very satisfactory manner, but as a rule the minute details are obscure, when not entirely obliterated, in fossil species.

The *form* of the shell varies greatly, yet within the limits of genera and species it is remarkably constant. Three types are distinguished,—the *tabular*, of straight or only slightly curved form and occurring only among the *Scaphopoda* and *Pteropoda;* the *symmetrical*, in which the shell is either conical or patelliform (*Archinacella*) or involute (*Bellerophon*); and the *spiral*.

The last is by far the most common type, and may in fact be looked upon as the typical form of the shell in the *Gastropoda*. In it the shell is essentially a spirally wound, elongated, conical tube, the coils or "whorls" being in most cases in contact and tightly cemented or amalgamated where they join. Sometimes the whorls are coiled nearly in the same plane, when the shell is said to be "discoidal," as in many of the *Euomphalidæ*. More generally, however, the whorls are wound about the axis in an oblique manner, a true spiral being formed, the shell becoming "turreted," "trochoid," "turbinated," etc. Occasionally the last whorl rises above the first or apical portion of the spire (*Ophileta, Maclurea*), but usually the embryonic shell or "nucleus" is at the top of a cone formed by the gradually enlarging and descending whorls, the mouth or "aperture" occurring at the extremity of the last and largest whorl, termed the "body-whorl." The whorls above the last constitute the "spire" of the shell. The line or groove marking the junction of the whorls is called the "suture." A shell is said to be "imperforate" when the axis or "columella" is solid (*Fusispira*), or it is "perforated" when the axis is hollow (*Trochonema*), the axial cavity itself being known as the "umbilicus." The "peristome" refers to the margin of the aperture; it is composed of an outer and an inner (or columellar) lip, of which the former is often expanded (*Bucanospira, Salpingostoma*) or fringed with spines. The peristome may be continuous or "entire" or it may be interrupted or "incomplete," in the latter case the left side of the aperture being formed only by the body-whorl. Not infrequently the aperture is drawn out and notched below, or there may be two notches, the second being above near the suture. These serve to protect the respiratory siphons. The posterior (upper) notch is probably represented by the median slit and perforation in *Scissurella* and *Fissurella*, and the same perhaps is true of the slit or notch in the outer lips of *Bellerophon* and *Pleurotomaria*.

In most spiral shells the whorls normally are wound to the right, the aperture when in view being on the right hand. In others, as for instance the recent *Physa* and the Lower Silurian *Clisiospira*, the volutions proceed in the opposite direction with such constancy as to be eminently characteristic. The apical part of the shell, which is directed backwards in all except some of the *Patellidæ*, presents important characters, as it contains the nucleus, or part formed in the egg, and the primative whorls, which are often very different from the succeeding turns. Careful investigation of the apex is likely to throw very reliable light upon the evolution of the fossil types.

In a large proportion of the *Gastropoda* the posterior portion of the foot secretes a calcareous, horny, or fibrous plate called the "operculum," which serves to close the aperture. Its inner surface is marked by a muscular scar whose lines bear no relation to its external lines of growth, nor is its form like the muscular scar in the shell. It begins its development in the embryo, the point from which it commences its growth being called the nucleus. Further growth may take place around the nucleus in a concentric or spiral manner, or the nucleus will be marginal the additions occurring on one side only. The spiral forms may make only one or two turns, or there may be as many as twenty. Opercula that were fit for preservation as fossils seem to be comparatively rare in Paleozoic rocks. When they are found it is nearly always as separate pieces so that it is in most cases very difficult to decide to which of the associated shells they really belong. Still, some of the early Paleozoic forms are interesting, being of unusual types, that of *Maclurea* especially being remarkable for the strong internal process to which the muscle was attached.

Regarding the markings of the external surface of the shell, the "lines of growth," which are more or less fine lines or stronger plications running parallel with the edge of the apertural lips, are nearly always distinguishable. Their importance to the paleontologist, who only too often must be satisfied with imperfect specimens, is obvious. Sculpture and color markings are *longitudinal* or *vertical* when they take the direction of the axis, and *revolving* when they follow the spiral. Of the more common varieties of sculpture we may mention the *striate*, in which the surface is covered with fine lines either longitudinal or revolving; the *carinate*, when the revolving sculpture is prominent and sharp; the *plicate* referring to a vertically ribbed sculpture; the *cancellate*, in which fine and straight vertical and revolving lines cross each other nearly at right angles; the *reticulate*, in which the decussating lines are not straight; the *punctate*, *granulose*, *nodose* and *spinous*, referring to conditions sufficiently expressed by the terms applied to them.

Finally, as regards the application of measurements, the distance between the apex and basal extremity of a gastropod shell is termed the *hight*, while the *width* or *diameter* of a spiral shell is the distance through the body-whorl at its periphery. *Length* should be applied only to patelliform shells, in which it refers to the distance from the anterior to the posterior margin. A whorl represents a single complete revolution of the spiral cone; its *periphery* is an imaginary spiral upon the outer wall corresponding with the line of greatest width. In counting the number of whorls we begin with the apertural margin from which to a point on the suture next above it constitutes one whorl. Repeating this process to the apex gives the total number. The *apical angle*, which is the angle formed by the diverging sides of the conical spire, is determined by means of a goniometer.

## CLASSIFICATION.

It is very difficult to decide which of the numerous systems of classification that have been proposed is the most convenient and at the same time the most natural. The old school of naturalists paid little attention to anything save the shell. Another and later school bases a classification almost solely upon the modification of the lingual dental apparatus. As neither method has proved entirely satisfactory, the most recent authorities are seeking to frame a system that will combine the best features of previous classifications. But it cannot be denied that the system that will do full justice to the evolution of the class is still a thing of the future. Ontogeny and chronogenesis will have much to do with it, from which it is obvious that a large proportion of the work must fall to the paleontologist.

The classification adopted by Zittel in his "Handbuch der Palæontologie," embraces all the *Mollusca* which are provided with a tongue in one class, the *Glossophora*. These are divided into four subclasses, the *Scaphopoda*, *Placophora*, *Gastropoda*, and *Pteropoda*. Nicholson retains the first two of these subclasses as distinct classes, and unites the last with the third. The *Gastropoda* he divides into two primary groups or subclasses, the *Branchiogastropoda* and the *Pulmogastropoda*. The *Branchiogastropoda* again he divides into four orders, the *Prosobranchiata*, *Opisthobranchiata*, *Pteropoda* and *Heteropoda*. Tryon, in his great work on "Structural and Systematic Conchology," arranges the same organisms as follows: class *Pteropoda;* class *Gastropoda*, subclasses *Prosobranchiata*, *Opisthobranchiata* and *Pulmonifera;* class *Scaphopoda*. Fischer's arrangement again is different: class *Pteropoda;* class *Gastropoda;* subclass *Univalvia*, orders *Pulmonata*, *Opisthobranchiata*, *Nucleobranchiata* and *Prosobranchiata;* subclass *Multivalvia*, order *Polyplacophora*.

If we should accept any of the foregoing arrangements it would be Zittel's, but as his scheme is not as well balanced as it might be a few changes are suggested in the following brief characterization of the principal divisions. Perhaps a more acceptable subdivision of the class would result if the various groups were reduced in rank, the subclasses to orders, the orders to suborders, and the suborders to superfamilies. The divisions *a* and *b* would in that case take the rank of subclasses. Though inclined to favor such a proceeding, we refrained from carrying it out because it entailed more responsibility than we cared to assume at the present time.

## Class GASTROPODA, Cuvier.

### *Division a.*

### I. Subclass Scaphopoda, Bronn.

Mollusks having neither eyes nor a distinct head, yet with the lingual armature. Sexes separate. Foot vermiform, lobate. Shell a hollow cylinder, open at both ends. *Dentalium* is the principal representative.

### II. Subclass Polyplacophora, Blainville.

Symmetrical mollusks having a distinct head, but neither eyes nor tentacles. Foot broad. Shell consisting of eight moveable calcareous plates arranged in a row. This division includes the chitons.

### III. Subclass Pteropoda, Cuvier.

Head and organs of sense rudimentary. Foot modified into two lateral wing-like expansions used in swimming. Animal naked or protected by a shell.

Order *Thecosomata*, Blainville; with mantle and external shell.

Order *Gymnosomata*, Blainville; both shell and mantle wanting.

### IV. Subclass Docoglossa. (Provisional.)

Approximately symmetrical gastropods, provided with dish-shaped or conical shells, or with spiral shells coiled in the same plane. A very primitive group of which the *Patellacea* and *Bellerophontacea*, comprised in the provisional order *Proteobranchia*, constitute the bulk, if not the whole.

### V. Subclass Opisthobranchiata, M. Edwards.

Branchiæ more or less free, behind the heart. Animals rather highly developed, naked or with a shell; the sexes united in the same individual.

Order *Nudibranchiata;* without a shell.

Order *Tectibranchiata;* with a shell.

*Division b.*

VI. Subclass PROSOBRANCHIATA, M. Edwards.

Head and organs of sense well developed. Animals breathing by means of gills or branchiæ situated in front of the heart; mostly marine, and provided with a spiral shell, and generally an operculum. Sexes separate. This is the largest and most typical division of the class.

Order *Nucleobranchiata* or *Heteropoda*; foot laterally compressed, with fin-like swimming lobes. Shell sometimes wanting; when present it is more or less symmetrical, involute and very thin.

Order *Pectinibranchiata;* branchiæ pectiniform, better and more constantly developed than in preceding order; shell spiral, not symmetrical.

VII. Subclass PULMONATA, Cuvier.

Animal breathing by means of a pulmonary chamber or lung instead of gills. Sexes united in the same individual.

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A classification of the Paleozoic genera of the *Gastropoda* and remarks on their geological distribution, especially of the Lower Silurian types, followed by a summary of the principal results of our work, will be found at the close of the chapter.

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# Class GASTROPODA.

## Subclass DOCOGLOSSA.

## Order PROTEOBRANCHIA.

### Suborder PATELLACEA.

### Family PATELLIDÆ.

The Paleozoic shells which are usually placed in this family are an exceedingly difficult group. While we may be reasonably confident that the relations of some of them are not far from the recent genus *Patella*, there are many others that remind one quite as much of *Lepeta* and *Acmæa*. These difficulties are of course largely due to the imperfect condition in which the shells are preserved. But, even when the muscular scars are retained, and this is all we can expect to learn of the internal and soft parts of the animals, it is not by any means easy to decide just what affinities they indicate most, because these scars, like the whole form of the shells, are in a general way very similar among the twenty or more recent patelloid genera and subgenera.

When, however, we consider the great diversity of structure of the soft parts that can exist in shells looking so much alike, it surely seems highly improbable that any of the Paleozoic types could have continued on till the present time without being materially modified structurally. And yet it is most difficult to sustain this supposition by a comparison with the fossils. While the latter, so far as known, can in no case be said to be strictly identical with any of the recent genera, the resemblances in several instances are still very striking. Thus, while *Tryblidium* differs from *Nacella* and the other *Patellidæ* chiefly in having the muscular scars separate, the otherwise very similar proposed genus *Archinacella* approaches the recent forms even more closely in having the scars indistinguishably merged into a continuous narrow impression. Little is known of the muscular scars of *Scenella* and *Helcionopsis*, but comparing external characters they agree very well, the first with *Acmæa* or *Lepeta*, and the second with *Helcion*.

While we admit freely that it may not be possible to prove that the Paleozoic *Patellidæ* are in all cases generically distinct from living types of the family, we are nevertheless fully convinced that such is the case. This conviction, as will be shown in the next paragraph, has something to support it besides the mere improbability of their identity. Obviously then we consider ourselves justified in proposing two new names and in retaining those which have already been proposed for those groups which it is convenient to distinguish. We were really forced to these views by the miserable failure of our efforts to distribute the Paleozoic species among the recent genera. After repeated endeavors, the results being different every time, we gave it up as being, to say the least, impracticable.

The distinctive evidence referred to in the preceding paragraph is shown in three specimens before us. It consists namely of a pair of rostral muscular imprints which seem not to belong to the usual ring of scars and which we do not find

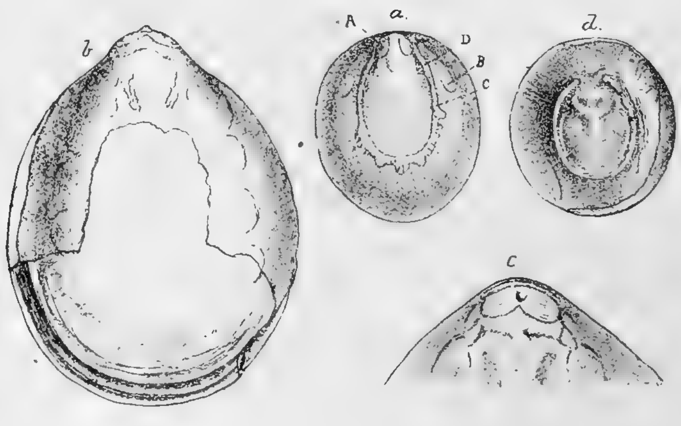


Fig. 1.—*a*, dorsal view of a cast of the interior of *Archinacella powersi* U. & S., showing the rostral scars at A; *b*, dorsal view of a partial cast of the interior of *Tryblidium unguis* Lindström; c, apical portion of same in a direct view to show the rostral scars; *d*, dorsal view of a cast of *Lepetopsis*, sp. undet., from Kansas City, Mo., showing muscular imprints very satisfactorily.

represented among recent forms. The first of these specimens (*a* of the accompanying cut) belongs to our new genus *Archinacella;* the second (fig. 1 *b* and *c*) is of the type species of *Tryblidium;* while the third (fig. 1 *d*) appears to belong to an undescribed species of *Lepetopsis.* The first, then, is a Lower Silurian fossil, the second Upper Silurian, and the third Carboniferous.

The recent *Patellidæ* are distributed into generic groups according to the anatomical peculiarities of the animals, the characters of the shell being considered as of minor importance. Obviously such a rule cannot be applied to the fossil representatives of the family, seeing that their shells only are preserved. But that should not prevent the paleontologist from attempting a classification of the numerous species that have been discovered in the rocks. The geologist requires some convenient means of discriminating between the groups of species, and the systematist is in a great measure bound to respect this desire, especially if the convenience of an arrangement does not directly oppose what he conceives to be the natural affinities.

In arranging the Paleozoic species we have made use of the muscular scars whenever these were available. But they are so seldom preserved that their use is necessarily very limited. In a large majority of the species the scars are entirely unknown, and even under the most favorable circumstances they are generally rather indefinitely outlined. We are, therefore, obliged to rely largely upon striking external features, of which the form and outline, the position of the apex and the character of the surface markings seem to be the most available. The groups may be characterized briefly as follows:

TRYBLIDIUM, Lindström. Shell patelliform, obovate, narrowest anteriorly, forming a very low cone; apex anterior, nearly marginal. Mucular scars in seven or eight disconnected pairs, arranged in an oblong circle, the anterior pair drawn out and meeting in front beneath the beak. Surface usually marked by concentric lines of growth only; occasionally also by obscure broad radial plications. Type, *T. unguis* Lindström.

ARCHINACELLA, n. gen. Shell patelliform, ovate to subcircular, usually widest anteriorly, forming a low cone with the apex in front of the center and often submarginal. Muscular scars forming a continuous band. Surface markings concentric only. Type, *A. powersi*, n. sp.

HELCIONOPSIS, n. gen. General form and position of apex as in *Tryblidium*, from which the species differ in having the surface marked by fine radiating striæ. Muscular scars unknown. Type, *H. fissicostata*, n. sp.

PALÆACMÆA, Hall and Whitfield. Shell forming a low cone, the base rounded or elliptical, the apex subcentral. Surface thrown into broad, rather regular, concentric folds, without radial lines. Muscular scars unknown. Type, *P. typica* H. & W.

Scenella, Billings. Shell conical, rather high, apex subcentral, surface with distinct radial lines or ribs crossed by fine lines of growth. Muscular scars large, situated above the mid-hight, forming a complete circle in which the impression of each muscle may or may not be distinguishable. Type, *S. reticulata* Billings.

Lepetopsis, Whitfield.* Shell patelliform, broadly oval, conical, low, with the apex subcentral. Muscular impression horseshoe-shaped, open in front, consisting of an irregular band. Surface with concentric lines of growth, occasionally perhaps also with a few radial lines. Type, *L. levettii* White, St. Louis group.

Stenotheca, (Salter) Hicks. Shell small, high, the whole curved so that the apex generally projects beyond the basal margin. Surface usually with strong transverse (concentric) folds and fine radiating lines. Type, *S. cornucopia* Salter.

Besides the above groups the Paleozoic strata doubtless contain others equally distinct that for want of material cannot now be characterized satisfactorily. The two Wisconsin Calciferous species which Whitfield describes in "Geology of Wisconsin" (vol. iv), under the names *Metoptoma recurva* and *retrorsa*, are, as has already been suggested by Lindström and Koken, certainly not *Metoptoma*. Nor can we consider them as being much nearer either *Tryblidium* or *Archinacella*. The peculiar retral bending of their apices is so unusual that it may well be considered as indicating a new generic type.

Another peculiar type is shown in *Metoptoma alceste* and *M. orithyia*, both described by Billings in "Palæozoic Fossils" (vol. i), the first from the Hudson River group of Anticosti and the other from the Calciferous of Canada East. These are relatively high conical shells, with a narrow vertical fold or blunt carina on one side running from the apex to the margin. The general form and the fold remind one of *Hercynella*, Kayser, founded upon Upper Silurian shells of Europe, and it is possible that they should be referred to that genus. Koken, however, refers *Hercynella* to the *Calyptræidæ* near *Capulus* and *Platyostoma*, a position we can scarcely believe proper for the two species in question.

*Metoptoma angusta* Billings, from the Quebec group, is another species of doubtful affinities. It is a large shell, with the apex "a little in advance of the middle, and apparently a little curved backwards," and "the anterior side flattened." The last feature suggests *Metoptoma*, but we doubt very much that it really belongs to that genus. *M. anomala*, of the same author and formation, cannot be a *Metoptoma*, but

* Bull. Amer. Mus. Nat. Hist., vol. i, no. 3, p. 67; 1882. All the known American Carboniferous patelloid shells seem to belong to this genus. In Europe the genus is represented by *Metoptoma*, Phillips, from which it differs in its rounded outline and in wanting the truncation and flattening of the posterior side which characterizes the species of Phillips' genus. Although *Metoptoma* has been used very frequently by American authors, it is quite clear that none of the species described by them really possess the essential features of that genus.

we are completely in the dark as to its probable affinities. The other species referred to this genus by Billings fall more or less naturally into one or the other of the generic groups above outlined and will be referred to in discussing the genera further on.

We ought perhaps to have included the illy characterized genus *Conchopeltis*, Walcott, among the Paleozoic *Patellidæ*, especially since the types of the second species described by the author of the genus came from the Lower Silurian of Minnesota. As neither is illustrated, we must rely upon Walcott's description of the genus. That gives us to understand that it is founded on conical patelliform univalves having the apex subcentral and the surface radially striated. So far as it goes it agrees with *Scenella* and that indeed is the position we assign to *C. minnesotensis* Walcott.

After considerable trouble Prof. N. H. Winchell succeeded in having drawings prepared of *C. alternata*, the first species described by Walcott, and the one therefore to be regarded as the type of the genus. As may be seen from the accompanying figures, the slopes in this species are divided into four, slightly convex, lobe-like

Fig. 2.—*Conchopeltis alternata* Walcott, Trenton limestone, Trenton Falls, N. Y. Two views prepared from the original types of the species (now preserved in the Cambridge Museum) showing the four lobe-like divisions of the shell, its form and surface workings.

parts by an equal number of narrow depressions radiating from the apex. So far as we are aware, none of the other described patelliform shells exhibit such a lobing of the shell, and we are therefore quite uncertain as to the affinities of the genus We should mention, however, that a similar peculiarity occurs in three new species of an undescribed genus of patelliform shells, two of them from the Cincinnati rocks, the other from the Devonian. In these there is a strong transverse division passing immediately above the beak and separating a lobe corresponding to the upper one in our figure of *Conchopeltis*, but the rest of the shell is not lobed. The outer layer of these shells is minutely and beautifully punctate.

## Genus TRYBLIDIUM, Lindström.

*Tryblidium*, LINDSTRÖM, 1880, Fragmenta Silurica, p. 15; 1884, Silurian Gastropoda of Gotland, p. 52.
*Tryblidium* (part.), WHITEAVES, 1884, Paleozoic Fossils, vol. iii, p. 30. WHITFIELD, 1888, Bull. Amer. Mus. Nat. Hist., vol. i, p. 303.
*Metoptoma* (part.) of BILLINGS and other authors.

For generic diagnosis see page 821.

Our description of this genus does not agree in all respects with that given by Lindström. This is partly because we believe his to be incorrect in several particulars, and partly because we have seen fit to leave out as unimportant one or two features, and to mention the style of surface markings. Of the three species described by Lindström in his last work (*op. cit.*), *T. reticulatum*, *T. unguis* and *T.? radiatum*, we would strike out the first and the last, while to the second we would assign the rank of type of the genus. This proceeding is not strictly in accordance with usage, since when, as in this case, no type is specified, it is customary to regard as such the first species following the generic description. The rule is both a good and a necessary one, yet there are cases, and we believe this is one of them, where it is best not to follow it.

The species *reticulatum* and *unguis*, of which we have through the kindness of Dr. Lindström good examples before us, represents according to our views two generically distinct types, of which the first is limited to one or possibly two species,* while the second is recognized in numerous Lower and Upper Silurian species. Herein lies the reason for the course here pursued with respect to the type of the genus, for, should our view of the generic distinctions of the two species available as types prevail, the greater justice and credit would accrue to the learned author of the genus if his name is adopted for the more abundant group of the two. As to the third species, *T.? radiatum*, we refer it with much confidence to our new genus *Helcionopsis*.

*T. unguis* and all the other species which we leave under *Tryblidium* have a concentrically striated thin shell composed, as far as known, of thin glossy lamellæ which are never porous. *T. reticulatum*, on the contrary, has a thick shell, especially at the edges, the external layer is minutely porous, and the surface strongly marked by salient oblique concentric laminæ, which in the anterior part cross each other, producing an "engine turning" style of network. Lindström is inclined to regard the porous character of the outer layer as produced by some parasitic organism. Such an explanation of the origin of the pores would no doubt be a good one if they occurred only occasionally, but considering the fact that they are always present in the Gotland specimens, and what is more, that they seem to be uniformly distributed over the whole exterior stratum, we may well question its sufficiency. The view

* Lindström mentions a Lower Silurian species from Esthonia which he says is closely related to *T. reticulatum*.

that these pores are really a normal feature of the external layer receives strong support from the fact that a porous outer layer occurs also in other patelliform shells. We have, namely, specimens before us of two shells belonging to an undescribed genus in which the whole external surface is beautifully punctate. One of these specimens is from the top of the Cincinnati group at Richmond, Indiana, the other from the middle Devonian at the falls of the Ohio.

Prof. J. F. Whiteaves, paleontologist to the Geological Survey of Canada, was the first to recognize the application of *Tryblidium* to American fossils. In referring to Canadian patelliform shells (*op. cit.*, p. 31), he subscribes to the suggestion of Mr. Dall (Amer. Journ. Conch., vol. vi, p. 281, 1881) that none of the nineteen species provisionally referred to Phillips' genus *Metoptoma* really belong to that genus as now understood. Continuing he says that in his judgment "*Metoptoma quebecensis* Billings, belongs to the genus *Palæacmæa* of Hall and Whitfield. *M. niobe, M. nycteis, M. eubule, M. erato* and *M. hyrie* Billings, are typical species of *Tryblidium*, Lindström." So far he expresses our views exactly, but when it comes to the new species, which he names *T. canadense*, we, as did also Lindström in his second work on the genus (p. 54), note differences that necessitate its removal from *Tryblidium*. To us it is an undoubted member of our new genus *Archinacella*.

In 1886 Prof. R. P. Whitfield (*op. cit.*) described two species, *ovale* and *ovatum*, which are unquestionably congeneric with *T. unguis* Lindström. In his remarks on the species he points out some differences which exist between his species and the generic description given by Lindström, and suggests that some of the characters mentioned in the latter are only specific and not generic. This is true of the aperture so far as its being straight or arched is concerned, but we cannot agree with him when he places in the genus species like his *T. conicum*, in which the apex is almost central. Such species should in most cases be regarded as belonging to *Scenella* or *Palæacmæa*. Further, he notes a difference in the number of the muscular scars, Lindström stating that the Gotland species have only six pairs, while his species have eight pairs. Again, he found that his species differed from Lindström's generic diagnosis in having the muscular scars "continuous around and below the apex of the shell, in a deep and continuous line, from the elongated clavate scars on the sides of the beak or apex, as they are in *Nacella*," instead of "open or nearly so towards the outer end."

A careful study of *T. unguis*, which we owe to the kindness of Dr. Lindström himself, enables us to show that there is no essential difference between the muscular scars of this Gotland type of the genus and those shown to exist in the Fort Cassin beds species by Whitfield. The fact is that *T. unguis* has eight instead of six pairs of scars, and the narrow ends of the anterior pair, which is smaller than usual, curve around in front to meet beneath the apex. (See fig. 1*c*, p. 820.) Lindström probably overlooked these anterior pairs because he noticed a slightly elevated, transverse, medially disconnected band just in front of the sixth pair. But this band is really the posterior boundary of the scars of an umbonal pair* of muscles which we have shown to exist in a number, if not all, of the Paleozoic *Patellidæ.*

As already stated, we regard *T. conicum* Whitfield, as a *Scenella,* while *Metoptoma simplex* Billings, which Whitfield places under *Tryblidium,* and *T. piliolum* Whitfield probably belong to *Archinacella. T.? acutum* Whitfield, with its flattened area-like slope beneath the projecting apex, seems to us to indicate an undescribed generic type.

### TRYBLIDIUM MODESTUM, *n. sp.*

PLATE LXXXII, FIGS. 1 and 2.

Shell small, somewhat acutely ovate in outline, the apex being pointed, scarcely incurved and projectly slightly beyond the narrowly rounded anterior margin of the aperture; the latter is scarcely, if at all, arched. Surface not well preserved, apparently marked by faint lines of growth. Internal characters unknown. Length 10.3 mm.; width 8.5 mm.; hight of apex about 2 mm.; greatest hight (near center of length) about 2.8 mm.

This species is founded upon a single imperfect shell. As the muscular scars have not been observed the generic reference is perhaps a little doubtful. Still, the form of the shell is such that we are fairly confident that it will prove to be a true *Tryblidium.* Of described species *T. erato* Billings sp., from the Black River limestone of Canada, appears to be the nearest. On comparison with the description of that species (it has not yet been figured) it is evident that *T. modestum* is much smaller, relatively wider posteriorly and not so convex. The fact that the shell is narrower in front than behind will distinguish it at once from all the species of *Archinacella.* Otherwise it looks very much like *A. patelliformis.* It also resembles *Stenotheca unguiformis,* but is wider and the beak is not so prominent in front, while the surface markings are quite different.

*Formation and locality.*—Black River group, Ctenodonta bed, near Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich.

## Genus HELCIONOPSIS, n. gen.

For generic description see page 821.

Of this genus we have at present only three species, the two about to be described and an Upper Silurian one from Gotland, which Lindström placed doubtfully

*These umbonal scars are shown in fig. 37, pl. I, of Lindström's "Gastropoda and Pteropoda of Gotland."

in his genus *Tryblidium* with the specific name *radiatum.* It is very closely related to our *H. striata.* Unfortunately we know very little of the muscular scars of these species, so that it is difficult to decide whether their affinities are nearer *Tryblidium* or *Archinacella.* What is known of them agrees better, as does also the form of the shells, with species of the former genus, while they are distinguished from both by the distinct radial sculpture of their surfaces. The marginal position of the apex separates them from *Scenella,* Billings. *Stenotheca,* Salter, includes laterally compressed and much higher shells.

The generic name is from the external resemblance which the species bear to the recent species of the genus *Helcion,* Montfort.

### HELCIONOPSIS STRIATA, *n. sp.* (*Ulrich.*)

PLATE LXI, FIGS. 29 and 30.

Shell rather strongly convex, acuminate-ovate in outline, broadly and regularly rounded behind, pointed in front where the apex projects slightly beyond the margin of the aperture; apex incurved. Surface marked by distinct, rounded, radiating lines, which in the outer half maintain an approximately equal size through bifurcation; about ten lines in 5 mm.; whole surface with very fine concentric lines; at intervals of 1 to 3 mm. irregular wrinkles marking stages of growth. Length 24.5 mm.; width about 19 mm.; greatest hight 9 mm.; hight of apex about 4.5 mm.

This species is quite distinct from all American patelliform shells, but is closely related to the Upper Silurian *H. radiata* Lindström sp.* As figured that species is a little more convex, the anterior outline blunter and the apex more incurved.

*Formation and locality.*—Rare in the upper beds of the Cincinnati formation, Marion county, Kentucky. Also, though of smaller size, in the Loraine group at Cincinnati, Ohio.

*Collection.*—E. O. Ulrich

### HELCIONOPSIS SUBCARINATA, *n. sp.*

PLATE LXI, FIG. 28.

Shell small, subovate in outline, the anterior and posterior margins subequal and sharply rounded in the middle. In the cast the apex is depressed, small and not quite marginal; an obtuse carination extends across the length of the shell. Surface of cast showing remains of very fine radiating lines, scarcely visible without a magnifier, and a few obscure lines of growth. Length 10 mm.; width 8 mm.; greatest hight 3.5 mm.; hight of apex 1.5 mm.

We have only two specimens of this interesting species. Both are casts and show impressions of the rostral muscles. One exhibits besides a series of muscular scars similar to those of *Tryblidium.* The lines converging from them towards the

* Silurian Gastropoda and Pteropoda of Gotland, p. 58; 1886.

apex are a peculiar feature, though probably of the nature of "progressive tracts."

The obtuse angulation of the back of the shell distinguishes the species from all the Paleozoic forms of this family known to us. When not in a good state of preservation it might be confounded with *Archinacella patelliformis* Hall sp., but in that species the angulation of the back does not extend to the extremities of the shell, while the anterior end is wider, the apex higher and the surface without radial markings.

*Formation and locality.*—Trenton group, Clitambonites bed, Goodhue county, Minnesota.

*Collection.*—E. O. Ulrich.

## Genus ARCHINACELLA, n. gen.

*Metoptoma* (part.), BILLINGS, 1865, Palæozoic Fossils, vol. i. WHITFIELD, 1878, Geol. Wis., vol. iv.
*Tryblidium* (part.), WHITEAVES, 1884, Palæozoic Fossils, vol. iii, p. 31. WHITFIELD, 1886 and 1889, Bull. Amer. Mus. Nat. Hist., vols. i and ii.

For generic diagnosis see page 821.*

The shells which we propose to refer to this genus are decidedly like those of *Tryblidium*, especially so far as the position of the apex and the surface markings are concerned. Their internal markings, however, are readily distinguished, that genus having the muscular scars in eight detached pairs, while they form a continuous band in *Archinacella.* Unfortunately the muscular imprints are in most cases very faint, even on well preserved casts, so that we are generally obliged to rely upon another character in determining the generic position. Namely, in all the species of which the muscular scars are known to occur in detached pairs the anterior outline is acuminate, or at any rate more narrowly rounded than the posterior margin. On the other hand, the anterior margin is as broadly rounded or wider than the posterior outline in all the forms of which it is known that their muscular scars are not detached. We have, therefore, considered it good practice to assume that when the anterior end is narrowly rounded the species is a *Tryblidium* and when this end is the wider the species belongs to *Archinacella.*

There may be some doubt about the affinities of that group of shells in which the outline, as viewed from above, is almost circular or regularily elliptical. In no case have we been able to make out the muscular scars, although we have studied some well preserved casts. Still, as the form of these shells agrees best with *Archinacella*, and as we know nothing seriously opposing our view, we think it best to arrange them, at least provisionally, under this genus. Besides the species of

* We omitted from the generic diagnosis one feature that ought perhaps to have been included, namely, a pair of scars (? muscular) occurring one on each side of the apex. They lie on the outside of the usual muscular band and have been observed in two species, *A. powersi* and *A.* (*Tryblidium*) *canadensis* Whiteaves. The latter is a Guelph species and, as shown in Whiteaves' figures (Pal. Foss., vol. iii, pl. v), has these scars more strongly impressed (in the cast) and further forward than they are in *A. powersi.*

this type described in the following pages, we refer to *Metoptoma instabilis* Billings (Quebec group), *M. simplex* Billings (Calciferous group), *M. trentonensis* Billings (Trenton group) and *M. estella* Billings (Hudson River group).

In addition to the species of which descriptions follow and those mentioned in the preceding paragraph, we regard *Tryblidium piliolum* Whitfield, *T. canadense* Whiteaves, *Metoptoma phillipsi* Walcott, and *M. similis* Whitfield, as belonging to this genus.

### ARCHINACELLA POWERSI, *n. sp.*

PLATE LXI, FIGS. 3–5.

Shell large for the genus, moderately convex, subovate, widest in the anterior half; anterior outline semicircular, the posterior semielliptical; margins of aperture rather strongly arcuate; apex rather blunt, slightly incurved, the extreme point just over the margin and at least two-thirds of the greatest hight of the shell above it. Surface with fine, distant, impressed lines of growth; near the margin the markings become somewhat lamellose. Length 29 mm.; width 25 mm.; greatest hight 10 mm.; hight of apex 6.5 mm.

Impressions of the interior markings are excellently preserved on the cast figured on plate LXI. The loop of muscular scars forms one continuous narrow band curving distinctly down in front so as to pass beneath the apex. The posterior third is somewhat wider and prolonged on the outer side into numerous irregular processes. Within the anterior end of the loop we see the pair of rostral scars, and just behind them a narrow pair lies close to the band. Finally, we observe faint impressions of a larger anterior pair without the band, which may be called anterolaterals.

This fine species is readily distinguished from all described heretofore. Collectors seem to have confounded it with *A. perovalis* Whitfield sp., which occurs in the same strata, but is smaller, decidedly narrower—in front especially—and has the apex not quite marginal.

*Formation and locality.*—Stone's River group, Beloit, Wisconsin, where the types were collected by Mr. H. C. Powers, for whom the species is named.

*Collections.*—University of Wisconsin; E. O. Ulrich.

### ARCHINACELLA CINGULATA, *n. sp.* (*Ulrich.*)

PLATE LXI, FIGS. 1 and 2.

Shell large, rather strongly convex, subovate in outline, very broadly rounded in front, more narrowly behind; hight, width and length respectively as 4.5 to 10 to 12; margin of aperture horizontal; apex bluntly pointed, curved downward to about half the hight of the shell, projecting distinctly beyond the margin. Surface with well marked sublamellose lines of growth, averaging in the outer half about 1 mm. apart. Length 32 mm.; width 26 mm.; greatest hight 11 mm.; hight of apex 5 mm.

This species resembles *A. powersi*, but may be distinguished at once by the contour of its aperture, the margins being strongly arched in that species while in this one they are horizontal. The surface markings are also stronger in *A. cingulata*, while the anterior outline is broader, the apex projects farther forward and the transverse section of the shell is more convex, especially in the post-central region. *A. patelliformis* Hall sp., and *A. simulatrix*, though much smaller, are probably more intimately related to *A. cingulata* than is *A. powersi*.

*Formation and locality.*—Trenton group, Amygdalocystites bed, Mercer county, Kentucky.

*Collection.*—E. O. Ulrich.

## Archinacella depressa, *n. sp.*

PLATE LXI, FIGS. 8 and 9.

Shell of medium size, depressed-conical, the outline almost regularly oval, rather wide; the width and length about as seven is to eight; apex situated about one-seventh of the length from the anterior margin; the point, which is a little imperfect in the specimen, seems not to have been much elevated or incurved; apertural margin arched. Surface exhibiting a few obscure concentric lines. Muscular scars not observed. Length 20.5 mm.; width 18 mm.; greatest hight (at apex) about 5.2 mm.

This shell agrees with *A. powersi* in the arched apertural margin and broad form, but differs decidedly in having the apex situated some distance from the margin. As the convexity of the shell also is somewhat less, the profiles are different. There is also a slight difference in the outline as seen from above. In all these features the species approaches *A. perovalis* Whitfield sp., but it is readily distinguished from that species by its greater width and lower form.

*Formation and locality.*—Stone's River group, Vanuxemia bed, Minneapolis.

*Collection.*—Geological and Natural History Survey of Minnesota.

*Museum Register*, No. 5523.

## Archinacella perovalis *Whitfield sp.*

PLATE LXXXII, FIGS. 3 and 4.

*Metoptoma perovalis* Whitfield, 1878, Ann. Rept. Geol. Surv. Wis., p. 74; 1882, Geol. Wis., vol. iv, p. 211, pl. v, figs. 13 and 14.

*Metoptoma explanata* Sardeson, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 336.

This species agrees very closely with *A. depressa*, the only difference of any consequence that we can now point out being the greater width of that shell. In

*A. perovalis* the width is to the length about as eleven is to fifteen, while in the other it is as seven is to eight. Specimens vary in length from 16 to 30 mm. The muscular scars, so far as they have been determined, agree very well with those of *A. powersi.* The apertural margin is slightly arched, and the surface appears to have been nearly smooth.

Whitfield describes and figures this species as being flattened and truncate in front, and the absence of anything of the kind in the Minnesota specimens led Mr. Sardeson into giving a new name to the latter. We also failed to notice such a feature in any specimen, even those from Beloit, Wisconsin, the typical locality for the species, being without it, though agreeing in every other particular with Whitfield's figures. It seems, therefore, to us that the slight anterior truncation exhibited by the type specimen may be due to some abnormal cause.

*Formation and locality.*—Stone's River group, Vanuxemia bed, Minneapolis, Minnesota, and Beloit, Wisconsin.

### ARCHINACELLA DELETA *Sardeson sp.*

PLATE LXI, FIGS. 16–20.

*Carinaropsis deleta* SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 335.

Shell small, obliquely subconical, rather convex, elliptical in outline, the width and length usually as three is to four; aperture nearly horizontal; embryonic shell very small, involute, forming about one volution, rarely preserved, the apex usually appearing as but little incurved; the apex situated constantly a short distance behind the anterior margin. Surface almost smooth, occasionally exhibiting a few lines of growth. Length 9.25 mm.; width 7.1 mm.; greatest hight 4.25 mm.; hight of apex about 3 mm.

This species commonly grew upon the shells of other mollusks and it is often attached to them. We have before us several specimens that, having grown upon the concave inner sides of dead shells of *Protowarthia pervoluta* and *Holopea obliqua*, are now represented by a biconvex fossil reminding one greatly of casts of some discinoid brachiopod. Two of these specimens are represented on plate LXI.

This is the first of a group of species that seems to be related to *A.* (*Carinaropsis*) *patelliformis* Hall (Pal. N. Y., vol. i, p. 183; 1847). One or the other of these forms occurs in, or in the equivalent of, every one of the principal beds between the base of the Black River group and the top of the Cincinnati formation. None of the western and northwestern species however seem to be strictly identical with the New York types of *patelliformis*, all of them having a nearly smooth surface, while Hall's species according to his figures and descriptions has the surface marked by regular, concentric, sublamelliform striæ.* The present species differs further in wanting the obtuse carination of the dorsum and in having a smaller apex.

*Formation and locality.*—Black River group, Rhinidictya and Ctenodonta beds, Minneapolis, St. Paul, Cannon Falls. Chatfield, and near Fountain, Minnesota. Of all the patelliform shells occurring in Minnesota rocks this is the only one that is reasonably abundant. We have seen about twenty specimens.

*Collections.*—Geological and Natural History Survey of Minnesota; Geological Department, University of Minnesota; W. H. Scofield; E. O. Ulrich.

*Museum Register*, Nos. 4067 and 8723.

## ARCHINACELLA VALIDA *Sardeson sp.*

PLATE LXI, FIGS. 14 and 15.

*Tryblidium validum* SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 337.

Shell rather small, oblique-subconical, strongly convex, the dorsum narrowly rounded; outline elliptical, the width and length about as four is to five; aperture not arched; apex just within the anterior margin, laterally compressed, but little incurved in casts, the point about two-thirds of the hight of the shell above the edge of the aperture; beneath the apex the outline is deeply cut out in a side view. Surface markings consisting of rather obscure lines of growth. Length (small specimen) 16.5 mm.; width 13.4 mm.; hight nearly 7 mm. In another specimen, proportionally larger, the length reaches 20 mm.

We believe the specimens here figured and described are specifically the same as the one which Mr. Sardeson recently proposed to call *Tryblidium validum.* A comparison of our figures with his, it is true, brings out some differences, the outline of the aperture in ours being more regularly elliptical and the profile in the side view less convex centrally. It would appear, however, that in Mr. Sardeson's figure 2 the convexity is exaggerated, since in his description he gives the hight of the shell as equalling only half the width. And this is true of both the specimens here referred to his species. In this same figure 2 he shows three detached muscle scars, of so large a size that the whole ring would be made up of only three or possibly four pairs! But this would be so much out of the regular order that we are fully convinced that they rest on faulty observation. So far as our specimens are concerned nothing of the kind is to be observed. On the contrary we notice faint indications of the *Archinacella* band, and hence refer the species to this genus.

Specifically *A. valida* is nearer *A.* (*Carinaropsis*) *patelliformis* Hall, from the Trenton of New York,than any other form known to us. The lateral profile especially is nearly or quite the same in the two species. The New York species, however, is smaller, has more distinct surface markings and is obtusely carinated on the back.

* In comparing this and other species with *A. patelliformis*, we refer to the Trenton form only, and, as we have not seen the original types, we are obliged to depend solely on Hall's figures and description for our conception of their characters.

*Formation and locality.*—Trenton group, Clitambonites bed, near Cannon Falls and Kenyon, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; Geological Department, University of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7416.

### Archinacella semicarinata, *n. sp.*

PLATE LXI, FIGS. 12 and 13.

Shell small, obliquely subconical, elliptical in outline; apex submarginal, small, scarcely incurved in the cast; dorsum obtusely carinate for a short distance from the apex, lateral slopes slightly flattened; hight of shell (the posterior part especially) less than usual, equalling about two-fifths of the width, the highest point just behind the apex. Surface nearly smooth. Length 12.5 mm.; width 10 mm.; hight 4 mm. Five specimens.

The dorsal angulation allies this species to *A. patelliformis* Hall sp., but it does not extend backward so far, the apex is much smaller and less incurved, and the whole shell more depressed than in that species. It is distinguished in a similar manner from *A. valida.*

*Formation and locality.*—Trenton group, Clitambonites and Fusipira beds, Goodhue county, Minnesota.

*Collections.*—E. O. Ulrich; W. H. Scofield.

### Archinacella simulatrix, *n. sp.*

PLATE LXI, FIGS. 10 and 11.

Shell small, aperture horizontal, subovate, somewhat wider in front than behind; apex incurved, just above or projecting slightly beyond the anterior margin; back high, sharply rounded, the lateral slopes flattened. Surface markings obscure, concentric. Two specimens, one from Minnesota, the other from Kentucky. The dimensions of the former are as follows: length 10.5 mm.; width 8.5 mm.; greatest hight 3.4 mm.; hight of apex 1.7 mm. In the other the same measurements give 15, 12.5, 5.5 and 2.8 mm.

This species is distinguished from *A. deleta, A. valida, A. semicarinata* and *A. patelliformis* in having a less regularly elliptical outline, the anterior half being wider. In this particular it is like the much larger *A. cingulata.*

*Formation and locality.*—Black River group, Phylloporina bed, St. Paul, Minnesota; Trenton group, Modiolodon bed, Frankfort, Kentucky.

*Collection.*—E. O. Ulrich.

### Archinacella subrotunda, *n. sp.*

PLATE LXI, FIGS. 26 and 27.

Shell rather small, strongly convex, broadly oval, or nearly circular, obliquely conical, with the apex obtusely pointed, not incurved, and situated close to the anterior edge; aperture slightly arched; beneath the apex, in a side view, the anterior outline is scarcely concave; backward from the apex the outline is gently convex, the highest point being about midway between the apex and the middle of the shell. Surface nearly smooth, exhibiting in the best specimens only three or four, distant, impressed concentric lines. Length 13 mm.; width 11.3 mm.; hight 5.5 mm.; hight of apex 4.5 mm.

This species is associated with *A. deleta* Sardeson sp., and *A. instabilis* var. *incurva*. From the first it is easily distinguished by its rounded (much wider) form, while in the second the apex is drawn out into a small involute projection, giving it a very different outline in the side view. The species is related probably also to *A.* (*Tryblidium*) *pileolum* Whitfield, *A.* (*Metoptoma*) *simplex* Billings, and *A.* (*Metoptoma*) *estella* Billings, but we cannot consider it identical with any of them.

*Formation and locality.*—Black River group, Ctenodonta bed, Goodhue county, Minnesota.

*Collection.*—E. O. Ulrich.

### Archinacella richmondensis, *n. sp.* (*Ulrich.*)

PLATE LXI, FIGS. 6 and 7.

Comp. *Tryblidium indianense* Miller, 1891, Adv. Sh. 17th Rep. Geol. Surv. Ind., p. 85.

Shell above the medium size, subovate in outline, obliquely conical, with the apex obtusely pointed, not incurved, and situated about one-sixth of the length behind the anterior margin; in a side view the anterior slope is slightly concave, while the slope backward from the apex is correspondingly convex, with the highest point near the apex; aperture nearly or quite horizontal. Surface marked by rather distant concentric lines. Length 24 mm.; width 20 mm.; hight 6.5 mm.

This species reminds one considerably of the geologically older *A. depressa*, but the arched aperture, lesser convexity and somewhat different outline of that species are sufficient proof of their distinction. It is probably more nearly related to *A. subrotunda*, but in this case we have obvious differences in outlines and in the position of the apex. We could come to no positive conclusion respecting Miller's *Tryblidium indianense*, but if his description is reliable it is certainly distinct.

*Formation and locality.*—Richmond group of the Cincinnati period, Richmond, Indiana.

*Collection.*—E. O. Ulrich.

### ARCHINACELLA RUGATINA, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 5 and 6.

This species agrees closely with *A. richmondensis* Ulrich, but may be distinguished by its more distinct and slightly incurved apex, somewhat arched aperture and stronger surface markings. The latter are coarsely lamelliform in the outer third.

*Formation and locality.*—Richmond group of the Cincinnati period, Middletown, Ohio.

*Collection.*—E. O. Ulrich.

### ARCHINACELLA INSTABILIS *Billings*, var. INCURVA, *n. var.*

PLATE LXI, FIGS. 21—23.

*Metoptoma instabilis* BILLINGS, 1865, Pal. Fossils, vol. i, p. 251.

*Original Description:* "Shell small, depresed conical; apex acute, slightly incurved, situated over the anterior margin; aperture circular; surface finely striated parallel to the base. Width of an average specimen, 8 lines, height 4 lines."

A single imperfect specimen, from the Black River group of Minnesota, agrees so well with Billings' description and figures of this species, that we hesitate to give it a distinct specific name. The specimen, it is true, is smaller than the Newfoundland types and shows besides certain peculiarities that, if they could be proved to be constant, might justify a separation. The apex, for instance, is more incurved in the Minnesota specimen,—indeed it curves inward sufficiently to form a complete volution,—and the whole dorsal outline is more convex in a side view. Provisionally it may be designated as var. *incurva*, and it should be added to the list of Black River species mentioned by Billings on page 372 of his Palæozoic Fossils, vol. i, that are represented by closely allied species in divisions I, K, L, and M of the Quebec group in Newfoundland.

*Formation and locality.*—The types of the species are from division L, Quebec group, Table Head, Newfoundland. Var. *incurva* was collected by E. O. Ulrich near Cannon Falls, Minnesota, in the Ctenodonta bed of the Black River group.

*Collection.*—E. O. Ulrich.

### ARCHINACELLA ROTUNDA, *n. sp.*

PLATE LXI, FIGS. 24 and 25.

Shell small, obliquely conical, moderately elevated, aperture circular, horizontal; apex situated almost directly over the anterior margin, apparently small, pointed and slightly incurved; in a side view the posterior part of the dorsal outline is very gently convex, but in nearing the apex the convexity becomes much stronger.

Beneath the apex the outline is decidedly concave. Surface of cast smooth. Muscular imprint, distinct, linear, the posterior part of the loop bending forward a little in the middle. Diameter about 7.7 mm.; hight 4.5 mm.

The specimen upon which this species is founded is important because it preserves the muscular imprint and shows that this agrees, in what we must for the present consider essential features, with the imprint found in the typical species of *Archinacella*. And it is upon the strength of this evidence that we refer all the rounded Lower Silurian patelliform shells having the apex submarginal to this genus.

Compared with related species, *A. instabilis*, *A. simplex* and *A. estella* of Billings are all higher. *A. pileolum* Whitfield sp. also is very similar, but as it belongs to a much lower horizon (Calciferous) it is fair to assume that it is distinct.

*Formation and locality.*—Cincinnati period, Utica horizon, near Graf, Iowa, where it was associated with *Orthoceras sociale* Hall.

*Collection.*—E. O. Ulrich.

## Genus PALÆACMÆA, Hall and Whitfield.

*Palæacmæa* HALL and WHITFIELD, 1873, 23rd Rep. N. Y. Mus. Nat. Hist., p. 242. LINDSTRÖM, 1884, Gastropoda and Pteropoda of Gotland, p. 58.

For generic characters see page 821.

We propose to use this genus for all those lower Paleozoic patelliform shells having the apex subcentral and the surface marked in a concentric manner only. In the typical forms, all of which are confined to the Potsdam and Calciferous formations, the markings consist of wide (2 mm. or more) concave undulations. This is true of *P. typica* H. and W., from the Potsdam of New York, *P. irvingi* Whitfield, from the same formation in Wisconsin, and *P.* (*Metoptoma*) *quebecensis* and *P.* (*Metoptoma*) *orphyne* of Billings, from the Quebec group of Canada. In the lower Trenton species about to be described these undulations are an unsteady feature and scarcely distinguishable in casts, while in the Gotland species (Upper Silurian) they are represented by narrow ridges, separated by usually short flat, rather than concave, interspaces on which very fine concentric lines are distinguishable.

Little or nothing is known of the muscular scars of all these species except the last, *P. solarium* Lindström. In this a "wreath of muscular impressions, nearly coherent," occurs near the top of the conical cast. All that can be made out of the scars of *P. humilis* appears to agree with Lindström's observations on the Gotland species, and, as the former is featured just as we might expect an intermediate stage between *P. solarium* and the Potsdam species to be, we may provisionally assume that the scars are essentially the same in the latter as well.

Lindström places this genus with *Tecturidæ* (*Acmæidæ*, Carpenter) and perhaps justly, but, as the family is not recognized by some conchologists and as it is highly probable that the Paleozoic patelloid shells are more intimately related among themselves than to recent types, it has seemed to us the wisest to embrace them all provisionally in one broad family, the *Patellidæ*.

### PALÆACMÆA HUMILIS, *n. sp.*

PLATE LXI, FIGS. 45–48.

Shell depressed conical, rather small, broadly subovate, the anterior part of the outline semicircular, the posterior slightly prolonged and more narrowly rounded centrally; apex pointed, not quite erect, leaning slightly forward and situated a short distance in front of the center. Surface marked with obscure, fine, concentric lines and usually with several strong wrinkles or undulations of growth. The latter are more or less variable and irregular, and in some cases may be wanting. On casts of the interior they are very faint or quite indistinguishable. Muscular scars not well preserved by any of the specimens seen, apparently detached and forming an oval band about the apical third of the cast. Length (small specimen) 12 mm.; width 10.7 mm.; hight 4.5 mm. In a larger specimen these dimensions are respectively 15.5, 14 and 5 mm.

The absence of radial surface markings will distinguish this species from the following forms of *Scenella*, and the subcentral position of the apex renders equally good service in separating it from the preceding species of *Archinacella*. As to *Palæacmæa*, it is certainly distinct from all other forms known to belong to the genus.

*Formation and locality.*—Stones River group, Vanuxemia bed, Minneapolis; Black River group Ctenodonta bed, at several localities in Goodhue county, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 5104.

### Genus SCENELLA, Billings.

*Scenella*, BILLINGS, 1872, Can. Nat. and Geol., vol. vi, p. 479; and Pal. Foss., vol. ii, p. 77.

For generic characters see page 822.

This genus has never been properly defined and it is perhaps impossible to do so even to-day. Still, we are convinced that, with *S. reticulata* Billings as the type, it may be made to include an easily recognizable and thoroughly natural group of patelloid shells having relations to *Palæacmæa* on the one side and to *Stenotheca* on the other. As understood by us the genus is characterized by the subcentral apex and the radial striæ. The latter vary in strength, being sometimes rather coarse, but in most cases very fine. When the radii are coarse (*S. radialis*) they show through the shell so as to be visible on the outer half of casts of the interior, but usually the casts are smooth, or exhibit only a few obscure concentric wrinkles.

The muscular scars of the typical species,—it is a Cambrian fossil,—are unknown, but in several Lower Silurian forms, which with our present light on the subject must be regarded as congeneric, they are very much as in *Palæacmæa*. Though they have not been observed very clearly, it is almost certain that they are imperfectly coherent and form a sort of wreath about the apical portion of the cast. The number of the scars is not established. Whitfield says that there are eight pairs in his *Tryblidium conicum*, a species which we believe to belong to this genus and very near *S.* (*Metoptoma*) *montrealensis* Billings. In our *S. beloitensis* the scars seem to have been divided into four sets of which the two in the posterior half appear to consist each of four almost completely coherent imprints.

When the surface markings are not preserved species of *Scenella* are distinguished from those of *Palæacmæa* by their higher conical form. In *Stenotheca* the shell is still higher and the apex curves far forward, projecting in most cases considerably beyond the anterior margin of the aperture. While these characters will suffice ordinarily in discriminating between the genera, there are still several forms of which it is difficult to decide whether they should be placed under *Scenella* or *Stenotheca* or arranged by themselves. *Metoptoma venilla* Billings, Quebec group, and *M. alta* Whitfield, Calciferous group, are examples of these doubtful species.

*Scenella* probably ranged through the greater part of the Paleozoic rocks, the oldest occurring in the Lower Cambrian, while the most recent known representative appears to be the Devonian species which Walcott has described from Nevada as *Metoptoma devonica*.

### Scenella superba *Billings.*

PLATE LXI, FIG. 35.

*Metoptoma superba* Billings, 1865, Pal. Foss., vol. i, p. 172.
? *Conchopeltis minnesotensis* Walcott, 1876, 28th Rep. N. Y. Mus. Nat. Hist., p. 93.

Shell large, subconical, the hight usually equalling somewhat more than half the diameter; aperture broadly ovate or circular, slightly arched in front and behind; apex subcentral or a little anterior, obtuse, inclining gently forward. Surface marked by radiating striæ, 1 mm. or less in width, and concentric lines and obscure wrinkles. In casts both sets of striæ are usually very obscure, while the radiating lines are seldom shown and then only for a short distance above the margin. Dimensions of an average example: length 64 mm.; width 58 mm.; hight 32 mm. In the largest specimen seen the aperture is nearly circular and between 85 and 90 mm. in diameter, the hight about 45 mm.

We can scarcely doubt that the Minnesota specimens above described really belong to Billings' *Metoptoma superba.* They agree exactly with his figures and description except that we see nothing of the "obscure carination" which he says "runs from the apex to the margin on one side." Perhaps it is an abnormal feature. As to *Conchopeltis minnesotensis,* Walcott's description, in the absence of figures, is too indefinite for identification.* Still we do not think it likely that his types, which we sought to see but failed, are distinct from the specimens here referred to *S. superba.* Nor do we believe that they are strictly congeneric with his *C. alternata,* the type of his proposed genus *Conchopeltis.* (See ante page 823.)

*Formation and locality.*—Stones River group, Cannon Falls, Minnesota. Walcott's locality for his *C. minnesotensis* is given as "four miles below Medford, Cannon River, Minn." Billings' type is from the Black River limestone at Pauquettes rapids on the Ottawa river.

*Collections.*—Geological and Natural History Survey of Minnesota; W. H. Scofield; E. O. Ulrich.

*Museum Register,* Nos. 3394, 7350 and 7490.

### Scenella magnifica, *n. sp.*

PLATE LXXXII, FIGS. 7—9.

Of this species we have only a single specimen which was found in association with the preceding species at Cannon Falls. It seems to have had surface markings like *S. superba,* and we believe it is closely related to that species. But the hight of the shell is so much greater that we cannot do otherwise than regard it as specifically distinct. Comparing other features we find that the aperture also is more arched and the whole shell more compressed laterally so that the outline from above is decidedly elliptical instead of subcircular. Length 76 mm.; width 58 mm.; hight about 75 mm. The specimen is imperfect at the apex.

*Formation and locality.*—Stones River group, Vanuxemia bed, Cannon Falls, Minnesota.

*Collection.*—Geological and Natural History Survey of Minnesota.

*Museum Register,* No. 3405.

### Scenella beloitensis, *n. sp.*

PLATE LXI, FIGS. 33 and 34.

Shell exceeding medium size, obtusely conical, the hight less than one-half of the smallest diameter; apex subcentral; aperture nearly or quite horizontal, somewhat irregularly subcircular. Surface of cast showing fine radiating striæ, about ten in 5 mm., over the marginal portion. Muscular imprints occupying the greater part of the inner half, apparently divided into four sets, each consisting of three or four, scarcely distinguishable, coherent scars. Length 28 mm.; width 26 mm.; hight 10.5 mm.

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*Walcott's description reads as follows: "Shell obtusely conical, base slightly elliptical; apex excentric, variable in different individuals; hight one-half the greatest diameter. Shallow undulations of growth occur one-half the distance to the apex, finer lines near the margin. Substance of the shell not preserved."

This species resembles *S. superba* Billings sp., but is readily distinguished by its more depressed form, horizontal aperture and finer surface markings. The muscular imprints also are much stronger than in that species.

*Formation and locality.*—Stones River group, Vanuxemia bed, Beloit, Wisconsin.

*Collection.*—University of Wisconsin, No. 307.

### SCENELLA COMPRESSA, *n. sp.*

PLATE LXI, FIGS. 38—41.

Shell small, compressed conical, the hight exceeding the longest diameter of the aperture, while the shortest diameter is to the hight as three is to five, or as two is to three; apex subcentral, laterally compressed, inclining forward slightly; back and sides of shell obscurely flattened, anterior part sharply rounded; aperture subovate, narrower in front than behind. Surface with fine radial lines, three or four in 1 mm., and somewhat irregular transverse lines and wrinkles. The shell seems to have been rather thick and the surface markings are not visible on the cast. Length 13 mm.; width about 9.5 mm.; hight 14.5 mm.

This peculiar species reminds one somewhat of the much larger *S. magnifica*, but we do not think its relations to that species are very intimate. Its affinities are probably nearer to *S. montrealensis* Billings sp., yet not enough so to render confusion between them at all likely. The narrowly rounded anterior slope and the flattening of the sides and dorsum are obvious peculiarities.

*Formation and locality.*—Stones River group, Vanuxemia bed, Minneapolis, Minnesota.

*Collection.*—E. O. Ulrich.

### SCENELLA AFFINIS, *n. sp.*

PLATE LXI, FIGS. 36 and 37.

Comp. *Metoptoma montrealensis* BILLINGS, 1865, Pal. Foss., vol. i, p. 394.
Comp. *Tryblidium conicum* WHITFIELD, 1886, Bull. No. 8, Amer. Mus. Nat. Hist., p. 306.

Shell small, conical, with the apex subcentral and directed slightly forward, the anterior part compressed, especially for a short distance beneath the beak where it is almost angular; aperture somewhat irregular, subovate, narrowest in front; in a side view the anterior outline is slightly convex in the middle and correspondingly concave above to the apex; behind the latter the outline is gently convex to the margin. Surface exhibiting very fine, easily abraded, concentric and radiating striæ, and some irregular wrinkles of growth. Length 10 mm.; width 9 mm.; hight 7.5 mm.

This form is probably a variety of *S. compressa*, distinguished by its lower and wider shell and finer surface markings. It seems also to be very closely related to

*Metoptoma montrealensis* Billings, and *Tryblidium conicum* Whitfield, but neither of these species has the anterior slope sharply rounded as in *S. affinis* and *S. compressa*. Whitfield's species, which we regard as a true *Scenella*, seems to be more closely related to *S. superba* and *S. beloitensis* than to *S. montrealensis*. The latter, judging solely from Billings' figures and description (*op. cit.*), appears to differ from all the species mentioned in having a more attenuate apex and the whole anterior outline concave in a side view.

Besides the typical specimens of *S. affinis* we have before us six others from the geologically higher Clitambonites and Fusispira beds. In these the anterior vertical ridge is less developed and the outline of the aperture more regularly elliptical. The shell also seems to have been thinner and smoother externally. If a subordinate name is desired for this later form of the species it might be called var. *obsoleta*.

*Formation and locality.*—Black River group, Ctenodonta bed, and Trenton group, Clitambonites bed, Goodhue county, Minnesota; Fusispira bed, Kenyon and Wykoff, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, No. 7487.

### SCENELLA OBTUSA *Sardeson.*

PLATE LXXXII, FIG. 10.

*Conchopeltis obtusa* SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 336.

Having seen no specimens which we could refer to this species, we reproduce the original figure and description without expressing any positive opinion as to its validity. So far as Mr. Sardeson's figure of the specimen upon which he founds the species permits of judgment, it seems to us to be a *Scenella* in which the apex is farther removed from the center and the apical angle wider than usual.

*Original description:* "Shell large, patelliform, or subconical, apex excentric, apical angle 110 degrees. Aperture subcircular, about three times as wide as the shell is high. Cast marked by four or five concentric furrows and by numerous elevated radiating lines, from 15 to 20 in one centimeter."

*Formation and locality.*—Black River group, Rhinidictya bed, Minneapolis, Minnesota.

### SCENELLA RADIALIS, *n. sp.*

PLATE LXI, FIGS. 31 and 32.

Shell large, depressed conical, hight slightly greater than one-third of the diameter; apex subcentral, obtuse; aperture almost circular, the margin apparently a little irregular though nearly horizontal. Surface with distinct lines radiating from the apex, five or six in 5 mm. These show through the outer parts of the shell and produce corresponding lines on the cast. Diameter about 55 mm.; hight about 21 mm.

This species is not nearly as high as *S. superba* and *S. magnifica*, while it differs from *S. beloitensis* in having coarser radii, and from *S. obtusa* in the more central position of the apex.

*Formation and locality.*—Trenton group, Clitambonites bed, St. Paul, Minnesota.

*Collection.*—Geological and Natural History Survey of Minnesota.

*Museum Register*, No. 5535.

## Genus STENOTHECA, Salter.

*Stenotheca*, (SALTER) HICKS, 1872, Quart. Jour. Geol. Soc., vol. xxviii, p. 180.

For generic characters see page 822.

The typical species of this genus are from the Cambrian, from which horizon some ten or twelve species have been described. From these it would appear that the generic type is distinguished from *Scenella* chiefly by the curved form and stronger concentric marking. The genus seems, however, even among the Cambrian forms, to be subject to considerable variation in the matters of form and surface marking, and in such ways that we consider ourselves justified in placing the two species about to be described within its limits. Neither of the latter is greatly different from certain varieties of the Cambrian *S. rugosa* as figured by Walcott.

*Stenotheca*, as is the case with *Scenella* also, is often placed with the *Pteropoda*. We fail, however, to see anything in these shells to justify such a view, at any rate nothing that is not overcome by evidence favoring an alliance with the *Patellidæ*. We must admit that *Stenotheca* is not a good member of this family, but it most probably represents an offshoot from *Scenella*, which is a better example, toward certain bellerophontoids (e. g. *Cyrtolites*).

### STENOTHECA EXSERTA *Sardeson.*

PLATE LXXXII, FIGS. 11–15.

*Tryblidium exsertum* SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 337.

Shell high, laterally compressed, curved, forming one-third or more of a volution; aperture subovate, the length and width about as three is to two, more narrowly rounded in front (beneath the apex) than behind. Surface marked with fine radiating lines, increasing in strength with the growth of the shell, with, so far as known, not less than two in the space of 1 mm. Obscure transverse markings are also present and on the basal half of a large cast several broad folds. On the specimen referred to we fail to see any signs of the radiating lines, but on the other casts, both from Minneapolis, they are faintly indicated. Muscular scars not observed.* Length of aperture 20 mm.; width of same 13.5 mm.; length of shell from apex to posterior margin 26 mm. These dimensions in a large and a very small specimen are respectively about 29, 16 and 42 mm., and 4.5, 3 and 5.5 mm. The large specimen has suffered from pressure so that the width is less than normal.

Aside from the fact that it grew to a much larger size, this species resembles *S. rugosa* var. *levis* Walcott (Tenth Ann. Rep. U. S. Geol. Surv., pl. LXXIV, figs. 5, 5*a*) more closely than it does any Lower Silurian shell known to us.

*Formation and locality.*—Stones River group, Vanuxemia bed, Minneapolis, Minnesota, and Beloit, Wisconsin.

*Collections.*—Geological and Natural History Survey of Minnesota; University of Minnesota; University of Wisconsin.

*Museum Register,* No. 715.

### STENOTHECA UNGUIFORMIS, *n. sp.* (*Ulrich.*)

PLATE LXI, FIGS. 42–44.

Shell unguiform, acuminate-ovate from above, rounded posteriorly, narrow in front where the apex curves more or less strongly downward, sometimes nearly to the plane of the aperture and projects considerably beyond the anterior margin; aperture horizontal, ovate, usually much more broadly rounded behind than in front. Surface with distinctly elevated, regular, sublamelliform, concentric lines, from 0.2 to 0.6 mm. apart, the distance between them increasing with growth; crossing them very fine radiating lines; test rather thick; surface of cast smooth. Three specimens have the following dimensions: length of aperture 6.5, 10.2 and 11.5 mm.; width of same 5.8, 9 and 9.1 mm.; length of shell 7.7, 12.8 and 15 mm.; hight of same 3, 4.5 and 6 mm. Old specimens have thick edges and are relatively longer than medium and young examples. This is because the increase of the shell, after a certain stage, takes place principally at the posterior border. For the same reason the beak appears more strongly incurved in old shells.

This species is clearly distinct from all previously described patelloid shells. There may be some doubt about the generic position, the anterior hight being less than it should be in a true *Stenotheca.* The Cambrian *S.? elongata* Walcott, however, exceeds our species in that respect, while in its younger stages it is decidedly like some of the forms referred to *S. rugosa* by the same author. We believe, therefore, that we cannot be far wrong in placing it under *Stenotheca.*

*Formation and locality.*—Upper beds of the Trenton group, between Burgin and Danville, Kentucky.

*Collection.*—E. O. Ulrich.

* Mr. Sardeson says of the muscular scars that they "are not distinct on the cast, but there appears to be a row of about 24 passing around the shell from 2 to 5 mm. above the lip of the aperture."

## Suborder BELLEROPHONTACEA.

This suborder is proposed for the reception of a type of *Gastropoda* that seems to be totally extinct. The elements to be comprised in it have heretofore been referred partly to the prosobranchiate order *Pectinibranchiata,* some to the *Heteropoda,* and others to the *Pteropoda.* They are all symmetrical shells and in this respect agree with the *Patellacea.* We believe that they are either descendants of the same unknown stock from which that suborder was derived, or that they represent an early offshoot from it, differing in the strongly involute (instead of patelliform) character of their shells. From recent *Heteropoda* they differ in having a stronger shell and in their habits, which evidently were litoral and not pelagic.

Systematists have experienced great difficulties in assigning this well-marked group of shells to its proper place in nature. Montfort, who was the first to attempt it, originally considered his *Bellerophon* as a cephalopod because he believed it to possess a number of septa pierced by a siphuncle. Although the total absence of anything like septa was soon demonstrated, Montfort's view was still maintained in the modified form necessitated by the monothalamous character of the shell. Blainville placed *Bellerophon* with the *Ophisthobranchiata,* but received very little support for his view. Not so however with the idea first advanced by Deshayes that these shells were *Heteropoda.* This view seemed to be so well established by the external resemblance of certain bellerophontids to the recent genus *Atlanta* that it became very popular. But it also has almost disappeared from modern literature.

The position to which they are now almost universally assigned is among the pectinibranchiate order of the prosobranchiate *Gastropoda.* This arrangement was inaugurated by De Koninck in 1843, when he drew attention to certain similarities existing between the shells of *Bellerophon* and *Emarginula.* His view was adopted by Pictet and Geinitz, but its general adoption was interfered with in 1866, when Meek seemed to prove that their affinities were even nearer *Pleurotomaria* and *Haliotis.* Since this date Meek's view of the natural position of this group of symmetrical involute shells has gradually gained many supporters, so that now it may be said to be the one that is generally accepted.

In our opinion the systematic position of the *Bellerophontacea* is at least approximately determined. All three of the views now current, Deshayes', De Koninck's, and Meek's, perhaps contain an element of truth; the second because *Emarginula* is either a direct descendant of the ancient type under consideration, or a reversion from the pleurotomarian type; the third because the *Pleurotomariidæ* probably sprang from the same ancestral stock; and the first because there are good reasons to believe that the *Heteropoda* have been derived from the pleurotomarian line of development. In other words the *Bellerophontacea*, *Emarginulidæ*, *Pleurotomariidæ* and *Heteropoda*, though distinguishable, are nevertheless so closely united, in one way or another, that no system of classification can afford to separate them very widely. The most natural arrangement at present suggested is to let them follow that central type of the *Gastropoda*, the *Patellacea*, in the order named. This arrangement, however, must be regarded as only provisional, since it does not take into account the grand divisional line which ought to be drawn between the symmetric and asymmetric *Gastropoda*, according to which the class may be divided into two great groups, with the *Scaphopoda*, *Pteropoda*, *Opisthobranchiata*, *Polyplacophora* and *Docoglossa* on one side, and the *Prosobranchiata*, *Heteropoda* and *Pulmonata* on the other. These two groups are distinct already in the oldest known fossiliferous rocks—so far as known then, we may say from the beginning. The members of each are determined not so much by the presence or absence of strictly bilateral symmetry of organization as by their developmental history.* A tendency to become *twisted* characterizes the whole class, but while it is a constant condition in the second group, it is never as marked and often quite absent in the first.

As regards the relation of the *Bellerophontacea* to the *Pleurotomariidæ* and so-called *Zygobranchia* in general, it is scarcely as intimate as usually supposed. So far as known both groups are equally ancient, and comparisons between the earliest types of each show that they are quite as distinct as any of the later ones. The apertural slit and slit-band which the two groups possess in common, and which is the only important feature in which they agree, became established somewhat earlier among the pleurotomarians than with the bellerophontids, from which it follows that the former is probably the more ancient instead of the younger type of the two. They may have had a common ancestor, but neither sprang from the other.

The derivation of the bellerophontids is still obscure. Of all the known and sufficiently ancient types only *Stenotheca*, which we refer to the *Patellacea*, appears at all likely to have been concerned in their evolution. In this genus the shell is more or less strongly curved, the surface frequently cancellated, and the dorsum sometimes subangular. From such a type it is not very far to *Cyrtolites*. But *Cyrtolites*, despite the fact that it is closely connected, by one species or another, to more typical members of the suborder, is very different from *Owenella*, which includes the only Cambrian bellerophontid known. Nor has the genus yet been found in rocks older than the Trenton. Although, in placing the *Bellerophontacea*

* Among recent *Gastropoda* only the *Polyplacophora* and *Ophisthobranchiata* are fundamentally symmetrical, but paleontology seems to show conclusively that the early or Paleozoic representatives of the *Docoglossa*, *Pteropoda* and *Scaphopoda* were perhaps equally so.

and *Patellacea* in the same order, we have taken the probable, yet not established, connection between *Stenotheca* and *Cyrtolites* into consideration, our principal reason for doing so lies in the fact that in both the shell is symmetrical.

During the preparation for this work we undertook as nearly a complete revision of the American species of the suborder as possible, the cabinet of one of the authors containing representatives of a large proportion of the described forms. Much time was spent also on the foreign species, though here we were obliged to rely almost entirely upon the published figures. Still, with our knowledge of the American species, the illustrations alone were in most cases sufficient for our purposes. Our comparative studies, though demonstrating the close interrelationship of the various types comprised in the suborder, still showed very clearly the actual existence of numerous natural and in most cases easily recognized groups of species which we deem of sufficient importance to rank as genera. Most of these have been already established, but, as some require sharper limitation and correction, we shall endeavor to characterize them all as fully and clearly as we can now do. Under each genus we add a list of the American species, and when desirable of the foreign as well, which we have examined and of whose affinities and position we are reasonably certain.

We recognize twenty-three genera and divide them into five families. In the following synopsis brief discussions follow the diagnosis of the genera of which no species are described by us, while the remarks on the others will be found immediately preceding the descriptions of the species of each.

## Family CYRTOLITIDÆ.

Symmetrical involute shells; volutions two or three, barely in contact, sharply angular dorsally; aperture not expanded, the sinus V-shaped, never deep, sometimes wanting; no slit, and the band occurs only in *Cyrtolitina*; surface reticulate.

CYRTOLITES, Conrad. Shell coiled in the same plane, symmetrically or nearly so; volutions two or three, scarcely contiguous, the last occasionally free, enlarging gradually, carinated on the back and often on the sides, giving a subquadrate cross-section; aperture not abruptly expanding, with or without a median notch in the outer lip; no slit-band; shell thin, without callosities of any kind; surface sculpture reticulated or cancellated, consisting of straight or obliquely curved regular transverse lines connected by short oblique lines. Type, *C. ornatus* Conrad.

*C. ornatus* Conrad. Cincinnati period.
*C. ornatus*, var. *minor* U. & S. Trenton group.
*C. retrorsus* Ulrich. Black River, Trenton, and Utica groups.
*C. retrorsus*, var. *fillmorensis* U. & S. Black Riv. gr.
*C. subplana* Ulrich. Trenton group.
*C. parvus* Ulrich. Utica group.
*C. carinatus* Miller. Utica group.
*C. disjunctus* U. & S. Richmond group.
*C.? dilatus* U. & S. Black River group.

Microceras, Hall, 1845. (Amer. Jour. Sci., vol. xlviii, p. 249.) Minute shells (1 to 4 mm. in diameter), gregarious in habit, in form like *Cyrtolites.* It is difficult to decide whether any of hundreds of specimens seen preserve the shell or not, though we are inclined to regard them as casts of the interior. They are always of a black or brownish color, with the surface perfectly smooth and generally glossy. The principal and typical species, *M. inornatus* Hall, seems to range from the Trenton to the Devonian.

The shells comprised in this somewhat doubtful genus are certainly not "embryonic volutions of bellerophontes," as supposed by Waagen, but they may be dwarfed varieties of species of *Cyrtolites* and perhaps of other genera. They usually occur associated with large numbers of *Cyclora,* another genus of minute gastropods, the species of which again may be but dwarfed forms of *Holopea* or *Cyclonema* and *Lophospira,* and with very small species of *Ctenodonta* and *Clidophorus.*

Cyrtolitina, n. gen. (Ulrich.) (*Cyrtolites* [part.], Lindström, 1884.) Symmetrically involute, small thin shells, consisting of one and a half or two rapidly enlarging, contiguous or free volutions, with rounded sides and a more or less well developed slit-band; aperture higher than wide, sinuate dorsally and somewhat deeply emarginated in front of the slit-band; marks of growth curving strongly backward, more or less distinctly lamellose, with crenulated edges and, when distant enough, traversed by small wrinkled longitudinal riblets. Type, *Crytolites lamellifer* Lindström. In the same work (Silurian Gastropoda of Gotland, pp. 82-84) Lindström describes three more species belonging to this genus, viz.: *Crytolites pharetra, C. arrosus* and *C. obliquus.* In America the new genus is represented by *Crytolites nitidulus* Ulrich (Jour. Cin. Soc. Nat. Hist., vol. ii, p. 12; 1879), a species of the upper part of the Trenton group.

## Family PROTOWARTHIIDÆ.

Symmetric, involute shells; aperture not abruptly expanded; outer lip and lines of growth with a broad or narrow dorsal sinus; slit and band wanting.

Owenella, n. gen.* Shell thin, subglobose, closely coiled; volutions compressed dorso-ventrally, moderately embracing, rounded on the back, enlarging gradually, not abruptly expanded at the aperture; umbilicus open; aperture transverse, the outer lip with a rather broad and not very deep median insinuation; slit-band wanting. So far as known the surface markings consist of transverse or growth lines only. Type, *Bellerophon antiquatus* Whitfield, Upper Cambrian, Wisconsin. *B. pettos* Koken, from Lower Silurian strata in Europe, seems to have all the essential characters of this genus.

* Named for that great pioneer in the geology of the northwestern states, Dr. David Dale Owen.

This is the oldest known representative of the suborder, but as all the essential bellerophontid characters are already well developed in it, we should look for, and may confidently expect to find, less advanced forms in the Middle and Lower Cambrian rocks.

The general expression of *O. antiquata* is such that we can scarcely doubt that it is of the type from which the *Bucaniidæ* sprang. The modifications required to reach the latter stage,—the formation of an apertural slit with its resulting dorsal band, and a not very great change in surface markings,—are quite in accordance with the developmental tendency prevailing in early Paleozoic times not only among the *Bellerophontacea* but among the *Eotomacea* as well. Further, we are satisfied that *Owenella* is the stock in which the roots of all the other types of the group, excepting the *Cyrtolitidæ*, are centered. Abundant evidence supporting this view occurs here and there through the following pages.

Protowarthia, n. gen. Aperture large but not abruptly expanded, the outer lip bilobate, with a broad and more or less deep sinus but neither a slit nor band; dorsum convex, never carinate; umbilicus closed; surface markings very fine, generally consisting of more or less obscure crowded lines of growth and delicate revolving striæ. The inner lip forms a thin granulose deposit over the dorsum of the inner end of the last whorl and extends on each side around the umbilical region. This portion is covered with interrupted or inosculating lines. Type, *Bellerophon cancellatus* Hall.

*P. cassinensis* Whitfield sp. Calciferous.
*P. rectangularis* U. & S. Stones River group.
*P. pervoluta* U. & S. Black Riv. and Trenton groups.
*P. obesa* Ulrich. Trenton group.
*P. cancellata* Hall sp. Trenton and Cincinnati periods.
*P. granistriata* Ulrich. Utica group.
*P. planodorsata* Ulrich. Utica group.
*P. subcompressa* Ulrich. Richmond group.
*P. concinna* U. & S. " "
*P. morrowensis* Miller sp. " "
*P. bilobatus* Sowerby sp. Low. Silur. (Probably not American.)
*P. ?acutilira* Hall sp. Hamilton group.

Bucanella, Meek.* (Not Koken.†) Back of shell distinctly trilobate, volutions enlarging rapidly, compressed dorso-ventrally, scarcely embracing; umbilicus large; aperture transverse, the outer lip sinuate; surface markings obscure, delicate, consisting apparently of both revolving and growth lines. According to Meek there is no slit-band. Type, *B. nana* Meek. The European Upper Silurian fossil, *Bellerophon trilobatus* Murchison, and our common Clinton *Bucania trilobata* Conrad, probably belong here.

Unfortunately we have not been able to secure a testiferous example of any of the three species referred to this genus.‡ Admitting the correctness of Meek's

* Proc. Amer. Philos. Soc., vol. xi, p. 426; 1870.

† N. Jahrbuch f. Mineralogie, etc., Beilage Band vi, p. 389; 1889.

‡ Since this page was in type we have, through the kindness of Prof. E. W. Claypole and Mr. Aug. F. Foerste, been enabled to see specimens of *B. trilobata* Conrad sp. which retained some of the shell. This we find to be comparatively thick, and marked externally with very fine revolving lines. The lines of growth are very faint and they form a broad sinus on he central lobe of the back about as in *Protowarthia*. There is no slit-band.

description, especially the part which relates to the absence of a slit and dorsal band, we place the genus near *Owenella* and *Protowarthia*, and consider it as well distinguished from those genera by the trilobate character of its shells. Koken (*loc. cit.*) without sufficient warrant considers Meek's diagnosis as incorrect and proposes to extend the limits of the genus so that it will include, beside the species placed here by Meek and which Koken admits he has not seen, two other groups of species, one falling under our *Tetranota*, the other, having revolving surface markings, probably under *Bucanopsis*. For further discussions see remarks specially devoted to the genera named.

## Family BUCANIIDÆ.

Symmetric, involute shells; whorls rather numerous, merely in contact, or embracing slightly, all visible in the umbilicus; aperture often expanded abruptly; dorsal slit-band distinct, the slit itself generally very long and narrow, sometimes represented by a row of openings; surface with transverse lamellæ or lines, usually crossed at right angles by short ribs.

TETRANOTA, n. gen. (*Bucania* [part.] of Hall and other authors; *Bucanella* [part.], Koken, not Meek.) Shell thin; aperture moderately expanded, laterally chiefly; inner lip without callosity; sinus more or less deep, terminating in a short slit; whorls generally compressed so that the transverse diameter greatly exceeds the vertical; umbilicus open, large or of moderate size; dorsal band very wide, margined on each side by a strong ridge; about midway between these ridges and the narrowly rounded or angular sides of the volutions there is another ridge on each side, making in all four constant revolving ridges; aside from these the surface markings consist of rather delicate, sublamellose, regular lines of growth, each crossed at right angles by its own set of minute ribs. The revolving ridges, the lateral ones especially, are best developed on the inner whorls and may become quite indistinguishable near the aperture. Type, *Bucania bidorsata* Hall.

*T. macra* U. & S. *T. wisconsinensis* Whitfield sp.
*T. sexcarinata* U. & S. *T. bidorsata* Hall sp.
*T. obsoleta* U. & S.
} All Lower Silurian fossils and described in this volume.

KOKENIA, n. gen. (*Bucanella* [part.], Koken, 1889, not Meek, 1870.) Volutions depressed; slit-band wide, flat, elevated, with a broad concave space on each side; umbilicus open, rather large; aperture not expanded, lips thin, the outer one deeply emarginated. Surface with straight, uninterrupted revolving ribs, strong on the lateral parts of the dorsum, fine on the slit-band; growth lines very delicate. Type, *Bucanella esthona* Koken (Neues Jahrbuch für Mineralogie, etc., Beilageband vi, p. 389; 1889), Lower Silurian drift, Berlin. One American species, *K. costalis* U. & S.

MEGALOMPHALA, n. gen. (Ulrich.) This name is proposed for the widely umbilicated group of species which Koken has provisionally designated as the "Gruppe des *Bellerophon contortus*." The general form of the shell and volutions in these species is precisely as in the typical section of *Bucania*, as here restricted and defined. They may, however, be distinguished at once by the total absence of revolving surface sculpture. The apertural slit also appears to be much shorter, though the slit-band is well developed. In the last respect they agree with our *Tetranota*, but the expression in general is different, while the absence of the four revolving dorsal ridges, which are such a striking feature of that genus, must, for the present at least, be regarded as forbidding their reference to *Tetranota*. Again, they remind one of *Owenella*, but the presence of a distinct slit-band, which is wanting in that genus, is sufficient to distinguish them. These varied resemblances, however, probably give us a reliable clue to the developmental history of the *Bucaniidæ*. At present the line of evolution appears to be from *Owenella* to *Megalomphala* to *Bucania* to *Salpingostoma* to *Tremanotus*. *Tetranota* to *Kokenia* and *Oxydiscus* to *Conradella* are separate lines.

Eichwald's *Bellerophon contortus* may be regarded as the type of *Megalomphala*. Excepting the doubtful Chazy species which Hall in 1847 called *Bucania rotundata*, and which may belong in this connection, the genus is not known to occur in American strata. In Europe, according to Koken, it is represented by *Bellerophon contortus* Eichwald and *B. vaginati* Koken, in the Lower Silurian, by *B. taenia* Lindström, in the Upper Silurian, and by *B. macromphalus* A. Roemer, in the Devonian. That the last really belongs to *Megalomphala* requires confirmation.

BUCANIA, Hall (restricted). Shell consisting of three to five more or less depressed volutions coiled in one plane, with generally a wide umbilicus and not greatly—never abruptly—expanded aperture. Surface markings consisting of equal or unequal revolving riblets and lines of growth, together producing a more or less cancellated appearance. Revolving lines wavy or wrinkled, oblique, especially in the umbilicus, crossing from the ventral side of a whorl to the dorsal slit-band in the space of about one half a volution. Frequently they are interrupted by strong lamellæ, the wavy edges of which are parallel with the lines of growth and the apertural margin. Aperture transverse and somewhat reniform in the typical section, higher and relatively larger in the *B. nashvillensis* section. In the former the lips are thin, the outer one sinuate, and the sinus prolonged into a rather long narrow median slit; in the latter the inner lip is rather thick and the slit shorter. Slit-band distinct, raised or depressed. Type, *B. sulcatina* Emmons sp.

TYPICAL SECTION.

*B. sulcatina* Emmons. Chazy.
*B. halli* U. & S. Stones Riv. and Black Riv. grs.
*B. emmonsi* U. & S. Stones Riv. & Black Riv. grs.
*B. minnesotensis* U. & S. Stones Riv. & Blk Rv. grs.
*B. sublata* U. & S. Stone's River group.
*B. rugatina* U. & S. Black River group.
*B. elliptica* U. & S. Trenton group.
*B. intertexta* Hall. Trenton group.
? *B. punctifrons* Emmons. Trenton group.
Foreign species.—*B. ozekanowskii* Schmidt, Lower Silurian, Russia.

B. NASHVILLENSIS SECTION.

*B. nashvillensis* Ulrich. Trenton group.
*B. lindsleyi* Safford. Trenton group.
*B. frankfortensis* Ulrich. Trenton group.
*B. subangulata* Ulrich. Trenton group.
*B. micronema* Ulrich. Trenton group.
*B. peracuta* Ulrich. Trenton group.
*B. singularis* Ulrich. Trenton group.
*B. nana* Ulrich. Trenton group.
*B. nana*, var. *subpatula* Ulrich. Trenton group.
*B. simulatrix* Ulrich. Richmond group.
*B. crassa* Ulrich. Richmond group.

SALPINGOSTOMA, Roemer. (Leth. Geognostica, 1876.) Shell symmetrically coiled in one plane; volutions numerous, enlarging gradually, scarcely embracing, the consequence being a large open umbilicus. Aperture abruptly expanded at maturity, trumpet like; peristome thin, the outer portion slightly sinuate. Inner volutions with a slit band as in *Bucania.* This is replaced in the outer half of the last whorl by a long narrow opening or slit which, however, does not extend to the apertural expansion, but is closed some distance behind it. Surface marked with simple or sublamellose lines of growth and more or less oblique, irregular and sometimes interrupted or wavy revolving lines. Type, *S. megalostoma* Eichwald sp.

AMERICAN SPECIES.

*S. buelli* Whitfield sp. Stones River group.
*S. buelli*, var. *kentuckiensis* Ulr. Black Riv. group.
S. *expansa* Hall sp. Trenton group.
*S. sculptilis* U. & S. Trenton group.
*S. imbricata* U. & S. Richmond group.
*S. richmondensis* Ulr. Richmond group.
*S. canadensis* Billings. Hudson River group.
*S. fraternus* Billings. Hudson River group.

EUROPEAN SPECIES.

*S. megalostoma* Eichwald. Lower Silurian.
*S. locator* Eichwald sp. Lower Silurian.
*S. compressa* Eichwald sp.

TREMANOTUS, Hall.* In all respects like *Salpingostoma* excepting that an expanded aperture is developed at frequent and regular intervals, and the dorsal slit closed at corresponding periods, so that, instead of a continuous long opening, there is a series of small, elongate elliptical perforations. Type, *T. alpheus* Hall.

AMERICAN SPECIES.

*T. alpheus* Hall. Niagara group.
*T. chicagoensis* McChesney sp. Niagara group.
*T. trigonostoma* Hall & Whitfield. Niagara group.
*T. angustata* Hall sp. Niagara.
*T. profunda* Conrad sp. Lower Helderberg group.

FOREIGN SPECIES.

*T. longitudinalis* Lindström. Up. Silur., Gotland.
*T. compressus* Lindström. Up. Silur., Gotland.
*T. maideni* Etheridge, Jr. ? Triassic, New South Wales.

CONRADELLA, n. gen. (*Phragmolites,* Conrad, 1838, Ann. Geol. Rep. New York, p. 119.) Shell coiled symmetrically, general form as in *Cyrtolites* and *Oxydiscus,* the volutions enlarging gradually and being strongly keeled dorsally. Aperture oval or

* Twentieth Rep. New York St. Mus. Nat. Hist., p. 347; 1868.

subcordiform, widest in the middle or below, without callosities of any kind, nor with a sinus in the outer lip. From the aperture to a point about half around the dorsal circumference of the last volution there is a narrow open slit lying between two sharply elevated edges; behind this point the slit is closed over and forms an ordinary slit-band with distinct lunulæ. Surface with close or distant transverse imbricating lamellæ, the anterior edges of which are zigzagged and sometimes greatly spread out. Lamellæ plicated, the successive folds often arranged so as to form small revolving ridges; over all very fine lines of growth. Type, *C. obliqua* U. & S.

*C. fimbriata* U. & S. Stones River group.
*C. triangularis* U. & S. Stones River group.
*C. grandis* Ulrich. Stones River group.
*C. obliqua* U. & S. Black River group.
*C. compressa* Conrad sp. Trenton group.
*C. similis* Ulrich. Trenton group.
*C. imbricata* Meek & Worthen sp. Trenton gr.
*C. elegans* Miller. Loraine group.
*C. bellula* Ulrich. Loraine group.
*C. dyeri* Meek. Richmond group.
*C. dyeri*, var. *cellulosa* U. & S. Trenton.
*C. pannosa* Billings. Hudson River group.

OXYDISCUS, Koken.* (*Tropidodiscus*, Meek,† Waagen‡, not Steininger, 1855.) Strongly compressed, disciform shells; volutions embracing very little, expanding gradually to the aperture, sharply keeled; aperture somewhat lanceolate or subtriangular, without an inner callosity; outer lip with a deep V-shaped excision, continuing in the dorsal keel as a long and very narrow slit; behind the slit the summit of the keel may show a more or less distinct band with lunulæ, or merely a delicately bordered raised line. Surface markings consisting of growth lines only. These bend strongly backward in passing from the ventral side of the whorl to the keel. Type, *O. imitator* Koken.

AMERICAN SPECIES.

*O. acutus* Sowerby sp. Lower Silurian.
*O. disculus* Billings sp. Black Riv. and Trenton.
*O. subacutus* Ulrich. Trenton.
*O. cristatus* Safford sp. Trenton.
*O. magnus* Miller sp. Cincinnati.
*O. curvilineatus* Conr. sp. Schoharie grit and Up. Held.

According to Koken *Euomphalus strongi* Whitfield, a "Lower Magnesian" fossil, probably belongs here.

EUROPEAN SPECIES.

*O.* (*Euomphalus*) *planissimus* Eichwald. Low. Silur.
*O.* (*Porcellia*) *scutigerus* Eichw. Upper Silurian.
*O.* (*Cyrtolites*) *discus* Lindström. Upper Silurian.
*O.* (*Cyrtolites*) *orbiculus* Lindström. Up. Silurian.
*O.* (*Cyrtolites*) *delanonii* Œhlert. Low. Devonian.
*O. imitator* Koken. Middle Devonian.

## Family BELLEROPHONTIIDÆ.

Symmetrically involute shells, the whorls enlarging rapidly, the mouth generally expanded laterally and ventrally, not dorsally, the umbilicus mostly small or closed. Inner lip more or less thickened, the outer sinuate and centrally emarginate,

* N. Jarhbuch f. Mineralogie, etc., Beilageband vi, p. 390; 1889.
† Proc. Chicago Acad. Sci., vol. i, p. 9; 1866.
‡ Pal. Indica, ser. 13, pt. 2, p. 131; 1880.

the slit short; slit-band always present. Surface with lines of growth only, or cancellated, the revolving lines straight and never oblique with respect to the longitudinal axis of the volutions.

Bellerophon, Montfort (as restricted by Waagen). Symmetrically involute, subglobose shells, with or without an umbilicus, the latter never very large in the typical section; volutions more or less rounded on the back; aperture generally expanded, usually with a callosity on the inner lip; outer lip with a more or less deep central emargination behind which there is a well developed slit-band or an elevated blunt keel; surface sculpture consisting of more or less strongly developed striæ of growth only. Type, *B. vasulites* Montfort.

American species.

*B. allegoricus* White. Quebec gr.
*B. charon* Billings. Black River, Trenton.
*B. troosti* (d'Orbigny) Safford. Trenton.
*B troosti*, var. *burginensis* Ulrich. Trenton.
*B. clausus* Ulrich. Trenton.
*B. subglobulus* Ulrich. Trenton.
*B. bilineatus* Ulrich. Trenton.
*B. platystoma* Meek & Worthen. Trenton.
*B. similis* U. & S. Trenton.
*B. rugosus* Emmons. Loraine.
*B. recurvus* Ulrich. Loraine.
*B. capax* Ulrich. Utica, Loraine.
*B. mohri* Miller. Richmond group.
*B. subangularis* Ulrich. Richmond group.
*B. miser* Billings. Hudson River group.
*B.* sp. undet. Niagara.
*B. plenus* Billings. Gaspé.
*B. pelops* Hall. Schoharie grit, Up. Held.
*B. propinquus* Meek. Upper Helderberg.
*B. nactus* Hall. Chemung.
?*B. combsi* Walcott. Devonian.
*B. gibsoni* White. St. Louis.
*B. sublœvis* Hall. St. Louis, Chester.
*B. crassus* M. & W. Coal Measures.
*B. giganteus* Worthen. Coal Measures.
*B. percarinatus* Conrad. Coal Measures.
*B. tricarinatus* Shumard. Coal Measures.

Foreign species.

*B. fasciatus* Lindström. Upper Silurian.
*B. globulus* Lindström. Upper Silurian.
*B. sphaera* Lindström Upper Silurian.
*B. lineatus* Goldfuss. Devonian.
*B. tuberculatus* d'Orbigny. Devonian.
*B. vasulites* Montfort. Carboniferous.
*B. bicarenus* Leveille. Carboniferous.
*B. recticostatus* De Koninck. Carboniferous.
*B. scalifer* De Koninck. Carboniferous.
*B. martini* De Koninck. Carboniferous.
*B. sulcatulus* De Koninck. Carboniferous.
*B. ferrussaci* d'Orbigny. Carboniferous.
*B. sowerbyi* d'Orbigny. Carboniferous.
*B. canaliferus* Goldfuss. Carboniferous.
*B. tenuifascia* Sowerb. Carboniferous.
*B. hiulcus* Sowerby. Carboniferous.
*B. costatus* Sowerby. Carboniferous.
*B. plicatus* Ryckhold. Carboniferous.
*B. tangentialis* Phillips. Carboniferous.
*B. jonesianus* DeKoninck. Permo-Carb.
*B. orientalis* DeKoninck. Permo-Carb.
*B. affinis* Waagen. Permo-Carb.
*B. impressus* Waagen. Permo-Carb.
*B. squamatus* Waagen. Permo-Carb.
*B. blandfordianus* Waagen. Permo-Carb.
*B. triangularis* Waagen. Permo-Carb.

Bucanopsis, n. gen. (Ulrich.) (*Bellerophon* [part.] of authors; *Bucania* [part.], Waagen, 1880, and Koken, 1889.) This name is proposed for shells agreeing in all respects with *Bellerophon* excepting that their surfaces are cancellated by regular revolving and transverse striæ. The volutions enlarge rapidly, giving a broadly expanded aperture; the umbilicus is of moderate size and may be closed entirely, while the inner lip is always somewhat thickened. The revolving lines are never oblique nor wrinkled. Type, *B. carinifera*, n. sp. (Ulrich.)

American species.*

*B. carinifera* Ulrich. Trenton.
*B. exigua* Foerste. Clinton.

Foreign species.†

*B. gemma* Lindström. Upper Silurian.
*B. latevittata* Lindström. Upper Silurian.

* All, save the first, originally described under *Bellerophon*.
† The four species credited to Waagen were described under *Bucania*, all others under *Bellerophon*.

AMERICAN SPECIES.

*B. leda* Hall. Hamilton.
*B. lineolata* Hall. Hamilton.
*B. lyra* Hall. Hamilton.
*B. reperta* Hall. Hamilton.
*B. rotalinea* Hall. Hamilton.
*B. textilis* Hall. St. Louis.
*B. marcouana* Geinitz. Upper Coal Meas.
?*B. elliptica* McChesney. Upper Coal Meas.
?*B. kansasensis* Shumard. Upper Coal Meas.
?*B. meekana* Swallow. Upper Coal Meas.

FOREIGN SPECIES.

*B. subdecussata* McCoy. Upper Silurian.
*B. substriata* Krause. Upper Silurian.
*B. neglecta* Koken. Devonian.
*B. clathrata* d'Orbigny. Carboniferous.
*B. decussata* Fleming. Carboniferous.
*B. elegans* d'Orbigny. Carboniferous.
*B. striata* Fleming. Carboniferous.
*B. textilis* De Koninck (not Hall). Carboniferous.
*B. angustifasciata* Waagen. Permo-Carb.
*B. integra* Waagen. Permo-Carb.
*B. kattaensis* Waagen. Permo-Carb.
*B. ornatissima* Waagen. Permo-Carb.

The position of the last three species in the list of American species is somewhat doubtful. They should perhaps be placed with the *Bellerophon patulus* group (*Patellostium*).

PATELLOSTIUM, Waagen (emend.). (*Patellostium*, Waagen, *Phragmostoma*, Waagen [not Hall], Paleontologica Indica, ser. 13, pt. 2, p. 131; 1880.) In this group of chiefly Devonian species the characters of the shell may be said to agree in the main with *Bucanopsis*, though this agreement consists chiefly in the fact that both have revolving surface lines. Still, even these are not exactly as in *Bucanopsis*, being generally weaker (sometimes very much so) than the transverse lines and easily abraded. But the principal peculiarities lie in the greatly expanded aperture and the extent to which the inner lip is thickened and reflexed. The callosity is sometimes granulose and it may be cut out where it touches the dorsum of the preceding whorl, reminding one in both respects of *Protowarthia*. In our opinion these striking forms should be separated from *Bellerophon* and *Bucanopsis*. The only difficulty is in regard to the name by which the group may be known. Waagen distinguished his *Patellostium* from *Phragmostoma* upon what, in the absence of other differences, we cannot regard as a generic character.* The latter being the older name might be employed, only it is well known that what Waagen understood under that name is not the same as the original *Phragmostoma*, which is identical with *Carinaropsis*. *Patellostium*, on the other hand, is founded upon Roemer's *Bellerophon macrostoma*, which, unfortunately, is as yet known only from casts of the interior. Still, as it is highly probable that Roemer's species is congeneric with *B. patulus* Hall, we would suggest that *Patellostium* be so amended that it will include the following American species:

*Bellerophon newberryi* Meek. Upper Helderberg.
*B. natator* Hall. Hamilton.
*B. patulus* Hall. Hamilton.
*B. rudis* Hall. Hamilton.
*B. explanatus* Hall. Chemung.
*B. triliratus* Hall. Chemung.
*B. montfortanus* Norwood & Pratten. Coal Measures.

* In the first the inner lip is said to be entire, in the other "cut out where it touches the preceding whorl."

Euphemus, McCoy* (emend., Waagen†). Shell more or less globular or lenticular; whorls rounded, embracing so that there is no umbilicus; aperture not abruptly expanded, with the outer lip bilobed, the central insinuation moderately deep and rather wide; slit-band wide, defined on each side by a thin or thicker ridge; inner lip somewhat callous in its lateral parts, while the central portion spreads itself as a thin, longitudinally folded sheet over the inner volutions. These revolving ridges, or, as Waagen calls them, columellar folds, extend a greater or less distance beyond the aperture, in some cases reaching a point half around the last whorl. Beyond them to the outer edge of the aperture the surface usually appears smooth, but in perfectly preserved specimens it presents very fine lines of growth running parallel with the outline of the aperture. Type, *E. urii* Fleming sp.

Both McCoy and Waagen deny the existence of a slit-band, but Koken maintains (*op. cit.*, p. 393)—and, so far as the American species are concerned, we have material before us which permits us to sustain his assertion with absolute certainty—that it was always present. That it often, indeed generally, appears to be absent is due to the extreme liability of the outer or sculpture bearing layer of the shell to destruction, while on the inner volutions it is covered by the revolving columellar folds. For further remarks see under *Mogulia* (page 856.)

American species.

*E.* (*Bellerophon*) *carbonarius* Cox. Coal Meas. *E.* (*Bellerophon*) *modocarinatus* Hall. Coal Meas.

Foreign species.

*E.* (*Bellerophon*) *orbignyanus* Portlock. Carboniferous. Europe.
*E. urii* Fleming sp. Carboniferous. Europe.
*E. indicus* Waagen. Permo-Carboniferous. India.
*E. apertus* Waagen. Permo-Carboniferus. India.
*E. laevis* Waagen. Permo-Carboniferous. India.
*E. lenticularis* Waagen. Permo-Carboniferous. India.

Warthia, Waagen.‡ Smooth globular non-umbilicated shells, with a broad and rather deep rounded sinus in the outer lip, but without either a slit or slit-band. Inner lip only very slightly thickened, not extensive nor spreading (as in *Protowarthia*) over the umbilical regions. Aperture without lateral expansions. No revolving lines; striæ of growth very indistinct. Type, *W. polita* Waagen.

This genus is readily distinguished from *Bellerophon* by the breadth of the sinus in the outer lip and the entire absence of a slit-band. It is however singularly like the early Paleozoic group of shells for which we have created the genus *Protowarthia*. For comparisons and remarks on the probable significance of this and the preceding genus see below under *Mogulia*. So far as known *Warthia* is not represented in American strata. Waagen describes three species from the

* Synop. Carb. Foss. Ireland, p. 25; 1862.
† Pal. Indica, ser. 13, pt. 2, pp. 131, 163.
‡ Pal. Indica, ser. 13, pt. 2, pp. 131, 158; 1880.

Permo-Carboniferous of India, *W. polita*, *W. brevisinuata* and *W. lata*. To these he adds three Australian species, *Bell. undulatus* Dan., *Bell. strictus* Dan., and *Bell. micromphalus* Morr.

Mogulia, Waagen. (Pal. Indica, ser. 13, pt. 2, pp. 131, 156; 1880.) General appearance of shell as in *Bellerophon*, from which it differs in having no slit nor slit-band, and only a shallow angular emargination in the outer lip. Surface markings consisting of lines of growth only. These are broad and strong and cross over the dorsum without further interruption than is occasioned by the sharp central bend. Only known species, *M. regularis* Waagen, Permo-Carboniferous of India.

This and the two preceding genera, *Euphemus* and *Warthia*, are of unusual interest because we believe they show that in the decline of the family it actually retraced its steps by the adoption of primitive characteristics. In other words we regard them as atavistic types in which the progressive development of the individual was arrested in the embryo, and in which, because of the failure to develop the adult features of their immediate ancestors, certain characters that under previous conditions were larval only became permanent. In the Devonian and Carboniferous *Bellerophontiidæ* the suborder obtained the hight of its development, and this was not reached until after the extinction of all the other families. The decline, which obviously was very rapid, took place during the time immediately preceding the close of the Paleozoic age. Facts like these permit us to assume that the three genera under consideration are retrograde descendants of Carboniferous *Bellerophontiidæ* and not remnants of types that flourished only in Cambrian and Lower Silurian times. Besides, this idea is entirely harmonious with laws that have been shown to operate in other branches of zoölogy, and according to which the earliest and latest representatives of a group of organisms may be more like each other than either is like intervening stages in the rise, acme and decline of the line of evolution to which they belong.

*Mogulia*, in the absence of a slit-band, the shape of the outer lip, the form of the aperture, and even in the strength and course of the lines of growth on the dorsum, compares closely only with *Owenella*, that most ancient of all the *Bellerophontacea*. *Warthia*, excepting that it has no spiral surface lines, nor those grano-lineate extensions of the inner lip, is precisely like that important group of Lower Silurian shells which we have called *Protowarthia*. *Euphemus*, again, in its broad and ridge-bordered slit-band, in the shape of the aperture, indeed in the form and characters of the whole shell, recalls the Lower Silurian genus *Tetranota* probably more than either *Owenella* and *Protowarthia*. But in the spiral columellar folds which spread over the umbilical regions and a large part of the dorsum of the last volution, we have an extravagant development of the delicate grano-lineate extension of the inner lip which is the principal difference between *Protowarthia* and *Warthia*.

The points brought out in the foregoing paragraph are significant and indicate, we believe, that *Owenella* and *Protowarthia*, followed by some *Tetranota*-like type, were important stages in the development of *Bellerophon*. The types named are obviously progressive. The first has no slit-band and only a very shallow sinus, the second is still without the band but has a broad and deep sinus, while the third and fourth have a narrow and very deep parallel-sided sinus or slit which with the growth of the shell causes the formation of a slit-band.

STACHELLA, Waagen. (Pal. Indica, ser. 13, pt. 2, pp. 132, 171; 1880.) Shells agreeing in all respects with *Bellerophon* excepting that they are smoother and somewhat unsymmetrically coiled, there being an umbilicus on one side and none, or at any rate a shallow one, on the other. Type, *S. bifrons* Waagen.

So far as known no shells of this type have yet been found in American deposits. Two species occur in the Permo-Carboniferous of India, and five in the Permian of the Alps. The latter are described by Stache in his monograph of the fauna of the Bellerophon limestone. Regarding the genus, it seems to mark an important departure from the ordinary types of the family. We suspect that *Stachella* may be the radical of the ophisthobranchs, but this is a mere suggestion. The Cretaceous *Bellerophina*, d'Orbigny, is a similarly unsymmetrical shell, but has no slit-band and only a shallow emargination of the outer lip.

## Family CARINAROPSIDÆ.

Symmetrical, almost patelliform shells, the aperture being greatly expanded; apex small, involute, overhanging the posterior margin, consisting of no more than two volutions. Within the aperture a broad concave septum. Anterior lip with a central emargination.

This family embraces a small group of Lower Silurian shells that is readily distinguished from other bellerophontids by the internal septum. We believe that it should include also the genus *Pterotheca*, which is now almost universally referred to the *Pteropoda*. A discussion of the affinities of this genus will be found under *Carinaropsis*.

CARINAROPSIS, Hall.* (*Phragmostoma*, Hall,† not Waagen.‡) Shell consisting of little more than two volutions, the inner one very small, scarcely embraced by the outer, and shown in the umbilicus; outer volution greatly expanded, the whole shell appearing somewhat patelliform; dorsum carinate, the carina sharp on the inner

* Palæontology of New York, vol. i, p. 183; 1847.
† Fourteenth Rep. N. Y. St. Mus. Nat. Hist., p. 91; 1861.
‡ Palæontologica Indica, ser. 13, pt. 2, p. 131; 1880.

whorls but becoming less angular if not quite obsolete in nearing the apertural margin; slit-band occasionally distinguishable; outer lip of aperture thin, sinuate and notched centrally; inner lip entire where it touches the preceding volution; within the edge it is first deeply concave, then produced into a broad thick flattened plate or septum, which extends a considerable distance into the aperture; upper surface of septum with a low but well defined median ridge; inner aperture covered (always?) by a triangular flat operculum. Type, *C. carinata* Hall.

*C. acuta* U. & S. Black River group.
*C. minima* U. & S. Black River group.
*C. phalera* Sardeson. Black River group.
*C. carinata* Hall. Trenton group.
*C. cunulæ* Hall. Trenton group.
*C. explanata* Ulrich. Top of Trenton group.
*C. cymbula* Hall. "Hudson River group."

## Genus CYRTOLITES, Conrad.

*Cyrtolites*, CONRAD, 1838, Ann. Rept. Nat. Hist. Surv. N. Y., p. 118.
*Cyrtolites* (part.), Hall, 1847, Pal. N. Y., vol. i, p. 187. MILLER, 1874, Cin. Quart. Jour. Sci., vol. i, p. 308; also 1889, N. A. Geol. and Pal., p. 401. WAAGEN, 1880, Pal. Indica, ser. 13, pt. 2, p. 132. LINDSTRÖM, 1884, Silurian Gastropoda of Gotland, p. 81.

For generic characters see page 846.

Restricting this genus to species of the type of *C. ornatus* Conrad, we have an isolated group of a shells that we find most difficult to classify satisfactorily. Despite the fact that authors have so generally agreed in uniting with the group that other peculiar type which we separate as *Conradella*, there is in reality but very little reason for considering them as related and much less as identical. In discussing that genus on a following page it is shown, we believe, to the satisfaction of every fair-minded student that *Conradella*, with its long dorsal slit and imbricated lamellæ, is nearer *Bucania, Salpingostoma* and *Tremanotus* than to *Cyrtolites.* Indeed, we cannot see how an unprejudiced comparison of *Conradella* and *Cyrtolites* can fail to impress the observer with the conviction that the two groups of species are not only generically distinct, but not even closely related.

*Cyrtolites* has been loosely employed by most authors for symmetrically involute, disciform shells, having the dorsum carinate or angular and the umbilicus broad so as to expose the inner volutions. These characters pertain to several widely distinct genera, and to use them as characteristic of a single genus is to bring together a most heterogeneous assemblage of forms. Thus we have among the species that have been referred to *Cyrtolites* several belonging to *Oxydiscus*, Koken (*Tropidiscus*, Meek), a genus that is nearer *Bucania* and *Bellerophon;* several of *Conradella,* which, as we have said, is nearer *Bucania;* and all of the species comprised in the new genus *Cyrtolitina.* Lindström and others have thought that *Porcellia*, even, is the same as *Cyrtolites.* With equal propriety we might refer to the same generic group also the recent genus *Atlanta!*

But this will not do, for it would be nothing less than ignoring most palpable facts. We must return to the original type, *C. ornatus*, and restrict the genus to species possessing essentially the same generic peculiarities. After the characters mentioned in the first sentence of the preceding paragraph, which brings us down in the identification of the genus to four or five similarly constructed types, these peculiarities consist of (1) the subquadrangular cross-section of the whorls, (2) the simple and sharp edged or minutely serrated character of the dorsal carina, (3) the total absence of a slit-band and (4) the pattern of the surface markings which, with a single exception, differs from that of all other bellerophontids. The second and third of the features is shared by *Oxydiscus*, but as the latter has more numerous and more compressed volutions, a much deeper apertural emargination and slit, and lines of growth only, there is little trouble in separating it from *Cyrtolites*. *Conradella* is distinguished by its slit-band and remarkably long apertural slit, by the rounded or cordate section of its whorls, and by its strongly imbricating and wavy surface lamellæ; *Porcellia* has a long slit like *Conradella*, rounded volutions, the inner ones unsymmetrically coiled, and different surface markings. For comparisons with *Cyrtolitina*, which of all the *Bellerophontidæ* at present seems to be the nearest, see remarks on that genus (some pages hence).

Such strong resemblances are to be traced between casts of species of *Carinaropsis* and *Cyrtolites*, that, despite our strong assertion to the contrary on a later page, we would really not be surprised if future discoveries should prove that the two genera are related genetically. At present, however, the origin of that genus is enveloped in the greatest obscurity. As to *Cyrtolites*, it may have sprung from Cambrian *Stenotheca*.

The species remaining under the genus as restricted are not many, and all (six) about which there is no doubt are illustrated in this work. Four of the six are described as new. Of the other American species that have been referred to the genus, *C. compressus* Conrad, *C. dyeri* Hall, *C. elegans* Miller, *C. imbricatus* Meek & Worthen, and *C. pannosus* Billings, belong to *Conradella; C. magnus* Miller and *C. cristatus* Safford, to *Oxydiscus; C. nitidus* Ulrich, to *Cyrtolitina; C. subcarinatus* Emmons, probably to *Carinaropsis*. *C. filosus* Emmons and *C. trentonensis* Conrad are *Cephalopoda*; while the remaining forms, *C. desideratus* Billings, *C. expansus* Hall, *C. gillanus* White & St. John, *C. sinuatus* Hall & Whitfield, and *C. sinuosus* Hall, are too little known to be placed with anything like certainty. Of European species that have been referred to *Cyrtolites* perhaps none really belong there. *C. delanouei* Œhlert, and *C. orbiculus* Lindström doubtless belong to *Oxydiscus*, to which we are inclined to refer *C. discus* Lindström as well, although it has a distinct slit-band which should not be the case in a true *Oxydiscus*. Perhaps it would be better to place the last species, together with *C. euryomphalus* Lindström, into our new genus *Cyrtolitina*, which is more especially intended for the reception of four other Gotland shells described by Dr. Lindström as *Cyrtolites lamellifer*, *C. pharetra*, *C. arrosus* and *C. obliquus*.

### Cyrtolites ornatus *Conrad.*

PLATE LXII, FIGS. 27—31.

*Cyrtolites ornatus* Conrad, 1838, Ann. Geol. Rept. N. Y., p. 118; *Ibid.* (1839), p. 63; *Ibid.* (1841), p. 37. Vanuxem, 1842, Geol. Rept., p. 65, fig. 2. Emmons, 1842, Geol. Rept., p. 402, fig. 2. Hall, 1847, Pal. N. Y., vol. i, p. 308, pl. lxxxiv, figs. 1*a*-*g*. Meek, 1873, Pal. Ohio, vol. i, p. 148, pl. xiii, figs. 3*a*, *b*. Miller, 1874, Cin. Quart. Jour. Sci., vol. i, p. 308. And of many other authors.

Shell varying in diameter between 12 mm. and 30 mm., with the average at about 23 mm. Volutions two or three, rapidly increasing in size, strongly and sharply carinate dorsally, rhombic subquadrate in section; sides prominent and subangular or narrowly rounded along a line about three-fifths of the hight of the volution within the dorsal carina, the dorsal slopes gently convex and distinctly undulated by strong slightly curved transverse furrows and subangular ridges, the ventral or umbilical slopes almost flat and usually without undulations; ventral side with a sharp central furrow for the reception of the dorsal carina of the preceding volution. Umbilicus well defined, wide and deep, the edge wavy. Aperture a little wider than high, the hight equalling usually a trifle more than half the greatest diameter of the shell, more or less rhombic-subquadrate, the outline often becoming a little rounded with age. Entire surface covered by a delicate network formed of raised lines running almost straight across the whorls and short connecting lines arranged alternately, the result being somewhat similar to the pitting of a thimble. In a good light the network is generally distinguishable without the aid of a magnifier, and, excepting three specimens, quite uniform in strength in different shells, there being on the outer half of the last whorl nearly always seven or eight of the transverse lines and eight or nine of the short lines in 2 mm. In the excepted specimens the network is more compact, there being over the outer part of the last whorl from ten to twelve of the transverse lines in the same space. On another, with the reticulation unusually coarse, the number averages between six or seven. On the last specimen a good magnifier brings out some very fine lines of growth running through the network. It is important to note that there is no perceptible backward curvature of the transverse lines in nearing and crossing the dorsal carina.

The above description applies to the species as it occurs in the groups of the Cincinnati period wherever these are exposed in the United States and Canada. In its typical form the species is not known to occur in the Trenton, but a variety has been found in the Clitambonites bed of the Trenton group in Minnesota. For this we propose the subordinate name *minor*, the specimens being unusually small, none exceeding 11 mm. in diameter. The volutions seem also to be narrow, the hight at the aperture in the specimens at hand exceeding the width by about one-sixth. The surface markings are precisely as in the typical form of the species excepting that the transverse striæ in crossing the dorsal carina are sometimes bent slightly backward. The variety is of consequence chiefly because it proves the existence of the *ornatus* type at quite as early a time as that in which the *C. retrorsus* lived. And this fact justifies us also in denying that *C. ornatus* was evolved from *C. retrorsus*.

*Formation and locality.*—The typical form is a common fossil of the Loraine and Richmond groups at numerous localities in Ohio, Indiana, Kentucky, Pennsylvania, New York and Canada. At Cincinnati the shell is often covered by a parasitic bryozoan (*Leptotrypa ornata* Ulrich) which, when carfully chipped away, generally leaves a good cast of the surface markings and not infrequently the test itself. The species has not yet been certainly identified in the Utica group, but we suspect that one or two casts collected in the lower part of this group at Covington, Kentucky, may belong to it. Variety *minor* was found by E. O. Ulrich in the Clitambonites bed of the Trenton group, near Cannon Falls, Minnesota.

### Cyrtolites retrorsus, *n. sp.*

PLATE LXII, FIGS. 32—37.

Shell rather small, the diameter rarely exceeding 15 mm., in one case 20 mm., in others mostly from 12 to 14 mm.; in general appearance decidedly like *C. ornatus*, the dorsal slopes being strongly undulated, and the surface distinctly reticulated. Carefully compared, however, it is found to differ in the following particulars: the keel is more prominent, the dorsal slopes are more concave, the sides sharper, the transverse section of the volutions more distinctly quadrangular, and their rate of increase greater. The most important difference is in the form of the mouth and the direction of the transverse surface lines. The mouth namely is deeply cut out and the lines instead of passing directly across the back are strongly curved backward. Finally there is a small ridge along the suture line that has not been observed in *C. ornatus*. The retral curve of the transverse lines is slightly greater than in *C. carinatus* Miller, with the typical form of which *C. retrorsus* agrees very closely so far as the inner volutions are concerned. But mature specimens of the two species cannot be confounded, the dorsal slopes in Miller's species becoming flat with maturity, while undulations are not developed except in the oldest examples. In *C. retrorsus*, on the contrary, they begin very early, while the concavity of the dorsal slopes continues through all stages.

There can be no reasonable question about the specific distinctness of this shell, nor do we doubt that it will include, if not all, at least a part of the Tennessee specimens referred to *C. ornatus* by Prof. Safford. If any are in doubt, then it is those which he obtained from his "Orthis bed," which, like the Clitambonites bed in Minnesota, we place at the base of the Trenton group. The same form occurs also in equivalent strata in Kentucky, but none of the specimens seen by us are sufficiently perfect to permit of a positive decision in the matter. So far as the form of the shell and volutions is concerned, the specimens in question certainly agree very closely with *C. retrorsus,* and, if appearances are not deceptive, they are like it also in the backward swing of the surface markings. The evidence at hand, therefore, seems to indicate that all of the Tennessee and Kentucky Trenton specimens hitherto referred to *Cyrtolites ornatus* really belong to *C. retrorsus.*

*Formation and locality.*—Upper part of the Trenton group between Burgin and Danville, Kentucky, and Nashville, Tennessee. Probably also in the lower part of the group near the same localities. About ten specimens, mostly casts of the interior, have been found by one of the authors in the upper part of the Trenton group and in the lower part of the Utica group at Cincinnati, Ohio, and at Covington and Newport in Kentucky.

*Collections.*—E. O. Ulrich; Prof. J. M. Safford.

### CYRTOLITES RETRORSUS, var. FILLMORENSIS, *n. var.*

PLATE LXII, FIGS. 38 and 39.

Under this name we propose arranging provisionally a form occurring not very rarely in the shales of the Black River group at localities in Fillmore county. Unfortunately, none of the specimens before us are in a good state of preservation, all excepting three being more or less distorted casts of the interior. On two of the excepted specimens the shell is preserved on the inner volutions only, while the the third retains a few lines near the aperture. So far as can be determined, the variety differs from the typical form of the species only in having the sides of the inner volutions almost rounded, the form of the outer volution and the surface ornamentation being apparently as in *C. retrorsus.* The rounded character of the sides of the inner volutions in this, the oldest known variety of the genus, is a noteworthy feature, since it may give us a clue to the origin of the genus.

*Formation and locality.*—Black River group, Ctenodonta bed, Chatfield and near Fountain, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register,* Nos. 4051, 7535.

### CYRTOLITES CARINATUS *Miller.*

PLATE LXII, FIGS. 50–52.

*Cyrtolites carinatus* MILLER, 1874, Cin. Quar. Jour. Sci., vol. i, p. 311, fig. 32.
Comp. *Cyrtolites conradi* HALL, 1862, Geol. Rep. Wis., p. 55. (Figured only.)

Smaller than *C. ornatus,* the size being about as in *C. retrorsus,* the average diameter about 13 mm.; in two of our specimens it exceeds 20 mm. Sides sharply carinated like the dorsum, the dorsal slopes strongly concave on the first and second whorls, nearly flat on the last, without undulations except near the aperture of the largest examples; transverse lines sweeping backward from the edge of the umbilicus, stronger than the connecting lines, the difference between the two sets increasing with age.

The original description of the species is not entirely correct, Dr. Miller claiming that the surface "never presents a cancellated appearance," but he seems to have doubted the correctness of his observations since he adds, "at least not on any specimen observed." Out of more than twenty specimens belonging to the cabinet of one of the authors several preserve the surface markings in a fairly satisfactory manner. These show that on the inner volutions the surface is minutely though distinctly cancellated. The short connecting lines are delicate, and as growth proceeds they become relatively more so, a short exposure to the weather sufficing in many cases to efface them entirely, when the specimen will appear to have transverse striæ only. Generally, however, when the stronger set of lines is preserved, more or less convincing traces of the other set also are retained.

Compared with *C. ornatus* the present species is distinguished by its sharper lateral carinæ, flatter and more concave dorsal slopes, almost total absence of surface undulations, and by the backward sweep of the lines of growth. From *C. retrorsus* it differs in being practically without dorsal undulations, in having a less prominent dorsal carina, and in the flattening of the dorsal slopes of the last volution. So far as the two species mentioned are concerned, *C. carinatus* is clearly distinct, but we cannot say as much when we compare it with *C. conradi*, a species named and figured by Hall (*loc. cit.*), without a description, as one of the fossils of the Hudson River or Maquoketa shales of Wisconsin and Iowa. Hall's illustration represents a small *Cyrtolites* very similar to *C. carinatus*, and, as the geological horizon is about the same for both, it is not unlikely that the two names apply to the same species. To establish this as a fact would in our opinion necessitate a comparison with Hall's original type of *C. conradi*, and if that is no longer possible, it would be well to drop the name entirely.

*Formation and locality.*—Not uncommon in the Utica group at Cincinnati, Ohio, and a number of localities in the vicinity of that city. The species occurs probably also in the lower shales of the Cincinnati period in Wisconsin and Iowa, in which case it may be looked for in southern Minnesota as well.

## Cyrtolites parvus, *n. sp.* (*Ulrich.*)

PLATE LXII, FIGS. 45-47.

Shell small, about 7 mm. in diameter, 6 mm. wide at the aperture, consisting of about two rapidly enlarging volutions, subquadrangular in section and somewhat wider than high; dorsum carinated, the keel not very prominent, minutely wavy in a side view; sides narrowly rounded, scarcely angular; dorsal slopes gently convex, without undulations except near the aperture where several obscure ones may be noticed. Surface with comparatively coarse lines of growth, curving strongly backward from the edge of the umbilicus to the dorsal carina which they cross without interruption. These lines are connected by more closely arranged and very delicate obliquely revolving lines, which, being lower than the transverse set, might easily be overlooked. On the last turn seven or eight of the transverse lines occur in 2 mm.

Considering the size of the shell, the surface markings are stronger than in any of the other species of the genus. From *C. carinatus* Miller, which it resembles most, it differs also in having the sides of the volutions narrowly rounded instead of sharply angular. In *C. retrorsus* and *C. ornatus* the surface ornamentation is much more distinctly reticulated, and, while the former has a much stronger keel and concave dorsal slopes, the latter is especially distinguished by the absence of a sinus in the outer lip and consequently in the more strictly transverse course of the surface markings. Internal casts of *Cyrtolitina nitida* resemble testiferous examples of this species; but if this fact is borne in mind, and further that in the former the back is flattened, the volutions more compressed laterally, and the surface markings of the cast thicker and wave-like rather than thread-like, it is almost impossible that confusion between them can ever occur.

*Formation and locality.*– Near top of Trenton group at Covington, Kentucky.
*Collection.*—E. O. Ulrich.

## Cyrtolites disjunctus, *n. sp.*

PLATE LXII, FIGS. 48 and 49.

Shell about 24 mm. in hight, consisting of about two entirely free or disjoined whorls, coiled very nearly or quite symmetrically; volutions strongly and sharply carinated dorsally, the sides somewhat narrowly rounded within the center, and strongly undulated transversely; ventral side less convex, with two abruptly elevated narrow central carinæ, forming a groove with raised edges or what is commonly called a "saddle"; hight of volutions increasing with age more rapidly than the width, the transverse section, excluding the dorsal and ventral carinæ, changing from transversely subelliptical to almost circular at the aperture of a fully grown specimen. Surface markings on the whole nearly the same as in *C. ornatus*, only the transverse ridges are not confined to the dorsal slopes but continue downward with a slight retral curve over the ventral slopes as well. The reticulation of the surface also changes with growth in a manner not observed in that species. Thus on the minute inner whorl the surface is almost smooth, only a few obscure revolving lines being visible on this part. With the beginning of the second turn the sculpture changes abruptly to the usual style of reticulation, but for some distance the transverse lines curve backward towards the dorsal carina as in *C. retrorsus* and *C. carinatus*. This retral curve, however, is soon lost so that on the greater part of the shell they pass directly over the carina as in *C. ornatus*.

The peculiarities of this beautiful shell are so obvious that comparisons are quite unnecessary. It is the only species of the genus in which the whorls are not in contact.

*Formation and locality.*—Richmond group of the Cincinnati period, near Spring Valley, Minnesota, where two specimens were found in association with *Orthis subquadrata* and numerous other *Brachiopoda* characterizing the horizon.

*Collection.*—E. O. Ulrich.

### CYRTOLITES (?) DILATATUS, *n. sp.*

PLATE LXII, FIGS. 20–26.

Shell 15 to 30 mm. in hight, the inner volutions unknown, the outer expanding very rapidly in width, sharply carinated or alated on the sides, more obtusely upon the back, transversely triangular quadrate in section; dorsal slopes flat except near the prominent lateral edges where they are concave; ventral side nearly flat, with a central groove probably for the reception of the dorsal carina of the inner volutions; aperture nearly or about twice as wide as high, subtriangular, the width slightly exceeding the hight of the entire shell, the outer margin with a broad, centrally angular sinus, the inner lip with a small "saddle." Surface markings unknown; outer part of a large cast of the interior with a few faint transverse wrinkles of growth.

Of this remarkable species we have seen but two specimens, one, a large cast of the interior, belonging to the Powers' collection of the University of Wisconsin, the other a smaller testiferous example collected by E. O. Ulrich in Minnesota. The latter exhibits no signs of surface markings, but this is evidently due to lack of preservation. In the absence of any knowledge of the superficial sculpture, the generic position is somewhat doubtful. The great width of the aperture and the wing-like expansion of the lateral edges are suspicious and possibly indicate a relation to *Carinaropsis*. When fully known we believe it will be recognized as the type of a new genus intermediate in position between *Carinaropsis* and *Cyrtolites.*

*Formation and locality.*—Ctenodonta bed of the Black River group, Goodhue county, Minnesota The Wisconsin specimen seems to be from an equivalent horizon at Beloit.

*Collections.*—University of Wisconsin; E. O. Ulrich.

## Genus CYRTOLITINA, n. gen.

*Cyrtolites* (part.), ULRICH, 1879, Jour. Cin. Soc. Nat. Hist., vol. ii, p. 12. LINDSTRÖM, 1884, Silurian Gastropoda of Gotland, pp. 82–84.

For generic characters see page 847.

The five species at present believed to have the characters of this genus were originally all referred to *Cyrtolites.* They are, however, quite distinct from the typical species (*ornatus*) of that genus, and, in certain respects at least, nearer to *Bucania* and *Conradella.* With the latter genera they agree in the surface sculpture, in having the aperture distinctly emarginated, and in possessing a slit-band, while they differ in these features from *Cyrtolites.* On the other hand the agreement with *Cyrtolites* is stronger only in the form of the volutions and in their number, the whorls being much less in number and higher than wide instead of the reverse as in *Bucania.* It is difficult to decide as to the relative merits of these agreements, and, as we are scarcely beyond the threshold of knowledge respecting the Paleozoic *Gastropoda,* we will not presume to attempt it. Still, while we pay tribute to prevailing opinions in both the selection of the new name and in referring the genus to the *Cyrtolitidæ,* it is to be understood that the arrangement is less in accordance with our views than if we had placed it among the *Bucaniidæ.* To this statement we may add the suggestion that *Cyrtolitina* may have been derived from some form of *Bucania* like *B. subangulata.*

Comparing *Cyrtolitina* with its possible relatives we find that it differs from *Cyrtolites* in having a slit-band, less carinate dorsum, an apertural emargination, higher (more compressed) volutions, and surface markings that are to be called lamellose rather than reticulated; from *Bucania* in having fewer and laterally instead of vertically compressed volutions; and from *Conradella* in having fewer and more rapidly enlarging volutions, much shorter apertural slit, no distinct dorsal keel, and the subimbricating surface lamellæ curved strongly backward on the dorsum.

### CYRTOLITINA NITIDULA *Ulrich.*

PLATE LXII, FIGS. 53–55.

*Cyrtolites nitidulus* ULRICH, 1879, Jour. Cin. Soc. Nat. Hist., vol. ii, p. 12.

Shell small, 6 to 8 mm. in diameter; volutions about two, rapidly increasing in size, the outer embracing quite a half of the inner; dorsum blunt, thick, flattened in casts; sides gently convex to the edge of the umbilicus into which they descend at first rather abruptly, then gently, the ventral part spreading saddle-like over the inner volution. Aperture subcordate, notched below; outer lip rather broadly and deeply emarginated. Umbilicus about 3.5 mm. wide in a specimen 8 mm. in diameter, narrowly rounded at the edge. Surface of casts with distinct, subregular, retrally curved, transverse striæ, averaging about five in 2 mm. on the sides and back. The striæ continue over and are quite distinct and curved on the flattened dorsum or slit-band. On the latter some very fine revolving lines are faintly distinguishable. Somewhat oblique and stronger revolving lines, about four in 1 mm., occur on the sides of the volutions. Greatest diameter of a large specimen 8.3 mm; width of aperture 5.0 mm.; hight of same 5.0 mm.

The original description and figures are incorrect where they differ from the present work on the species. It is scarcely necessary to go into details.

Of American fossils we can compare this pretty shell only with species of *Cyrtolites* and possibly of *Bucania*. *Cyrtolites retrorsus* and *C. carinatus* are found with it, but both have more volutions, are sharply keeled and without a slit-band. The new *Cyrtolites parvus* is also associated and, because of its small size and relatively coarse markings, is more likely than any other fossil known to us to be confused with *C. nitidula*; still, they may be readily distinguished, *C. parvus* having the usual sharp dorsum and wider subquadrate aperture. Besides, it should be borne in mind that they are testiferous specimens and not casts of the interior of the species of *Cyrtolites* mentioned that look like casts of *Cyrtolitina nitidula*. Casts of *Cyrtolites* never show an imprint of the surface ornamentation, but those of the *Cyrtolitina*, on the contrary, are very distinctly marked.

*Formation and locality.*—Upper part of the Trenton group, in the river quarries ust west of Covington, Kentucky.

*Collection.*—E. O. Ulrich.

## Genus PROTOWARTHIA, n. gen.

*Bellerophon* (part.), of numerous authors.

For generic characters see page 848.

The, chiefly Lower Silurian, group of shells for which this genus is proposed is strikingly similar to the Permo-Carboniferous species embraced in Waagen's genus *Warthia*. Indeed, there is little more than a single character, and that possibly is not always well developed, which distinguishes them. In *Protowarthia*, namely, the inner lip is prolonged as a thin grano-lineate sheet around the umbilical regions and over a greater or lesser portion of the dorsum of the posterior end of the last volution. Nothing of this kind has been observed in *Warthia*. That the surface of at least some of the forms of *Protowarthia* is delicately cancelled is not now considered of special consequence. A more significant fact is that while *Protowarthia* is almost or entirely restricted to the earlier periods of the Paleozoic, *Warthia*, if the geological record is even approximately reliable and complete, did not make its appearance till just before the close of that age. Here we have a difference in geological distribution that can be accounted for in only two ways: either the Permo-Carboniferous *Warthia* is distinct from *Protowarthia* and originated in some nearly contemporaneous (say Carboniferous) type, or we must assume that the two are the same and that the connecting species, which in that case must have existed during the Upper Silurian, Devonian, Lower Carboniferous and Coal Measures, were either destroyed or remain yet to be discovered. Considering the abundance of other bellerophontids in these strata, the latter alternative is certainly very improbable.

On page 856 we express the opinion that *Warthia* (also *Euphemus* and *Mogulia*) is a result of the decline and approaching extinction of the *Bellerophontidæ*. As stated there, such a return to primitive characters is quite in accordance with theories that are rapidly entering the realm of facts. We would have been pleased to discuss the questions involved at greater length, but the lack of space necessitates a postponement to some perhaps more appropriate future opportunity.

Compared with other bellerophontid genera *Protowarthia* is distinguished by the absence of a slit-band and the width and size of the sinus in the outer lip; *Bellerophon* has a distinct slit-band and centrally angular sinus and slit; in *Owenella* there is an umbilicus, the sinus is much shallower and centrally subangular, and the form of the shell more nearly globose; *Bucanopsis* has a slit-band, and so has *Bucania*, coupled with a large umbilicus; finally, in *Oxydiscus* the whorls are laterally compressed and sharply keeled and the shell broadly umbilicated.

Respecting the species of *Protowarthia*, they are among the most characteristic and abundant fossils of the Lower Silurian system. None are known in the Upper Silurian and only a single Devonian species. The last, moreover, is doubtfully referred to the genus.

### PROTOWARTHIA RECTANGULARIS, *n. sp.*

PLATE LXIII, FIGS. 15–20.

Shell of medium size, rather closely coiled, leaving only a small umbilicus in the cast which, in the shell itself, is probably closed as in *P. cancellata;* outer volution sharply rounded dorsally, with a nearly flat or gently convex slope on each side, then turning rather abruptly into the umbilicus; aperture transverse, subtriangular, about twice as wide as high, the width but little less than the hight of the entire shell; sinus deep, the lobes not rounded but bending at almost a right angle in the middle; inner lip slightly reflexed and thickened on each side; test thin, composed apparently of two layers, the inner nacrous. Surface of specimens marked by more or less obscure lines of growth. These are usually the strongest on the dorsum, where they may be seen also on some casts of the interior. The latter, however, are in most cases quite smooth and without a trace of markings. External layer of shell not seen in good condition, so we cannot say positively, though we suspect it to be so, that it was marked near the umbilicus, as in the following species, by fine granulose striæ. Hight of shell 20.5 mm.; median hight of aperture 8.3 mm.; width of same 19 mm.; width of inner volution 7 mm.; depth of sinus 8 mm. In two other specimens, one very large, these dimensions are respectively, 24, 10, 23, 7 and 9 mm., and 30, 13.5, 27, 8 and 12 mm.

This species is often met with in collections under the name of *Bellerophon bilobatus*, but it is really quite distinct, as anyone may see by comparing the accompanying figures of that species with those of *B. rectangularis* given on plate LXIII.

A B C

Fig. 3. A and B, two views of *Protowarthia bilobata* Sowerby sp., and C, two views of *Bellerophon* (*?Oxydiscus*) *acutus* Sowerby; Caradoc sandstone, England. Copies of the original figures of these species on plate XIX of Murchison's "Silurian System," 1839.

It will be noticed that *B. bilobatus*, or *Protowarthia bilobata* as it should now be called, is a more ventricose shell, causing the back to be fuller and much more broadly rounded, while the apertural lobes, are, as usual, rounded in front instead of angular. The rectangular outline of the apertural lobes which has suggested the specific name, distinguishes *P. rectangularis* from all the other forms referred to *Protowarthia*. Indeed, it is a peculiarity that is not possessed by any other species of the whole suborder.

We have before us three specimens of a variety of this species from the Trenton limestone at Trenton Falls, New York. So far as this material at hand shows, the variety differs only in having the apertural lobes less angular than usual. We have also a number of internal casts from the Black River and Trenton shales and limestones of Minnesota which may represent other varieties of the species, but as we cannot be certain about them we prefer to leave them unclassified for the present.

*Formation and locality.*—Rather a common fossil of the Stones River group, at Mineral Point, Janesville and Beloit, Wisconsin, and Dixon, Illinois. In Minnesota it occurs, though not abundantly, in the Vanuxemia bed at Minneapolis, St. Paul and Cannon Falls.

*Collection.*—E. O. Ulrich.

## Protowarthia granistriata, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 28—30.

Shell scarcely reaching the medium size, closely coiled, leaving no umbilicus; center of dorsum raised into a low broad ridge, defined on each side by an obscure wide furrow; with age the outer boundaries of the latter increase gradually in distinctness, the back of the outer half of the last volution in the largest specimens presenting a flattened appearance; but the central ridge, though decreasing somewhat in hight, continues to the aperture. In casts of the interior there is a small umbilicus, while the central ridge is nearly as on the shelf itself. Aperture transverse, about twice as wide as high, the width generally equalling the hight of the shell; sinus wide, only moderately deep, the margin of the lobes bending rather sharply where the apertural margin is intersected by the faintly raised boundaries of the flattened dorsum. Except in the umbilical regions the test is thin. Out of nearly thirty specimens, only two preserve anything of the external layer. These show that it is marked by fine lines of growth and by very delicate revolving lines. All of the other testiferous examples preserve only the inner and middle layers, the latter appearing in every case quite smooth. Most of the specimens preserve what may be called a fourth layer. This seems to have been deposited by the inner mantle over the inner volutions, including the smaller half of the outer, while on each side it extends around the callous filling of the umbilicus. The whole of this layer is finely granulose, except the lateral extensions and these are covered by wavy revolving striæ. Hight of an average shell 19 mm.; width of aperture 19 mm.; median hight of same 9.3 mm.; width of inner volution 6 mm.; depth of sinus 5 mm.; width of same about 10 mm.

In this species the sinus is only about half as deep as in *P. rectangularis*, the apertural lobes are not rectangular, the umbilicus is closed entirely, and the volutions rounded rather than subtriangular in cross section. It is nearer *P. cancellata* Hall, but that species has a slightly deeper sinus, and a rounder back, the back never being flattened, nor is there ever a sign of the low dorsal ridge and obscure furrows characterizing *P. granistriata.*

*Formation and locality.*—At present this species is known certainly only from the Utica group in the vicinity of Cincinnati, Ohio.

*Collection.*—E. O. Ulrich.

PROTOWARTHIA PLANODORSATA, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 31—35.

Of this form we have six specimens. These show that it is of the type of *P. granistriata,*—perhaps it should be called a variety of that species,—differing in having the flattening of the back of the last volution much more decided, while the central ridge is wanting entirely, at any rate it is so for the outer volution. The dorsum of the volutions seems to be rather narrowly rounded. The surface markings are essentially the same in the two forms, as is also the form of the aperture and the dimensions, the largest specimen being about 24 mm. in hight.

The broad dorsal flattening will distinguish *P. planodorsata* at once from all other species of the genus and family known.

*Formation and locality.*—Utica group, Covington, Kentucky.

*Collection.*—E. O. Ulrich.

PROTOWARTHIA PERVOLUTA, *n. sp.*

PLATE LXIII, FIGS. 21—27.

This also may be only a variety of *P. granistriata,* but it is one well worthy of a distinct name. It is almost constantly smaller, the hight in the majority of the specimens being less than 15 mm., and in only one out of over fifty is it 20 mm. Comparing the two forms we find that *P. pervoluta* is more closely inrolled, giving a more globose form. The aperture also is relatively wider and the umbilical callosity has a columella-like twist that is not seen in *P. granistriata.* The volutions further are nearly uniformly rounded dorsally and never show anything either of a central ridge or a flattening. Though some of the specimens before us are tolerably well preserved, none of them exhibit any satisfactory evidences of external markings save the granostriate marking of the inner volution. This is more extensive, but in other respects essentially as in the two preceding species. Here and there a small patch of the external layer is retained and these sometimes exhibit faint traces of exceedingly delicate transverse and revolving lines.

*Formation and locality.*—In Kentucky this species occurs in the Black River group and in the lowest bed (Orthis or Modiolodon bed) of the Trenton group. In Minnesota casts of the interior are not uncommon in the Rhinidictya and Ctenodonta beds of the Black River group at St. Paul and Minneapolis. Testiferous examples are rare here, but further south near Cannon Falls and at Chatfield they are more abundant.

*Collections.*—E. O. Ulrich; W. H. Scofield.

## PROTOWARTHIA CANCELLATA *Hall.*

PLATE LXIII. FIGS. 1–14.

*Bellerophon cancellatus* HALL, 1847, Pal. N. Y., vol. i, p. 307.
Compare *Bellerophon bilobatus* of Hall and other American authors, not of Sowerby.

The general form of this shell is much as in *P. rectangularis* and *P. planodorsata*, the average of characters being about intermediate between these two species. From the first it is distinguished by the more rounded back of the volutions and the rounded instead of angular outline of the apertural lobes. The sinus in the outer lip also is less V-shaped. From the second it is sufficiently distinguished by the rounded instead of broadly flattened dorsal region of the last whorl. Young specimens, especially if casts only were compared, would perhaps prove inseparable.

We refer here a large number of casts from the Black River and Trenton groups of Minnesota and elsewhere, as well as casts and testiferous specimens from the Utica, Loraine and Richmond groups of the Cincinnati region. The specimens from the Trenton period might be separated as var. *trentonensis*, as they are almost constantly a trifle more narrowly rounded dorsally than is the geologically higher typical form of the species. And yet we have specimens from the Black River group at Chatfield, Minnesota, that are, so far as it is possible to determine, precisely the same as the common variety of the species found in the lower part of the strata at Cincinnati, and which we regard as typical of the species.

Specimens preserving the shell in a satisfactory manner are everywhere rare. The outer layer which carries the transverse and revolving lines is nearly always gone, and, so far as our observation is concerned, this layer is retained, if we except two or three instances, only by specimens that have been removed from the solid limestone. These show that the perfect shell was ornamented with fine lines of growth, generally a little unequal, and even finer (just visible to the naked eye) revolving lines. The former may be obscurely visible on the inner layers of the test, but the latter are entirely superficial. Now, while most of the testiferous examples are almost entirely smooth, the greater number preserve the irregular or wavy revolving lines which surround the umbilical regions. This is true not only of this species but of the preceding forms as well, and proves that these thin extensions of the callosity of the inner lip are composed of a more durable substance than is the usual sculpture-bearing layer of the shell. So far as observed the inner whorls are not granulose dorsally as is the case in *P. granistriata*, *P. pervoluta* and *P. planodorsata*. The umbilical callosities of the inner lip are sharply defined, oblique and somewhat flattened, though always more or less excavated.

We have not seen the original type of this species which Hall sought to separate from the specimens which he regarded as *Bell. bilobatus*. But we have little or no doubt of the correctness of our identification, nor of the specific identity of a large proportion of the specimens that American authors generally and erroneously place under Sowerby's *Bellerophon bilobatus* and *P. cancellata.* The only difference between the two supposed species mentioned by Hall is that one has a cancellated surface, the other not. According to our view this difference is merely a matter of preservation, and if we are correct in this then *P. cancellata* is the commonest by far of all the Lower Silurian bellerophontids.

As to *P. bilobata* Sowerby, the original figures of which are reproduced on page 869, we have not the least doubt that it is specifically distinct from *P. cancellata,* that species being a larger and more globose form. Indeed, we doubt very much that Sowerby's species occurs in America.

*Formation and locality.*—Not uncommon in the Black River group, principally in the Ctenodonta bed, at Minneapolis, St. Paul, Cannon Falls, Chatfield and other localities in Minnesota. Also in Mercer county, Kentucky, and in Canada. It is very abundant in the Trenton, Utica, Loraine, and Richmond groups, in the first three especially, at numerous localities in Minnesota, Wisconsin, Iowa, Illinois, Kentucky, Ohio, Indiana, Tennessee, New York and Canada.

### PROTOWARTHIA SUBCOMPRESSA, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 40—44.

Shell large, compressed-subglobose, the greatest hight and width about as six is to four; back broadly rounded, sides somewhat flattened, umbilicus closed, wanting; aperture semi-ovate, outer lip thin, inner lip moderately thick and reflexed in the umbilical regions; callosity extending over the whole front of the inner volution, apparently smooth; sinus broad and about as deep, the depth decreasing slightly with age; apertural lobes rounding very gently to the sinus where the outline makes a rather sharp curve. Surface marked by fine lines of growth and near the aperture by some obscure wrinkles. The callosity which extends over the inner volutions exhibits the usual fine irregular revolving lines in the umbilical regions. When the shell is removed, the cast shows a narrow furrow down the center of the back and several more faintly on each side. Greatest diameter 41 mm.; smallest diameter 29 mm.; width of aperture 27.5 mm.; hight of same (central) 19.5 mm.; width of inner volution 13 mm.; depth of sinus 7 or 8 mm.

This fine species, besides attaining a greater size than *P. cancellata,* differs from it in being narrower and in wanting, as far as known, the delicate revolving lines of that species. The umbilical callosity of the inner lip is also less and does not slope outwardly, the edge only being reflected. *Bellerophon morrowensis* Miller and Dyer, which also may belong to *Protowarthia,* is insufficiently known. According to the descriptions, it seems to differ in having the dorsal side sharply angular. *P. planodorsata* has a wider aperture, revolving lines, and a flat dorsum.

*Formation and locality.*—Richmond group of the Cincinnati period, Versailles, Indiana, and Butler county, Ohio.

*Collection.*—E. O. Ulrich.

## Protowarthia concinna, *n. sp.*

PLATE LXIII, FIGS. 36—39.

Comp. *Bellerophon morrowensis* Miller and Dyer, 1878, Contr. to Pal., no. 2, p. 8.

The specimen upon which this species is founded has, although it is much smaller, relatively nearly the same dimensions and form as *P. subcompressa.* The dorsum however is narrowly rounded instead of broadly, the aperture is triangular rather than semi-ovate, and the sinus is narrower, while the thickened base of the lip forms a small sharply defined and shallow umbilical depression which is not seen in that species. The surface of the specimen is without markings of any kind save on the small end of the visible volution where some traces of minutely granulose lines are to be detected. Greatest diameter 18 mm.; transverse diameter 13 mm.; width of aperture 11.5 mm.; central hight of same 8 mm.

It is possible that this is not distinct from the *Bellerophon morrowensis* described by Miller and Dyer from about the same horizon in Ohio. If they prove to be the same then their type specimen must be considerably crushed since it is described as "lenticular in form" and with the "dorsal side sharply angular." Under the circumstances we are obliged to consider our species as distinct.

*Formation and locality.*—Richmond groups of the Cincinnati period, near Spring Valley, Minnesota.

*Collection.*—E. O. Ulrich.

## Protowarthia obesa, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 45—47.

Shell rather large, obese, the greatest diameter between 30 mm. and 45 mm., the greatest width of the aperture usually about one-tenth less; volutions ventricose, almost uniformly rounded, the center of the dorsum just appreciably elevated; umbilicus covered by the reflexed or thickened lip, small in the cast; aperture transverse, the central hight somewhat greater than half the width; apertural lobes rounded, sinus very broad and comparatively shallow, but the depth seems to be somewhat variable; test thick. The specimens are all casts of the interior and exhibit merely obscure traces of the lines of growth. A small patch of the shell on one of the specimens shows that the growth lines are fine and unequal, and that revolving lines are wanting. Two or three broad transverse furrows cross the back of each of the five specimens before us. These furrows were produced by thickened bands upon the inner side of the shell, passing almost directly from side to side,—at any rate they are much less sinuate in the middle than is the margin of the aperture.

The ventricose volutions, shallow sinus and broad transverse furrows (on casts) are the distinctive features. Very young specimens may look much like the largest of *P. pervoluta*, but the adult form, which is all we have seen, is certainly quite distinct. *P. obesa* should be compared with the British *P. bilobata* Sowerby sp. (see fig. 3, p. 869) because it is, according to our opinion, the nearest known American representative of that much (mis-) quoted species. And still the American form is distinct if only for the reason that the apertural sinus is deeper in the *bilobata*.

*Formation and locality.*—Lower beds of the Trenton group, Burgin and Danville, Kentucky.

*Collection.*—E. O. Ulrich.

## Genus TETRANOTA, n. gen.

*Bucania* (part.), HALL, 1847, Pal. New York, vol. i, p. 186.
*Bellerophon* (part.), WHITFIELD, 1874, Geol. Wis., vol. iv, p. 223.
*Bucanella* (part.), KOKEN, 1889, Neues Jahrbuch f. Mineralogie, etc., Beilageband vi, p. 389.

For generic characters see page 849.

Superficially examined the systematic position of this genus will probably appear to be between *Megalomphala* and *Euphemus*. The relation to the latter however is more apparent than real. Comparing the five species now referred to *Tetranota* we find that the umbilicus, though always present, is yet somewhat variable, being very large in *T. macra*, *T. sexcarinata* and *T. bidorsata*, moderate in *T. obsoleta*, and comparatively small in *T. wisconsinensis*. The vertical expansion of the aperture is extremely limited in all save the last mentioned, and in this the vertical diameter of the volutions also is greatest. The external sculpture, aside from the revolving ridges, consists chiefly of lines of growth. These are always regular and sharp, but vary in strength with the species.

While strong revolving lines like those of *Bucania* or of *Bucanopsis* do not occur, it is nevertheless a fact that in all cases of *Tetranota* preserving the external layer of the shell, or an impression of the same, we observed a row of minute prominences on each of the sublamelliform lines of growth. In a few instances we found further that these prominences were in reality the anterior terminations of very fine short striæ crossing from line to line. This style of sculpture, excepting that it is much finer, is essentially the same as that marking the *B. lindsleyi* section of *Bucania*. We attach great weight to this point and believe that it proves our association of the genus with the *Bucaniidæ* to be well founded.

The four revolving dorsal ridges, which we regard as the principal peculiarity of the genus, are always distinctly developed on the inner volutions. In *T. sexcar-*

*inata* they continue also over the outer volution quite to the margin of the aperture. In *T. bidorsata* and *T. wisconsinensis* the two central ones become more prominent toward the aperture, and on casts of the interior usually appear as a broad and more or less flat-topped single ridge. In the former the lateral ridges, though much less distinct, are still distinguishable in the outer half of the last whorl, but in the latter not a trace of them is to be seen on any part of the outer volution of casts of the interior, the only condition in which the species is known. The same is true of *T. obsoleta* with the addition that the double central ridge also is much less developed than in the other species.

The unusual width of the slit-band, which lies between the two central ridges and is more or less concave—never much so,—is another important characteristic, though not entirely confined to *Tetranota*.

Briefly the new genus differs from all the other genera of the suborder in the possession of four dorsal ridges. In most other respects we find that *Tetranota* agrees closely with *Bucania* and *Megalomphala*. Still there are some good additional differences. Thus, *Bucania* has a narrower slit-band and longer slit, besides stronger revolving surface sculpture, while *Megalomphala* agrees in all respects with *Bucania* excepting that it has no revolving lines. The Cambrian *Owenella*, though reminding one in a general way of *Tetranota*, is distinguished at once by the absence of a slit-band. It is scarcely necessary to extend our comparisons to such widely different types as *Bellerophon*, *Bucanopsis* and *Protowarthia*.

As to the shells of *Euphemus*, about which genus we have already (see page 856) expressed the opinion that it is an atavistic type of Carboniferous *Bellerophontidæ*, they have no umbilicus and their apertures are even less expanded. Further, they have an inner lip slightly thickened laterally and its central portion, which bears more or less numerous revolving folds, is spread as a thin sheet over the inner volutions and part of the outer. These folds may recall the ridges of *Tetranota*, but are in reality quite different, being a feature of the ventral side of the shell in the one case and of the dorsal side in the other.

Koken (*loc. cit.*) connects several Silurian and Devonian species of Europe with *T. bidorsata*. In this he has doubtless committed an error, while his proposal to use Meek's *Bucanella* for the group seems to us quite unwarranted. In the first place his *Bucanella esthona* and *B. subtriata* Krause sp. (we are not sufficiently acquainted with the others to include them in our opinion) are not congeneric with *T. bidorsata*, being without the characteristic dorsal ridges, while they have uninterrupted straight revolving lines which do not occur in a *Tetranota*. Where the *subtriata* belongs is most difficult to say just now,* but of the *esthona* we may say that it is kept out of

* We refer to this species again in our remarks on *Bucanopsis*.

*Bucania* by its wide slit-band and straight revolving lines, while the first character, together with its different (*Bucania*-like) aperture excludes it from *Bucanopsis.* Having to describe a similar species from Minnesota, we have concluded to establish a new genus, *Kokenia,* for their especial benefit.

The vertical range of three of the species of *Tetranota* is more extended than usual with *Bellerophontacea.* *T. obsoleta* occurs in the Vanuxemia bed of the Stones River group, in the Ctenodonta bed of the Black River group, and reappears; apparently very slightly modified, in the Utica group at Cincinnati; *T. bidorsata* occurs in the lowest division of the Stones River group of Tennessee, in the Black River group in Minnesota and Canada, and in the Trenton of Minnesota, Kentucky, Tennessee, New York and Canada; *T. sexcarinata* is found in the Vanuxemia bed in Minnesota, Wisconsin and Illinois, in the "Glade limestone" of Tennessee, and in the Fusispira bed of the Trenton in Minnesota. *T. wisconsinensis* is as yet known only from the Vanuxemia bed in Minnesota, Wisconsin and Illinois, while *T. macra* occurs in the same bed at Minneapolis.

### TETRANOTA BIDORSATA *Hall.*

PLATE LXV, FIGS. 10–18.

*Bucania bidorsata* HALL, 1847, Pal. N. Y., vol. i, p. 186.

Shell usually about 12 mm. in hight, but the hight may exceed 20 mm., and occasionally reaches 25 mm.; volutions two and a half to three and a half, vertically compressed, sublunate in section, the width for the inner volutions or in young specimens a little greater than twice the hight; in old examples the increasing altitude of the centro-dorsal ridges causes the width just behind the aperture to be proportionally somewhat less; umbilicus large, deep, rather sharply defined, the width generally about half of the greatest diameter of the shell; the latter dimension is to the greatest width of the aperture about as three is to four. Aperture somewhat abruptly expanded laterally, the hight and width about as three is to seven; slightly indented by the preceding whorl; lips thin, the outer one with a moderately deep emargination, taking up between one-fourth and one-third of the anterior outline; depth of the same about one-fifth less than its width. Dorsum with four strong revolving ridges, the two central ones nearer each other than to the lateral ones, and higher, the altitude also increasing gradually to the aperture; between them lies the broad slit-band which is more distinctly concave on the shell than on internal casts, the double ridge in the latter, particularly near the aperture, often appearing as a broad and more or less flat-topped single ridge; on each side of the central ridges there is first a broad groove, then an obtusely angular ridge, and finally a narrower groove which slopes down to the angular or sharply rounded side of the volution. While the central pair of ridges increases in prominence, the lateral pair becomes more and more indistinct on the last volution, till at the apertural margin they are scarcely distinguishable,—at any rate this is true of casts. The transverse surface markings are prominent, regular, visible to the unassisted eye, about three in 1 mm.; the course of the striæ from the umbilicus is at first nearly straight across, and it is only in the centro-lateral grooves that they curve backward very strongly. When the characters of the external layer are preserved, these very fine short lines are to be seen crossing the transverse lines rectangularly.

### Variety MINOR, *n. var.*

(Not figured.)

This subordinate name is proposed for a small variety of the species which we have found in the Black River shales of Minnesota. The largest specimen seen is less than 10 mm. in hight. All four of the dorsal ridges retain their prominence to the apertural margin, and in this respect the variety is like *T. sexcarinata.* The edge of the umbilicus, however, is not angular, but narrowly rounded, while the transverse striæ are much finer, eight or ten occurring in the space of 1 mm. On the best specimen each of the transverse lines carries a row of very minute prominences.

Although we have not seen the original types of this species, we are still reasonably confident that the specimens above described are of the form to which the name *bidorsata* should be restricted. That authors and collectors have included under this name more than one species is clear from published lists, they having no doubt viewed the dorsal ridges as a specific feature, while we regard them as of generic importance.

*Formation and locality.*—Stones River group (Central limestone), Murfreesboro, Tennessee; Black River group (Ctenodonta bed,—var. *minor*), Minneapolis, St. Paul, Cannon Falls, and near Fountain, Minnesota; Trenton group (Clitambonites and ?Fusispira beds), St. Paul, Cannon Falls, and near Fountain, Minnesota. In Canada Billings catalogues it as a Black River and Trenton fossil; in Kentucky and Tennessee it occurs in the same groups. Hall's original types are from the lower beds of the Trenton at Middleville and Watertown, New York. Testiferous examples are very rare in Minnesota, but casts are rather common in the Clitambonites bed at several points in Goodhue county.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield:

*Museum Register*, Nos. 7382, 7435, 7439, 7456, 7513, 7522.

## TETRANOTA SEXCARINATA, *n. sp.*

PLATE LXV, FIGS. 3–9.

This species grew to a larger size than Hall's *T. bidorsata,* the average hight being from 25 mm. to 30 mm. The volutions also are somewhat wider, the hight and width being respectively as two is to five. The dorsal ridges differ in this that the centro-lateral pair continues in full strength almost or quite to the apertural margin. There is besides a lateral pair of ridges, not so strong as the others though still quite distinct, making in all six revolving ridges. This outermost pair may occasionally appear to be represented in *T. bidorsata*, though never so distinctly; yet when carefully compared it will be noticed that *T. sexcarinata* really has an extra pair, since the ones which in Hall's species form the extreme lateral boundaries of the volutions, and at the same time the edge of the umbilicus, are present also in *T. sexcarinata*. The umbilicus is of about the same size and character in the two species, but the mouth and surface markings are different. The sinus in the outer lip, namely, is deeper and much wider, the backward sweep of the lines of growth beginning already between the edge of the umbilicus and the outer ridge instead of at the centro-lateral ridge. Furthermore, the lines are much farther apart and coarser, the distance from line to line averaging about 1 mm. Finally, the lines of growth are, though more or less obscurely, reproduced on casts of the interior, while no trace of them is observable on casts of the other species.

With the differences mentioned there can be no reasonable doubt about the specific distinctness of *T. sexcarinata* and *T. bidorsata*; and the others are still farther removed. Good adult specimens cannot be confused, only the young being sufficiently alike to render separation difficult.

*Formation and locality.*—Stones River group (Vanuxemia bed), Minneapolis, St. Paul and Cannon Falls, Minnesota; Beloit and Janesville, Wisconsin; Dixon, Ill.; Lebanon and Lavergne, Tennessee. Trenton group (Fusispira bed), Fillmore county, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, Nos. 5064, 7530.

## TETRANOTA MACRA, *n. sp.*

PLATE LXV, FIGS. 1 and 2.

This species reminds one in its markings of *T. sexcarinata*, but has only four dorsal ridges. The lines of growth also are stronger, showing distinctly on casts. The umbilicus is relatively larger than in any of the other species of the genus and the sides of the volutions more sharply angular. Corresponding differences occur in the form of the aperture.

*Formation and locality.*—Vanuxemia bed, Stones River group, Minneapolis, Minnesota.

*Collection.*—E. O. Ulrich.

### TETRANOTA OBSOLETA, *n. sp.*

PLATE LXV, FIGS. 19–23.

This species differs from *T. bidorsata* in several obvious respects. Chief among these is the fact that the revolving ridges are much less developed, especially on the last volution, the centro-lateral pair being quite obsolete except on the inner volutions, while even the central pair does no more than to merely maintain the same strength relatively that it held in earlier stages. Interior casts of mature shells exhibit a broad, comparatively low and more or less distinctly grooved central ridge, beyond which the surface is first shallowly excavated and then gently convex to the lateral boundaries of the volutions, which again are not angular but narrowly rounded. The exterior of the shell looks the same, only the ridges bordering the slit-band appear thinner and sharper. Continuing our comparisons with *T. bidorsata* we find that the umbilicus is smaller and less abrupt, and the volutions more rounded on each side and therefore elongate-reniform in cross-section.

The form of the aperture and the surface markings seem to be very nearly the same in the two species. The latter were easily abraded, and on only a single specimen,—it is from the Utica group at Cincinnati and doubtfully referred to the species,—have we been able to make them out at all. In this specimen they are imperfectly preserved near the aperture. Here they appear to be somewhat finer than in *T. bidorsata* and each seems to have borne a row of minute prominences.

It is scarcely likely that any one will ever find it difficult to separate *T. obsoleta* from *T. sexcarinata*, the apertural sinus being deeper and the revolving ridges even more prominent and constant in that species than in *T. bidorsata.*

The largest specimens of *T. obsoleta* occur in the Vanuxemia bed of the Stones River group at Minneapolis. One of these has a hight of nearly 30 mm. The others range from this size down to about 15 mm. The average hight of the specimens from the Black River and Trenton groups is less, being only about 15 mm., while in the largest it did not exceed 20 mm. In the Utica group however the average was increased again to almost 20 mm.

*Formation and locality.*—Stones River group (Vanuxemia bed), Minneapolis and St. Paul, Minnesota; Janesville, Wisconsin. Black River group, Mercer county, Kentucky; (in Ctenodonta bed) Chatfield and six miles south of Cannon Falls, Minnesota. Trenton group (Fusispira bed), Goodhue couty, Minnesota. Utica group at Cincinnati, Ohio, and localities in the vicinity of that city.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, Nos. 510, 5109, 7294, 7465.

## Tetranota wisconsinensis *Whitfield.*

PLATE LXV, FIGS. 26—29.

*Bellerophon wisconsinensis* Whitfield, 1878, Ann. Rept. Geol. Surv. Wis., p. 76; also 1882, Geol. Surv. Wis., vol. iv, p. 223, pl. vi, figs. 15, 16.

Greatest hight of shell varying in the material before us from 8 mm. to 37 mm.; closely coiled for the genus, subglobular in form when young, but becoming strongly bilobed, with the last volution less inrolled and the lips greatly expanded laterally and somewhat also above (yet not materially thickened) in the adult form; in the latter the outer lip is deeply notched in the middle, the notch spreading anteriorly more slowly than usual, the lobes on each side rounded-triangular in outline. Dorsal periphery of casts with a broad, revolving band, the top of which may be slightly convex, flat or concave, the whole increasing in elevation with age; on each side of the central band the inner volutions (as seen in fractured specimens) have first a concave space and then a ridge, but these pertain chiefly to the exterior side of the shell, being only in rare cases, and always with difficulty, distinguishable on casts; inner volutions elongate-reniform in section, outer volution more triangular; umbilicus comparatively small, the width only about one-fifth of the greatest diameter of the shell. Surface markings nôt fully determined, apparently as in *T. obsoleta* and *T. bidorsata.*

The essential generic characters (i. e., the revolving ridges) were overlooked by Prof. Whitfield. Still he noticed the resemblance to the adult form of *T. bidorsata,* which species he regarded as a *Bucania,* while his *wisconsinensis* he held to be "a true *Bellerophon,* as is readily seen by the closed or nearly closed umbilicus." But differences in the size of the umbilicus, when other characters agree, are now considered as of small importance. In this case certainly it is not of material consequence. Besides, the umbilicus is not by any means closed, there having been no axial thickening which might have filled the not very small cavity seen in casts.

Young specimens showing the inner volutions of *T. wisconsinensis* closely resemble those of *T. obsoleta,* the only difference observable in casts being that the umbilicus is slightly smaller and the volutions more ventricose in the present form. Adult specimens of the two species cannot be confounded, the last volution being higher, with flattened slopes, and less inrolled in *T. wisconsinensis,* the whole producing a very differently shaped aperture. *T. bidorsata* and *T. sexcarinata* have more compressed whorls, much larger umbilicus, and a wider as well as otherwise differently shaped mouth, while for both the lateral ridges are conspicuous features of casts, which is not at all the case in *T. wisconsinensis.*

*Formation and locality.*—Stones River group, Beloit and Janesville, Wisconsin; Minneapolis and St. Paul, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; University of Wisconsin; E. O. Ulrich.

*Museum Register*, Nos. 665, 5108, 7297, 7316, 7284.

## Genus KOKENIA, n. gen.

*Bucanella*, KOKEN, 1889, N. Jahrbuch f. Mineralogie, etc., Beilageband vi, p. 389. (Not Meek.)

For generic diagnosis see page 848. For remarks see the following specific description and under *Tetranota* and *Bucanopsis*.

### KOKENIA COSTALIS, *n. sp.*

PLATE LXIV, FIGS. 46–49.

Shell small, about 10 mm. in hight; volutions enlarging (apparently) gradually to the aperture, depressed, somewhat reniform in section, the hight and width respectively as four is to six and a half; slit-band wide, flat, sharply defined, somewhat elevated; on each side the surface descends first into a broad concavity, beyond which the slope continues, now with increasing convexity, to the sharply rounded or subangular edge of the umbilicus; the latter is deep, and about one-third as wide as the greatest diameter of the shell. Surface with seven straight revolving lines on each side between the edge of the umbilicus and the slit-band; the first on each side of the latter weaker than the others. The slit-band show faint evidence of having borne four or five very fine longitudinal lines. Transverse lines very fine, about eight in 1 mm., running, with little curvature, obliquely backward from the sides of the volutions to the slit-band, joining the same at an angle of something like 45 degrees.

We have seen but a single imperfect specimen of this species, and were it not that it belongs to a very interesting and easily recognized type, we would scarcely be justified in describing it. We regard it as closely related to Koken's species *esthona*, which he, as we have already stated (pp. 849, 876), erroneously places with Hall's *Bucania bidorsata*, in the genus *Bucanella*, Meek. Since Koken's species is not a *Bucanella* and the *bidorsata* is the type of our *Tetranota*, the question arises, can the *esthona* also be included in that genus? We will admit at once that they are related forms, yet we think the answer must be in the negative, and for two reasons: first, the aperture is much less expanded laterally in the species *esthona* and *costalis* than it should be in *Tetranota;* second, the revolving surface lines continue to the aperture and are too numerous to be considered as equivalent to the four constant dorsal ridges of *T. bidorsata*. As there is no other genus in which the two species might be placed, we propose a new one with the name *Kokenia*.

Specifically, *K. costalis* differs from *K. esthona* in the lesser prominence of the slit-band. A careless or inexperienced observer might confuse it with the associated *Tetranota bidorsata*, yet any one accustomed to the work of discriminating between fossils can scarcely fail in separating them at once.

*Formation and locality.*– Clitambonites bed of the Trenton group, near Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich.

## Genus BUCANIA, Hall.

*Bucania* (part.), HALL, 1847, Pal. New York, vol. i, p. 32. WAAGEN, 1880, Pal. Indica, ser. 13, pt. 2, pp. 130–150. KOKEN, 1889, N. Jahrbuch f. Mineralogie, etc., Beilageband vi, p. 379.

For generic characters see page 850.

As originally defined by Hall, this genus was to include bellerophontid shells having a large umbilicus. For many years the genus was regarded as of very doubtful value, paleontologists having learned that the relative size of the umbilicus was not of itself sufficient ground for a separate genus. The fact that the original types of *Bucania* had revolving lines was not considered of consequence by Hall in 1847, nor by any other paleontologist who had occasion to refer to the bellerophontids previous to 1880. In this year an important work on these symmetrically involute shells was published by Waagen (*op. cit.*). This author proposed to apply the name *Bucania* to all bellerophontids possessing revolving striæ, and he redefined the genus in accordance with his view.

While it is not to be denied that Waagen's proposal was a decided improvement upon previous attempts, it is still evident that his arrangement is artificial. His definition is too broad since it includes a variety of types that, while agreeing with the originals of *Bucania* in having spiral lines, are nevertheless widely removed from them genetically and readily distinguished by other characters. Lines of one kind or another, having a spiral direction, occur not only in species of the type of *Bucania sulcatina*, but in *Salpingostoma* and *Tremanotus* and in the new genera *Cyrtolitina*, *Conradella* and *Tetranota*. Then they occur in the very best development in a large group of species, ranging in time from the Trenton group to the close of the Paleozoic age, which we have decided to separate as a new genus under the name of *Bucanopsis*.

The trouble with *Bucania* has been that its real peculiarities have never been appreciated. Hall, as stated, regarded the large open umbilicus as distinctive for the genus. His description says also that the mouth is abruptly expanded, but in this doubtless he was influenced by his *B. expansa*, which now is not a *Bucania* but a *Salpingostoma*. The name of the genus was most probably inspired by the same species, and if it had been customary at that time to designate the type of a genus his choice would, we believe, have fallen upon the *expansa*,—and it would have made a good type of a good genus. But, since Roemer has described a genus that will include the *expansa*, and both Waagen and Koken take *B. sulcatina*, the first species following Hall's description of the genus, as the type,—a course that is fully justified,—it would not be good policy, and only add to confusion where there is too much already, if we were to revert to what evidently was Hall's original intention. Nor can we blame either Roemer or Waagen for overlooking or ignoring his intention, since in the absence of a more complete knowledge of *B. expansa* than was furnished by Hall, they would not have been justified in departing from the rule which, when the type is not designated, gives that rank to the first species following the generic description.

As we are all agreed to adopt *B. sulcatina* as the type and to restrict the genus to species having essentially the same characters as that species, the first thing to do is to determine exactly which are the essential peculiarities and which are not. This may not have been possible for either Waagen or Koken, and we are probably the first having sufficient material, both in the way of species and individuals, to do it in an approximately satisfactory manner.

The amended description of *Bucania* given on page 850 rests on no less than twenty Lower Silurian species. These show that the umbilicus is nearly always large, certainly never small. The outer lip has a broad V-shaped sinus and a central slit, the slit-band is narrow and slightly elevated, flat, or channel-like. The surface markings run in two directions, transversely and spirally, and both sets cross the volutions obliquely from the umbilicus to the slit-band, the degree of obliquity of the spiral lines depending upon the rate of increase in size of the volutions, being greatest in those in which the expansion is the most rapid. The transverse (growth) lines are oblique because they curve in directions parallel with the margin of the aperture. But the feature of the surface sculpture that deserves the most attention, and this applies to the *Bucaniidæ* as a whole, is that the intersections of the two sets of lines are nearly always rectangular.

According to the remaining characters, the species fall into two groups, the first or typical section, containing the type of the genus and seven other species, being characterized by a thin shell, very broad umbilicus, slowly and gradually enlarging depressed volutions, relatively wide yet not expanded aperture, thin lips, and long slit. In the second or *B. lindsleyi* section the shell is thicker, the umbilicus smaller, the volutions enlarge more rapidly and are higher, the inner lip is thicker and slightly reflected on each side, and the slit shorter. These differences will be better understood after a comparison of figures 1–12 with the remaining figures on plate LXVI.

Concerning the slit, perhaps not one specimen in a thousand of the *B. sulcatina* section preserves it entirely. As a rule the delicate apertural portion of the shell is broken away quite to the posterior end of the slit. In the other section a complete aperture is a much more frequent occurrence, both because the slit is shorter and the shell stronger.

It will be noticed that the characters brought out in the foregoing paragraphs are different from those pertaining to much the greater part of the genus as defined by Waagen and Koken. They derived their ideas of the genus chiefly from Upper Silurian, Devonian and Carboniferous spirally ribbed species, which with few exceptions (none of them true *Bucania*) will fall into the genus that we propose to call *Bucanopsis*. It is to be noted, however, that Koken with his usual acumen draws attention (*op. cit.*, p. 380) to differences in the aperture and surface sculpture between the "*Sulcatina*-typus" and the Devonian and Carboniferous species. Unfortunately he did not, or for want of material could not, carry his comparisons to their logical conclusion.

According to our opinion *Bucania*, as here restricted, is (1) strictly a Silurian genus and possibly not even represented in the Upper Silurian, (2) it is the stock from which *Salpingostoma*, and later *Tremanotus*, was derived, and (3) it is not genetically related to *Bucanopsis*. In support of the first statement we have the fact that while the twenty known Lower Silurian species fit closely together, not one of the succeeding forms could be included without materially altering the generic diagnosis. The truth of the second statement is but too apparent to those who are obliged to discriminate between imperfect specimens of associated species of *Salpingostoma* and *Bucania*. Casts of the former from which the abruptly expanded aperture has been broken away, and on which the dorsal fissure is not clearly represented, are most difficult, if indeed it is at all possible, to separate from casts of *Bucania*. The important agreement, however, lies in the surface sculpture which in all essential respects is the same in the two genera. But it is scarcely necessary to discuss the relation of *Bucania* to *Salpingostoma* here since we shall do so quite fully some pages hence in our remarks on that genus. The third statement refers to *Bucanopsis*. This genus was evolved, we think, not from *Bucania* but from *Bellerophon*. No better description of the genus could be given than that which says that it includes species agreeing in all respects with *Bellerophon* excepting that they have revolving striæ which, with the transverse lines, produce a cancellated sculpture. Without the revolving lines *Bucanopsis* would be nothing more or less than *Bellerophon*. Not so, however, with *Bucania*, since that genus would still be distinguishable. Again the spiral lines are not the same in *Bucania* and *Bucanopsis*, being straight in the latter and not oblique nor wrinkled nor ever interrupted as in the former.

Among the species of the *B. lindsleyi* section it is common to find that the obliquely revolving lines are sharply interrupted by the regular development of lamellæ whose wavy anterior edges are decidedly elevated and parallel with the margin of the aperture, of which indeed they represent previous stages. The effect is considerably as in the otherwise widely different genera *Conradella* and *Cyrtolitina*. The surface sculpture of *Tetranota* also, though of a finer pattern, is essentially of the same type.

Of the species originally referred to *Bucania* by Hall,* *B. sulcatina* and *B. intexta* are typical of the genus; *B. punctifrons* Emmons sp., though provisionally retained in the genus, is a peculiar form having a reticulated surface sculpture very much like that of *Cyrtolites ornatus*; *B. rotundata*, if correctly described, belongs to *Megalomphala; B. bidorsata* is the type of our new genus *Tetranota*; and *B. expansa* belongs to *Salpingostoma*.

## BUCANIA HALLI, *n. sp.*

PLATE LXVI, FIGS. 4–8.

Shell 20 to 30 mm. in hight, consisting of about three and a half depressed volutions; volutions increasing in size gradually to the aperture, gently convex on the back, subangular at the sides, slightly concave in the middle third of the ventral part, acutely subelliptical in section, and about twice as wide as high; umbilicus large, deep, well defined, with flattened slopes, and equalling nearly two-thirds of the greatest diameter of the shell. Aperture transverse, the hight usually not exceeding half of the width, acutely subelliptical, angular and narrow at the lateral extremities, and slightly indented below by the preceding volution; outer lip very broadly sinuate, medium slit not fully seen, probably a half volution in length. Surface with subequal revolving wrinkled ribs, averaging about seven in 5 mm.; the total number increasing with age by bifurcation and interpolation; in the umbilicus, especially behind the anterior half of the last volution, the ribs are decidedly oblique, but on the back of the volutions they are nearly longitudinal; at intervals of 2 or 3 mm. they are interrupted by more or less distinct transverse lamellæ, running obliquely backward from the edge of the umbilicus to the slit-band which they join at an angle of about 65°. Slit-band narrow, in some specimens appearing as slightly elevated; in others the center is excavated. Casts of the interior are quite smooth. A small specimen is 20 mm. in hight; the aperture is 15.5 mm. wide and 7.5 mm. high; the greatest width of the inner volution (at edge of inner lip) 5.5 mm. The surface markings are not perfectly retained by any of our specimens.

* Pal. New York, vol. i, 1847.

One seems to show obscure traces of very fine spiral lines between the stronger ones, and it is possible that such lines will be found on the perfect shell.

*B. halli* is closely related to *B. sulcatina*, but that species has wider volutions, and, although they do not enlarge any more rapidly, the proportional width of the aperture is greater, being quite equal to the hight of the shell, which is not the case in the present species. The whole form of that shell is also more globose. *B. intexta* is a smaller and narrower shell, and has more closely arranged revolving ribs and less depressed volutions.

We have four fragmentary casts of the interior, collected in the Fusispira bed of Goodhue and Fillmore counties, that may belong to this species.

*Formation and locality.*—Stones River group, Cannon Falls, Minnesota (six specimens); Black River group, Mercer county, Kentucky (eight specimens).

*Collections.*—E. O. Ulrich; W. H. Scofield.

### Bucania minnesotensis, *n. sp.*

PLATE LXVI, FIGS. 9 and 10.

This is associated with and probably closely related to *B. halli.* Still there should be no difficulty in distinguishing the two forms since this grows to much greater size and yet has the same number of volutions. The last whorl especially enlarges rapidly, though relatively more in hight than in width. The sutures are deeper and the slope of the umbilicus, taken as a whole, is not so flat. Still the flatness of the slope increases with growth until on the last third of the outer whorl it has become decidedly concave; causing the sutural portion to appear swollen. The surface markings seem to be about the same in the two species.

*Formation and locality.*—Vanuxemia bed of the Stones River group, Goodhue county, Minnesota.

*Collection.*—E. O. Ulrich.

### Bucania emmonsi, *n. sp.*

PLATE LXVI, FIGS. 1–3.

This species differs from *B. halli,* which it resembles closely, in being smaller and in having on the whole narrower yet more speading volutions. The volutions are more rounded in the umbilicus, causing the suture line to be deeper. The latter is peculiar in being deepened at regular intervals by the development of short, wave-like dents in the ventral side of the volutions. Similar dents are to be seen also on the sides of the volution in the Fountain specimens, but they cannot be seen on the even better preserved Tennessee shell. These sutural indentations distinguish the species not only from *B. halli* but from the even nearer *B. intexta* and all the other species now known of the genus. In a specimen 18 mm. high, the width of the last volution increases from 5 mm. to about 17.5 mm. The hight of the aperture is about 10 mm.

*Formation and locality.*—"Central limestone" of the Stones River group, near Murfreesboro, Tennessee. Vanuxemia bed, Cannon Falls, Minnesota. Black River group (?Ctenodonta bed), near Fountain, Minnesota.

*Collection.*—E. O. Ulrich.

### Bucania elliptica, *n. sp.*

PLATE LXVI, FIGS. 11 and 12.

Of this species we have only three casts of the interior, and all are more or less incomplete. The best is figured on plate LXVI. In this, as in the others, the apertural portion is broken away quite to the posterior end of the slit. In the figured example the last volution appears as though it had been free and possibly expanded at the aperture, in which case we would have to call it a *Salpingostoma*. But the slight expansion shown by the specimen is most probably the result of crushing. The volutions, as far a sobserved, are elliptical in cross section and enlarge slowly, the last in width from 6 mm. to 14 mm. On the whole the cast of the interior resembles *B. halli* U. & S., *B. emmonsi* U. & S., and *B. intexta* Hall, the last in particular, but a distinct species is indicated by the rounded instead of angular sides of the whorls. Detailed comparisons with the species named will bring out several other differences.

In the Kentucky specimens the volutions are less convex in the back than the Minnesota type of the species, and it is possible that more perfect material will prove them to belong to a distinct species.

*Formation and locality.*—Lower part of Fusispira bed, Trenton group, three miles south of Cannon Falls, Minnesota; base of Trenton or top of Black River group, Mercer county, Kentucky.

*Collection.*—E. O. Ulrich.

### Bucania sublata, *n. sp.*

PLATE LXVI, FIGS. 16–19.

This is a small subglobose shell, with wide volutions, broadly rounded on the back, flatly sloping in the umbilicus; and sharply angular on the sides. The umbilicus is sharply defined and deep, but comparatively small, its greatest diameter equalling only about half of the hight of the shell. The volutions increase gradually in size to the aperture, are acutely subelliptical in section, about twice as wide as high, and two and a half or three in number; the width of the aperture equals the hight of the shell. The surface markings are preserved on only a very small part of the shell. As near as can be determined they appear to have been about as in *B. halli.* The slit-band lies between two thin elevated lines and is a trifle wider, and the slit shorter, than usual. Hight of shell 12 mm.; width of aperture 12 mm.; hight of same about 6 mm.; width of umbilicus 6.5 mm.; width of inner end of last volution about 4.7 mm.

The form is more globose and the umbilicus relatively smaller than in any of the preceding species of the genus. In both of these aspects it reminds one strongly of *B. sulcatina*, of which it is probably a dwarfed descendant.

*Formation and locality.*—The types are from the upper part of the Trenton group, near Burgin, Ky. A cast of the interior, agreeing in every respect with the type, was found in the Ctenodonta bed of the Black River group, near Fountain, Minnesota; another (fig. 19) is from the Stones River group, at Minneapolis. A very small specimen, presumably of the same species, occurred in the Fusispira bed at Wykoff.

*Collection.*—E. O. Ulrich.

### BUCANIA LINDSLEYI *Safford.*

PLATE LXVI, FIGS. 24 and 25.

*Bellerophon lindsleyi* SAFFORD, 1869, Geol. of Tenn., pl. G., figs. 3*a*, *b*, *d* and *e*. (3c doubtful.) Not described.

Shell 30 mm. to 40 mm. in hight, the width of the aperture slightly less than the greatest hight of shell; volutions about three, embracing less than a fourth of the next within, rounded on the back, somewhat semi-circular in cross-section, narrowly rounded beneath the middle line of the sides; umbilicus moderately steep, of large size considering the rapid expansion of the volutions, its greatest width equalling about one-third of the hight of the shell; aperture somewhat expanded in the lower part, semi-elliptical in outline, the lateral angles narrowly rounded and scarcely reflected, the center of the lower outline very slightly indented by the preceding whorl; lower lip entire, thickened inwardly; upper or outer lip thin, the margin sweeping backward to form a broad shallow sinus, the center continuing backward as a narrow slit, the latter having a length of at least 10 mm. in a specimen 38 mm. in hight. Surface coarsely lamellose, the lamellæ, which indicate the margin of the aperture at previous stages, occurring at intervals on the back of the last volution varying from less than 2 mm. to 4 mm. or more, the average being about 3 mm. Usually the lamellæ are crossed approximately at right angles by more or less unequal and irregular ribs, seven to ten in the space of 5 mm., and these again by fine lines of growth. Often the ribs are irregularly broken up and sometimes they combine to form an obscure network reminding one of the surface sculpture of *B. punctifrons* Emmons. (See pl. LXVII, fig. 44). Slit-band distinct, slightly concave, margined on each side by a sharply elevated, thin line; lunulæ somewhat unequal but always clearly defined, rather crowded.

This fine shell is readily distinguished from all of the preceding species of the genus by the rapid expansion of its whorls.

*Formation and locality.*—Trenton group (Middle Nashville), DeKalb county, Tennessee. A small imperfect specimen, possibly of this or the next species, occurred in the Clitambonites bed near Cannon Falls, Minnesota.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

### BUCANIA RUGATINA, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 13–15.

Resembles *B. lindsleyi* closely, but is smaller, the hight of what appears to be a full-grown individual being a trifle less than 20 mm. Of other differences we may mention that the whorls are more tightly enrolled, causing the umbilicus to be appreciably smaller, the transverse markings are relatively stronger, more equidistant, closer, averaging 1 mm. apart and appear more like waves or wrinkles than overlapping plates. A slight groove on each side of the slit-band occurs on the specimen illustrated. The other specimens are not in condition to permit us to decide whether these grooves are characteristic of the species or not. At any rate nothing of the kind has been observed on good specimens of *B. lindsleyi.*

*Formation and locality.*—Upper part of Trenton group, near Burgin, Kentucky.

*Collection.*—E. O. Ulrich.

### BUCANIA NASHVILLENSIS, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 36–40.

This species is based on six specimens received from Prof. J. M. Safford and supposed by him to belong to his species *lindsleyi.* A careful comparison with the original type of that species, good figures of which are given on plate LXVI, proves that they represent a closely related yet distinct species. In the first place the volutions expand more rapidly, two and a half turns making as large a shell as three whorls in the *lindsleyi.* Next the umbilicus is smaller and more abrupt, the sides of the volutions being more sharply rounded. Again the dorsum is more prominent along the central line, causing a more or less decided flattening of the dorso-lateral slopes. The slit-band also, instead of being sunken, is slightly raised. Finally, as regards the surface markings, the transverse lines are much less regular, and crowded rather than distant, while as a rule they would scarcely be described as lamellose. They are also much less distinct except near the aperture of large specimens where they are strengthened and emphasized, as usual with old shells, by irregular wrinkles. The oblique revolving lines also are little more than half as strong, while in the umbilical cavities, where these lines are usually very conspicuous in Safford's species, they are scarcely distinguishable. After adding to these differences that the shell of *B. nashvillensis* is thicker, we believe we have given ample reasons for the creation of a new species.

*Formation and locality.*—Trenton group, De Kalb county, and Nashville, Tennessee.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

### Bucania frankfortensis, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 30–33.

This species is related to both *B. lindsleyi* and *B. nashvillensis*, but is distinguished from both by its subtriangular aperture, thicker inner lip and coarser surface sculpture. The volutions are also narrower and the hight of the shell, as compared to the width, relatively greater. While it is scarcely possible that any one will confound it with the first named, such an occurence is not improbable with the second, since in both the dorsum is obtusely angular. Still, where good ventral views can be compared (see plate LXVI, figs. 32 and 37), showing their different mouths and the more rapid lateral expansion of the outer volution of *B. nashvillensis*, a glance should suffice to separate them.

*Formation and locality.*—Near top of Trenton group, Frankfort, Kentucky.

*Collection.*—E. O. Ulrich.

### Bucania subangulata, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 20–23.

In this well marked species the dorsum is obtusely angular, the slope of the surface from the slit-band to the edge of the umbilicus somewhat flattened, and the sides sharply rounded or subangular, these features imparting a widely triangular, perhaps it would be better to say rhomboidal, section to the volutions, which of itself is sufficient to distinguish the species from the associated *B. rugatina.* Continuing our comparisons with that species, we find that the surface markings, though similar in pattern and strength, are not so regular, and the umbilicus is a little larger and better defined, while the slit-band forms the flat summit of a low keel instead of a smooth groove. Both *B. frankfortensis* and *B. nashvillensis* are probably closely related, though readily distinguished by their greater size, relatively smaller umbilicus, and more rapidly enlarging volutions. At maturity, however, the ventro-lateral angles are more abruptly expanded in *B. subangulata,* giving the aperture a more broadly triangular form than is the case in either of the larger species. It is to be borne in mind, further, that these large shells require no more turns to attain their full growth than do specimens of the present species less than half their size.

In the largest of eight specimens the hight is about 23 mm., the width of the aperture about 25 mm., the hight of same (in a side view) 17 mm. In a small specimen the same measurements resulted respectively in 9 mm., 9 mm., and 5 mm., showing that the aperture is relatively larger in adult examples. The small specimen, which is one of several, was at first believed to be distinct, but a careful comparison of the whole series resulted in the conviction that the small examples were merely immature.

*Formation and locality.*—Upper part of Trenton group, Mercer and Boyle counties, Kentucky.

*Collection.*—E. O. Ulrich.

### BUCANIA MICRONEMA, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 26–29.

Of this form we have but a single example. Although closely resembling *B. sublata*, *B. lindsleyi* and *B. rugatina*, in one or another feature, we are fully persuaded of its specific distinctness. The specimen, which has the appearance of being mature, is so much smaller than the second of the species mentioned that further comparisons with it are probably unnecessary. As to *B. sublata*, the present shell has it volutions narrowly rounded on the sides instead of sharply angular, its aperture is relatively larger, and its surface markings, which are not visible to the unassisted eye, are much finer. Compared with *B. rugatina*, with which it was found, its volutions expand more rapidly, giving a wider aperture, and its surface markings are much finer. Besides the transverse lines are much less distinct and not wave-like, while the lines running in the opposite direction, of which there are about five instead of two in 1 mm., are not only finer but more continuous, appearing like irregular wavy, knotted lines, running obliquely forward from the umbilicus to the slit-band.

*Formation and locality.*—Near top of Trenton group, Danville, Kentucky.

*Collection.*—E. O. Ulrich.

### BUCANIA SIMULATRIX, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 48 and 49; PLATE LXVII, FIG. 45.

Shell large, known from casts of the interior only. These consist of three or four comparatively slender and loosely coiled volutions, leaving a large umbilicus in which all the inner whorls are clearly exposed. Volutions somewhat reniform in section, narrowly rounded in the ventral third of the sides, the ventral surface gently concave, the dorsal part of the section nearly semi-circular. Last volution obtusely carinated, with the dorso-ventral diameter increasing toward the aperture more rapidly than is the case with the inner volutions, the hight and width of the whorl just behind the aperture being about equal, while at the smaller end the two dimensions are respectively about as three is to five. Aperture somewhat triangular-ovate, wide below, the expansion taking place chiefly at the lower part of the sides. In the cast the expansion appears very abrupt, but doubtless it is much less so in the shell itself. Inner lip slightly reflexed at the sides, thick centrally; outer lip broadly and deeply sinuate. Surface markings unknown; slit long. The best specimen seen has the following dimensions: entire hight 46 mm.; hight of aperture 29 mm.; greatest width of same 33 mm.; width and hight of last volution just behind the aperture about 23 mm.; hight and width of inner end of same 5 and 8.5 mm. respectively; greatest diameter of umbilicus about 23 mm.; length of slit about 31 mm.

The hight in this species is relatively greater than in *B. frankfortensis*, which we consider as more closely related than any of the other species. The aperture also is less nearly triangular, the apertural margin, as seen in a side view, less uniformly curved, the umbilicus larger, and the volutions more evenly rounded on the back. The next species, *B. crassa*, is a more closely coiled and heavier shell, having, therefore, also a smaller umbilicus. The form of the mouth and sinus is also different. Casts of *B. simulatrix* resemble those of the associated *Salpingostoma richmondensis* in a remarkable degree. For comparisons see description of that species.

*Formation and locality.*—Richmond group of the Cincinnati period, Richmond, Indiana.

*Collection.*—E. O. Ulrich.

## Bucania crassa, *n. sp.* (*Ulrich.*)

PLATE LXVII, FIGS. 46—48.

This species, though closely resembling *B. frankfortensis* and *B. nashvillensis* in many respects, will be distinguished almost at a glance by its uniformly convex instead of subangular dorsum. This difference, in conjunction with a greater relative width of the whorls, causes the aperture to be proportionally wider. The lower lip also, though strong, has a longer slope and its surface is less convex. The umbilicus is somewhat smaller and more abrupt than in *B. frankfortensis*, and the shell more globose.

The specimen figured has suffered considerably from maceration, the slit-band and all, excepting the strongest of the surface markings, being quite obliterated. On two other specimens, neither as complete as the one illustrated, there is a low, yet well defined, rounded dorsal ridge, and in one this is accompanied on each side by a faint furrow, while anteriorly it terminates in an open slit about 17 mm. long. Whether this dorsal ridge was originally flat or concave on the summit, and bore lunulæ, we are unable to say. Still, it is to be expected that such a condition obtained on the perfect shell. As to the surface markings, what remains of them indicates a sculpture similar to that shown in our figures of *B. lindsleyi* and *B. nashvillensis.* (See plate LXVI.)

The shell in this and the species with which we have compared it is unusually thick for the genus, especially on the ventral side of the volutions, and casts of the interior must look very different from the shells themselves. We have not, however, seen any casts which seemed at all likely to belong to either.

*Formation and locality.*—From the uppermost beds of the Richmond group, near Richmond, Indiana.

*Collection.*—E. O. Ulrich.

### Bucania singularis, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIG. 47.

This species is remarkable for the prominence of the transverse lamellæ and for the unusual length of the intervals between them. They appear to be especially thick and prominent on the lateral portions of the back. The slit-band is elevated and, like the lamellæ, shows rather distinctly on the cast of the interior. Aside from the lamellæ the whorls are rather broadly rounded on the back, and narrowly rounded on the sides, leaving an umbilicus, the greatest width of which equals about one-third of the entire hight of the shell. The mouth is transverse and somewhat elliptical in outline, the inner lip thick, cut out in the middle and with a comparatively narrow prominence immediately above the excision, the outer lip with a very wide angular sinus and a narrow open slit at least 15 mm. long in a specimen 30 mm. in hight. The surface markings are obscured by a delicate bryozoan which we failed to remove satisfactorily. As near as we can make them out they appear to consist of (1) lines of growth, and (2) of elevated points arranged in decussating series or of lines running rectangularly across the spaces between the elevated edges of the lamellæ. Similar variations of sculpture have been observed in *B. lindsleyi.*

Though clearly a *Bucania*, we are in doubt about the specific alliances of this shell. Selecting from the species described in this work, *B. crassa* and *B. lindsleyi* (Safford) appear to be the nearest. Still, the differences are so manifest that comparisons are deemed quite unnecessary.

*Formation and locality.*—Upper beds of Trenton group, Nashville, Tenn.

*Collection.*—E. O. Ulrich.

### Bucania punctifrons *Emmons.*

PLATE LXVII, FIGS. 41–44.

*Bellerophon punctifrons* Emmons, 1842, Geol. Rept. 2nd Dist. New York, p. 392.
*Bucania punctifrons* Hall, 1847, Pal. New York, vol. i, p. 187.

Shell rather small, probably not exceeding 20 mm. in hight. Volutions three or three and a half, rounded on the back, subangular on the sides; umbilicus large, its width somewhat greater than half the hight of shell; aperture slightly wider than high, subpentagonal. In a transverse section the volutions are semicircular in the dorsal half, with the umbilical slopes almost straight and the ventral side broadly indented by the preceding whorl. The width of the last volution expands from 6 mm. to 12 mm. in a specimen 18 mm. high. In the same specimen the slit has a length of 16.5 mm., and a width of about 0.7 mm. The slit-band is concave, bordered on each side by a delicate line, and crossed by numerous fine lunulæ. On each side of the slit and band the whole exposed surface is covered by a strong and very sharply defined network, the deep meshes of which are so arranged that they form rows running in two directions, one almost directly across the volutions, the other obliquely forward and outward from the band. Finally, in certain lights, a third arrangement of the meshes will be observed, namely, in series passing obliquely forward from the sides to the slit-band. The last direction is approximately at right angles to certain more or less distinct lines or varices of growth which interrupt the regularity of the network on old examples. (See figs. 43 and 44).

Excepting the surface markings, *B. punctifrons* agrees very well with the typical section of the genus. Even the retiform character of the sculpture is not entirely foreign to *Bucania*, since a kind of reticulation is frequently observed in the *B. lindsleyi* section that would not require a very great modification to produce the ornamental sculpture of the species under consideration. Still, we have no suspicion that *B. punctifrons* is closely related to any of the *B. lindsleyi* section. For the present we consider it as a species standing entirely alone.

*Formation and locality.*—Trenton group, at several localities in New York and Canada. The specimens upon which the above description is based were found in the lower part of the group ("Orthis bed") near Nashville, Tennessee, by Prof. Jas. M. Safford.

## Bucania nana, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 41–44.

Shell small, 10 mm. or less in hight, volutions two and a half or three, each embracing more than half of the preceding turn, expanding gradually and with moderate rapidity quite to the aperture, reniform in cross-section, broadly rounded on the dorsum and rather narrowly where the surface descends into the umbilicus; the latter is small, equalling only about one-fourth of the greatest diameter of the shell; aperture rounded when perfect, usually appearing more or less reniform, scarcely expanded, its width equalling about four-fifths of the hight of the shell; lips thin, the outer one with a central slit probably less than 2 mm. in length, the sinus also being unusually shallow, the inner lip prolonged slightly on each side and forming a very thin callosity over the back of the preceding whorl. Surface sculpture consisting of sharp, regular, rather closely arranged and but very little curved striæ of growth, and exceedingly fine, obliquely revolving lines, the latter obscure on even the best specimens. Slit-band raised, distinct, narrow, concave, bordered on each side by a sharply elevated thin line; lunulæ not very distinct. Out of eleven specimens the largest is about 10 mm. high, the smallest about 5 mm. In an average shell the hight is 7.0 mm.; the diameter at right angles to the hight 5.2 mm.; the width of the aperture 5.5 mm.; its hight about 5.0 mm.; greatest width of umbilicus about 2.0 mm.

### Variety SUBPATULA, *n. var.* (*Ulrich.*)

PLATE LXVI, FIGS. 45 and 46.

Under this subordinate name we propose to classify provisionally three specimens found in association with *B. nana*, but differing in several respects from the typical form of the species. Thus, the aperture is wider, its width fully equalling the greatest diameter of the shell. Then the umbilicus is narrower, being almost closed. On one of the specimens the surface is in good condition, but we failed to notice any evidence of the delicate revolving lines occurring on no better preserved examples of *B. nana.* If it could be shown that these lines are always absent, then we would favor a removal of the supposed variety to the genus *Bellerophon*, in which case the varietal name should be promoted to the specified rank. We may add that we have before us three casts of the interior from the lowest beds at Cincinnati, Ohio, that look very much as if they might belong to this variety.

We are not satisfied that either the variety or the species is a true *Bucania.* The umbilicus is too small and the sculpture not what it should be. The markings of *B. nana* are considerably like those found on *Tetranota bidorsata*, but the *nana* is most certainly not a *Tetranota.* We suspect that the species and variety are close relatives of two Clinton group shells described by Foerste as *Bellerophon* or *Bucania exigua* and *fiscello-striata.* In the surface markings, the last reminds one also of *Bucania punctifrons.* All five of these forms require further study before their positions can be established.

*Formation and locality.*—Upper part of Trenton group, Mercer county, and Covington, Kentucky.

*Collection.*—E. O. Ulrich.

### BUCANIA PERACUTA, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 34 and 35.

Of this remarkable shell we have seen only a single imperfect specimen which was collected by Prof. J. M. Safford and kindly sent to one of the authors for description. When entire it must have looked like a gigantic *Cyrtolites*, and we were at first inclined to place it in that genus. Closer investigation, however, showed that the surface markings were in reality different and the shell too thick for a *Cyrtolites*, while in both respects it proved to correspond with some of the *Bucania lindsleyi* group of species. The curving transverse folds of the flattened dorsal slopes are represented in other species of *Bucania* by the salient edges of the imbricating lamellæ, while the fine obliquely revolving lines in the depressed interspaces are commonly present in the genus. The volutions expand very rapidly, and in this particular, as well as in the dorsal angulations, the species corresponds perhaps best with *B. nashvillensis*, figured on the same plate. A view of the aperture of the specimen therefore agrees rather closely, in its lower part, with figure 37 of the plate. But the umbilicus is larger and much more sharply defined than in that species, the sides of the volutions being compressed into knotted keels. These lateral keels are nearly central on the inner whorls in a side view, but as growth proceeded its position became more ventral, the umbilical slope becoming at the same time more abrupt. For the same reason the transverse section of the whorls changes from rhomboidal to triangular. Only a small portion of the slit-band remains. This is slightly elevated and flat. Seven or eight of the revolving lines, which as usual are irregularly wrinkled, occur in 4 mm.

*Formation and locality.*—Upper part of the Trenton group, DeKalb county, Tennessee.

## Genus SALPINGOSTOMA, F. Roemer.

*Salpingostoma*, F. Roemer, 1876, Lethæa Geognostica.
*Bucania* (part.), Hall, 1847, Pal. New York, vol. i.
*Bellerophon* (part.), Eichwald.
*Bucania* (?*Tremanotus*), Whitfield, 1882, Geol. of Wis., vol. iv, p. 224.

This genus will include a number of species that most American paleontologists have considered as typical of the genus *Bucania*. However, in discussing the latter genus (see page 883) we have given our reasons for restricting its use to species conforming strictly with the type *B. sulcatina*, and for placing those of the type of Hall's *B. expansa* in *Salpingostoma*. It is therefore unnecessary to again take up this part of the subject.

*Salpingostoma*, as understood by us, will include shells whose inner volutions correspond in nearly every respect with the whole shell of the most typical species of *Bucania*, and it is only in fully grown entire examples that the peculiarities of the genus are apparent. These consist in the abrupt development of a thick and greatly expanded aperture and in the anterior closing of the long dorsal apertural slit. A dorsal slit, equivalent to that of *Salpingostoma*, was present in the middle of the apertural sinus in all *Bellerophontacea* having a slit-band. In some it was very long (*Bucania* and *Conradella*), but in the majority it was comparatively short; and in all cases it is the feature that gave rise to the slit-band, the posterior end of the slit having been pushed forward in proportion with the growth of the shell.

In only two genera of the suborder, however, *Salpingostoma* and *Tremanotus*, was the slit closed in front. In both of these genera the aperture is enormously expanded, not only laterally and ventrally, but dorsally as well, and it is the last peculiarity, one in which these genera stand practically alone, that we consider as the most important. The anterior closing of the slit was, we think, merely incidental to this expansion of the aperture, and perhaps dominated entirely by the necessity of overcoming the extreme liability to fracture to which the aperture would have been subject had the slit been allowed to continue to its outer margin.

Regarding the dorsal slit of *Salpingostoma*, it is questionable if the entire length of it that is represented by a ridge on casts of the interior was open. There is some reason to believe that a portion of the posterior end was covered by a thin film of shell. The greater portion of it, however, seems to have been permanently open. While there may be some doubt about the covering of the posterior end, there is none when we come to the anterior end. Here, from the beginning of the apertural expansion, backward for a distance equalling about one-half of the transverse diameter of the volution, the slit is undoubtedly closed, though continuing in some specimens as a gradually diminishing furrow on the inner side of the shell. In other specimens, of the same species even, there is a broad internal thickening, leaving a furrow instead of a ridge on casts of the interior. Behind the slit there is a distinct band with lunulæ, precisely as in *Bucania* and *Bellerophon*.

The surface markings of *Salpingostoma* are practically the same as in *Bucania*. Beneath the apertural expansion they consist of more or less oblique and wavy, wrinkled, revolving striæ, interrupted at subregular intervals by lines of growth. The former may be represented, as in *S. buelli*, by small, partially disconnected knots, which are arranged in series in such a manner that when viewed with the light coming from different directions the predominent element of the markings is changed from the oblique to the longitudinal. In *S. sculptilis* the revolving lines are zigzag and unite with the transverse lines in producing a network in which the pattern is complicated by an extra thread running obliquely through the alternating meshes. In nearing the mouth and continuing over the expansion the revolving lines usually become the most conspicuous element of the surface ornamentation, but they seem never to lose their irregularly wavy character entirely. As a rule the transverse lines predominate in the umbilical regions, and occasionally also on the dorsal part of the apertural expansion. The inner side of the aperture is always smooth.

Regarding the expanded aperture, we believe that it was developed only once during the life of the animal, and that it marks the fully matured condition. Two facts lead us to this opinion: first, the uniform size (in each species) of the specimens in which it is developed or preserved; and second, the thickness, as of age, to which the expanded rim may attain. As demonstrating the first we will give the results of measurements of two species. In ten average specimens of *S. richmondensis* the hight of the shell, excluding the apertural expansion, is 45 mm. in the smallest and only 50 mm. in the largest; in five specimens of *S. buelli* the same measurement varied between 35 and 37 mm. Herein lies the principal difference between *Salpingostoma* and *Tremanotus*, and it at the same time explains the development of a row of small openings in the latter instead of a single long slit.

In *Tremanotus*, namely, the expanded aperture is a periodic development, a new one being formed at frequent intervals. There is, therefore, no narrow limit to the size of the specimen. The expansion is also always very thin, and the old ones were either broken away or reabsorbed, the latter being in our opinion more likely. As in *Salpingostoma*, the development of each expansion was preceded or accompanied by the anterior closing of the apertural slit, continued growth at last producing a row of openings instead of a continuous fissure. The number of these openings remaining uncovered varied probably according to their sizes and with the species. The only evidence on this point now available is furnished by casts of the interior. These seemed to show that they remained open for a distance equalling about a third of a volution. In this distance, which slightly exceeds the average length of the slit in *Salpingostoma*, different species of *Tremanotus* show from four to about ten openings.

The surface markings of *Tremanotus longitudinalis* Lindström, the only species of the genus on which they have been observed in a thoroughly satisfactory manner, are on the whole more like those of *Bucania* than *Salpingostoma*, but as they are practically of the same type in all three genera, they are of but little assistance in referring a shell to its proper genus.*

Finally, we wish to state emphatically our conviction that *Bucania, Salpingostoma* and *Tremanotus* stand in close generic relationship to each other. The

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*Koken draws some fine distinctions between the different surface sculpturings of a number of European and one American species belonging in this connection, yet, if his observations on the others are not much nearer the truth than those which pertain to *Tremanotus*, they are certainly of little value. But we are perhaps more severe here than we intend, since in our opinion Dr. Koken has given us a most praiseworthy and valuable work. Because of the general minuteness and correctness of his observations, an error so palpable as the one he has fallen into with respect to *Tremanotus* is to be regretted more than condemned. Where he got the idea that the inner side of the aperture in *Tremanotus* is radially folded, and that "the folds are restricted to the inner side and in no wise dependent upon the outer side," is beyond our comprehension. It is simply not a fact.

development was progressive from one to the other in the order named. In the first the aperture is never greatly expanded, in the second it flares abruptly at maturity, while in the third an expanded mouth is developed at more or less frequent intervals. The second type was probably evolved in times preceding the Trenton period, but the evolution of the third seems to have been postponed till after the close of the Lower Silurian.

### SALPINGOSTOMA BUELLI *Whitfield.*

PLATE LXVII, FIGS. 34—37 and ?38.

*Bucania buelli* WHITFIELD, 1878, Ann. Rept. Geol. Surv. Wis. for 1877, p. 76.
*Bucania* (*Tremanotus?*) *buelli* WHITFIELD, 1882, Geol. of Wis., vol. iv., p. 224.

Shell of medium size, consisting of about three and a half volutions. The greatest diameter of the shell, just before the development of the expanded aperture, varies usually between 35 mm. and 36 mm., while the width of the last volution at the same point is about 20.5 mm., and its hight one or two mm. less. Volutions appressed, subreniform in section, the hight of the inner ones just a little more than half the width; dorsum broadly convex, the sides narrowly rounded or subangular, the ventral surface slightly concave where it is in contact with the preceding whorl. Umbilicus large, exposing all the inner whorls, with the sutural line deep. Aperture abruptly expanded, nearly horizontal, slightly raised and gently sinuate in front, broadly ovate or subcircular in outline with the hight and width nearly equal, the latter usually a little the greater; average hight about 35 mm. Transverse surface markings (behind the apertural expansion) consisting of fine sharp lines, three or four in 1 mm., and at intervals increasing with growth from 1 to 2 mm., of a stronger wrinkle-like set; both sets sweep backward with very little curvature between the sides of the volutions and the slit, joining the latter at an angle of about 60°; the transverse striæ are crossed by nodular revolving lines, the nodes being arranged in such a manner that by changing the direction of the light a diagonal arrangement will become more prominent than the longitudinal. Toward and on the apertural expansion the revolving lines increase gradually in strength, assuming at the same time a radial disposition, while the interpolation of a smaller set produces a distinct alternation in size at the margin. Inner surface of aperture perfectly smooth or exhibiting a few obscure concentric lines.

Dorsal slit about 24 mm. long, its edges raised, represented by a narrow rough ridge on casts. Behind the slit an ordinary band, appearing raised because bordered on each side by a narrow groove. In front of it to the beginning of the expansion a similar band; this continues as a gradually diminishing small ridge to the sinus in the lip.

The lateral view of a cast of this species given by Whitfield (*op. cit.*, pl. VI, fig. 13) does not agree with our specimens, the outer third of the last volution being much fuller in the figure, and represented as convex or straight almost to the edge of the aperture instead of deeply concave. Still, we cannot for a moment doubt that we have really described the species intended by Prof. Whitfield, since the majority of them are from the locality which furnished the original types, and all are precisely like specimens in the museum of the University of Wisconsin labelled in Prof. Whitfield's hand as *Bucania buelli.* That the figure objected to may not be true to nature is indicated by the fact that it does not agree with his fig. 12 which is stated to be of the same specimen. It may be that the specimen is in part a cast of the exterior, which would account also for the presence of the radiating ribs. Not a trace of the latter is visible on any specimen seen by us that is truly a cast of the interior.

The surface sculpture of *S. expansa* Hall sp., of the Trenton of New York, is not well known, but casts of the interior are readily distinguished from those of this species, the volutions being less depressed, and subtriangular in section instead of subreniform. We have several fragments of a variety or closely related species from the Black River limestone of Kentucky, differing from the typical form of *S. buelli,* so far as the imperfect material will admit of judgment, in having a thicker shell, coarser surface markings, and smaller inner volutions when compared with the expanded aperture which is fully as large as *S. buelli.* The aperture also is not so abruptly turned outward dorsally. In the last feature it is more like *S. expansa* but the specimens are too small for that species and the volutions rounded on the back instead of subangular. Since the form is close to *S. buelli* we may designate it provisionally as var. *kentuckyensis.*

The specimen represented by fig. 38 on plate LXVII is considerably smaller than any other of the species seen. The radiating ribs on the apertural expansion also are stronger than they should be in *S. buelli.* If these differences prove constant in other specimens they should be distinguished as a variety at least.

*Formation and locality.*—In Minnesota *S. buelli* is a rare fossil and so far known only from the limestones of the Stones River group, at Minneapolis, Cannon Falls and Old Concord. In Wisconsin, however, it is not uncommon and continues into the overlying limestones of the Black River group; Beloit and Janesville are the principal localities. In Illinois it occurs at Rockton and Dixon.

*Collections.*—Geological and Natural History Survey of Minnesota; University of Wisconsin; Charles Schuchert; E. O. Ulrich; W. H. Scofield.

*Museum Register*, Nos. 7293, 7318, ?5544.

## SALPINGOSTOMA SCULPTILIS, *n. sp.*

PLATE LXXXII, FIGS. 16—20.

Shell scarcely attaining medium hight, consisting of at least three and one-half volutions, the hight, including apertural expansion, about 40 mm. Inner volutions enlarging very slowly, somewhat rhomboidal in section, obtusely angular on the dorsum and more narrowly angular on the sides, the hight and width respectively as six is to ten. Aperture expanding abruptly till it measures at least 30 mm. in width and 28 mm. in hight; anterior sinus very shallow. Umbilicus large, exposing all the whorls. Surface markings forming a coarse network of alternating hexagonal meshes; an extra thread passes in an obliquely forward and inward direction through each mesh. In the umbilicus the oblique thread is the most conspicuous. About six rows of meshes occur on the small part of the outer volution on each side between the slit-band and the lateral edges. On the apertural expansion the markings increase in strength, though numerous longitudinal threads are interpolated as the space to be covered grows larger. Dorsal fissure about 17 mm. long.

This species may be related to *S. expansa* Hall sp., but it is readily distinguished by its smaller size and by the angularity of the back of its inner volutions, these being more rounded in that species (*i. e.* elliptical or reniform in section). The dorso-ventral diameter of the aperture also is relatively less in that species. The surface ornamentation of *S. expansa* being as yet unknown, we cannot say how it compares with that of *S. sculptilis.* Compared with *S. buelli* Whitfield, it will be found that *S. sculptilis* is smaller, has different surface markings, and volutions that are not only narrower but rhomboidal instead of reniform in section.

*Formation and locality.*—Four specimens, all from the Fusispira bed of the Trenton group, three from different localities in Goodhue county, and one from Ollie Hansen's farm near Fountain, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, No. 7462.

## SALPINGOSTOMA IMBRICATA, *n. sp.*

PLATE LXXXII, FIGS. 21 and 22.

Of this species we have but a single imperfect cast, the greater part of the expanded aperture being broken away. In the remaining parts it resembles *S. sculptilis* but the whorls are even narrower, the hight being to the width as five is to six and the section broadly subelliptical. The back of the volutions is broadly convex, the sides narrowly rounded or subangular, and the umbilical or ventral slope slightly flattened. The dorsal slit seems to have been at least 30 mm. in length. The shell is entirely gone except in the umbilicus, where, in the suture lines especially, there are remains of very regularly recurring, salient, thin, transverse, imbricating lamellæ, seven or eight in a distance of 5 mm. On the dorsal parts of the shell these lamellæ must be much farther apart. Revolving lines are faintly indicated on the back. There is something so suggestive of *Tremanotus* about this species that it is to be hoped that better specimens may soon be discovered.

*Formation and locality.*—Richmond group of the Cincinnati period, near Spring Valley, Minnesota.

*Collection.*—E. O. Ulrich.

### Salpingostoma richmondensis, *n. sp.* (*Ulrich.*)

PLATE LXVII, FIGS. 39 and 40.

Shell slightly exceeding medium size, the hight, including apertural expansion, 50 to 55 mm.; known from casts of the interior chiefly. These consist of about three strong volutions, the inner ones wide, depressed, sharply rounded on the sides, broadly and evenly convex on the back, less convex and with a very slight central cavity on the ventral side, the whole giving a transversely elongate subelliptical cross-section, whose width is a little more than twice the hight. Dorso-ventral diameter of last volution increasing very rapidly in the outer half, while the transverse diameter enlarges very slowly. Just behind the apertural expansion, where the volution is more or less distinctly compressed laterally, the dimensions in three specimens (casts) are as follows: width 22, 23 and 24 mm.; hight 26, 27 and 27 mm. At the opposite side of the shell the volution is about 15 mm. wide and 7 mm. high in all three specimens. The umbilicus is of the usual size for the inner volutions, but for the entire shell it is comparatively small. This is because the angular or narrowly rounded boundary moves gradually toward the ventral side of the volutions, causing the wall of the umbilicus to become more and more abrupt. Just behind the aperture it is nearly or quite perpendicular, the ventral surface of the volution being almost flat. Apertural expansion abrupt, apparently not very wide, with recurved edges, broadly ovate in outline, slightly narrower above than below. Dorsal slit about 20 mm. in length, beginning the same distance or somewhat more behind the apertural expansion. The slit is represented by a rough (fractured) ridge on casts. Behind it the cast is smooth, but in front of it there is a more or less distinct broad furrow.

The surface markings have been observed only on the back of the second volution. Here they consist of about seven irregular revolving ribs on each side of a very narrow elevated slit-band. At intervals of about 1.5 mm. the ribs are interrupted by transverse lamellæ. Where they are shown the volution has a width of 7 mm.

Collectors have heretofore identified this species with Hall's *Bucania expansa* from the Trenton of New York,* but a comparison proves it quite distinct. In the first place, though of about the same size, there is one volution less. Next, the last volution is relatively narrower and higher just behind the aperture, and the latter very differently outlined. Finally, the last volution is nowhere triangular as is the case in the Trenton species. Compared with *S. buelli* and *S. sculptilis* the outer volution will be found much larger especially as regards the dorso-ventral diameter.

In practice the most difficult perhaps to separate from this species is the associated *Bucania simulatrix.* Though of widely different affinities, casts of these two species, especially when, as is usually the case, the aperture is imperfect, are very apt to be confused. Still, after familiarizing one's self with certain differences, they may be distinguished almost at a glance. In the first place the volutions of the *Bucania* are more slender. This difference is particularly striking in an apertural view, the small end of the outer volution, in specimens of the same hight, being at least a fourth wider in the *Salpingostoma.* In the *Bucania* again the width of the last volution continues to increase quite uniformly instead of being almost constricted near the aperture. When the latter is preserved the difficulties have vanished, for this part is readily distinguishable.

*Formation and locality.*—Richmond group of the Cincinnati period, at Richmond, Indiana, where casts of it occur rather abundantly. Good specimens, however, are anything but common.

*Collection.*—E. O. Ulrich.

## Genus CONRADELLA, n. gen.

*Phragmolites*, CONRAD, 1838, Ann. Geol. Rep. New York, p. 119.
*Cyrtolites* (part.), HALL, 1847 and 1871. MEEK and WORTHEN, 1868. MEEK, 1873. S. A. MILLER, 1874 and 1892.

For generic characters and list of species see pages 851, 852.

It is strange that this sharply defined genus of shells has been so uniformly confused with *Cyrtolites.* Aside from the fact that the whorls are similarly coiled in the two groups, there is not a single character in which they are identical. While the typical forms of *Cyrtolites* have no slit-band and in some cases not even a sinus in the outer lip, *Conradella* has not only a sharply defined raised band, but an unusually long apertural slit as well. The form of the volutions also is different, the transverse section in the former being more or less rhomboidal, while in the latter it is ovate or obcordate. Finally, the surface markings are not at all similar,

* The erroneous identification of this and a number of other Trenton fossils in the upper member of the Cincinnati period, is responsible for the commonly prevailing yet groundless idea that the fauna of the "Cincinnati group" is a sort of mixture of "Trenton and Hudson River types." The sooner paleontologists will come to realize that a careful comparison of the fossils themselves is one of the first necessities in a successful identification or discrimination, the better it will be for stratigraphical geology. Mistakes are always possible, but time and care will avert most of them.

*Cyrtolites* having fine thread-like lines arranged in a reticulate manner, while in *Conradella* the surface is covered by strongly imbricating transverse lamellæ, the raised edges of which are serrated.

It seems to us that *Conradella* is in reality nearer *Bucania* than *Cyrtolites*. A careful comparison brings out what we conceive to be important agreements. Thus, in *Bucania* there is a rather long apertural slit, a large umbilicus and the whorls increase somewhat slowly in size, while the surface sculpture, though differing in detail, is of the same type. Of course, we do not wish to be understood to say that *Bucania* and *Conradella* are closely related, nor that there is any difficulty in keeping the two genera separate, the strong dorsal keel, less depressed and more slowly enlarging volutions, and the directness of the transverse imbrications in the latter being very obvious peculiarities. Yet, when we consider the general sameness of the types, we cannot escape the conviction that they were derived from the same stock. The great development of the lamellæ, each of which must at first have been abrupt apertural expansions, is corroborative evidence for this view, since it is a feature recurring in even greater development in *Tremanotus,* a genus that doubtless was derived from *Salpingostoma* and *Bucania.*

In the new genus *Cyrtolitina* (see pages 847, 856), the surface markings are somewhat similar, but the lines of growth sweep backward on nearing the dorsum, causing a sinus in the outer lip, the apertural slit is much shorter, and the volutions fewer in number and much more rapidly enlarging. The long slit and the general form of the shell of *Conradella* remind one greatly of the Devonian and Carboniferous genus *Porcellia,* Leveille, yet it is more than doubtful if there is any true relationship between them. In *Porcellia* the surface markings are of a different type, while the innermost volutions are unsymmetrically coiled, showing that it was derived from a pleurotomarid rather than a bellerophontid stock, the symmetric coiling of the later whorls probably indicating partial atavism.

Respecting the name of this genus, we would have been glad to restore Conrad's *Phragmolites* (partitioned stone) were it not objectionable because it gives an incorrect idea of the fossil. Conrad believed his *P. compressus* to be a chambered shell. This, however, was soon learned to be an error, and as Hall placed the species unreservedly into *Cyrtolites,* which was proposed by Conrad at the same time, all subsequent paleontologists have followed in ranking *Phragmolites* as a synonym under *Cyrtolites.* Had the name ever attained currency, we would feel ourselves bound to revive it, on the score of priority, despite its inappropriateness, but as no one, so far as we can learn, ever adopted it, we thought it best to view the name as one that has failed of being established because of incorrect and insufficient definition. Yet we think it but justice to Mr. Conrad, who was a better paleontologist than he is usually credited with having been, that his name should be connected with the genus. Hence the name *Conradella.*

### CONRADELLA OBLIQUA, *n. sp.*

PLATE LXVII, FIGS. 1–6.

Shell discoid, small, commonly from 10 mm. to 15 mm., and not known to exceed 20 mm., in diameter. Whorls three or four, enrolled so that the keel of each is partly imbedded in the base of the next; transverse section of whorls subcircular, or transversely elliptical, the dorsum (excepting the keel) sometimes slightly flattened. Keel sharply elevated, narrow, nearly 1 mm. high in the largest specimens, the summit with distant subimbricating lunulæ bordered on each side by a delicate raised line. Slit long, extending backward from the aperture almost half a whorl, having a length of fully 20 mm. in a specimen 14 mm. in diameter; borders of slit raised, though not as prominently as the keel farther back. Transverse, serrated surface imbrications crossing the whorls obliquely, seeming to sweep strongly backward from the umbilicus, without however forming a sinus on the back. Serrated edges moderately prominent, the elevation in no case exceeding 1.0 mm., being in most cases less than 0.5 mm.; behind each sinus a rib, dying out before it reaches the preceding lamina.

On the inner volutions the transverse imbrications are crowded, but on the last the distance between them is increased so that the average at the keel equals about one-third of the width of the volution. Between the serrated edges the surface is very finely cancellated, the longitudinal lines being somewhat less distinct than the transverse.

This species is readily distinguished from *C. compressa* Conrad, *C. pannosa* Billings and *C. dyeri* Hall by the obliquity of the transverse imbrications, and the greater width of the volutions.

*Formation and locality.*—Not uncommon in the Rhinidictya and Ctenodonta beds of the Black River group, at St. Paul, Minneapolis, Cannon Falls, Chatfield and Fountain, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register,* Nos. 4051, 6853, 7536.

### CONRADELLA SIMILIS, *n. sp.* (*Ulrich.*)

(Not figured.)

This species is closely related to *C. obliqua* differing from it chiefly in the transverse section of the whorls. In that species the section is almost circular, but in the form which we propose to call *C. similis* it is broadly obcordate. This difference causes the keel to appear as less abruptly elevated, the slope on each side of it more gentle, and the edge of the umbilicus more narrowly rounded. The ventral side of the volutions being flatter, the umbilicus therefore is not only more abrupt at its circumference, but also a little smaller. The transverse imbrications, though not quite so oblique, are similarly disposed, but the serrations are broader and fewer in number, there being on each side only six or seven, to ten or eleven in *C. obliqua*. In *C. compressa* Conrad the transverse imbrications are but little, if at all, oblique, and the dorso-ventral diameter of the whorls the greater, while for *C. similis* the opposite is true.

*Formation and locality.*—Upper part of the Black River group, in Mercer and Boyle counties, Kentucky.

*Collection.*—E. O. Ulrich.

### Conradella fimbriata, *n. sp.*

PLATE LXII, FIG. 66; PLATE LXVII, FIGS. 7–10.

Shell discoid, from 18 mm. to 25 mm. in diameter. Volutions about three, enlarging more rapidly than usual for the genus, very strongly and rather abruptly carinate, broadly subcordate in section, wider than high, narrowly rounded in the lower part of the sides; umbilicus comparatively small, equalling two-fifths of the diameter of the shell; slit extending nearly a half-volution posterior to the apertural margin. Aperture abruptly expanded at frequent intervals, the expansion left behind forming transverse, imbricating, folded lamellæ, the anterior edges of which are strongly serrated and project, collar-like, 3 or 4 mm. forward and outward from the surface of the last volution. Each expansion has seven folds, the lower one faint, the upper ones strong. Occasionally a smaller one is developed between each pair of the latter. The entire surface covered by very fine longitudinal and transverse lines. All the transverse markings cross the volutions obliquely. When, as is generally the case, the projecting lamellæ are broken away, the surface presents two or three more or less obscure revolving ribs on each side of the prominent keel. Greatest width of last volution, without the apertural expansion, in a specimen 25 mm. in diameter, about 12 mm.; with the expansion about 18 mm.; hight of aperture about 15 mm. Intervals between imbrications varying on the outer whorls between 1 and 2 mm.

When the apertural expansions are broken away this shell reminds one greatly of *C. similis*, the only difference being that the whorls enlarge more rapidly. But the perfect shell cannot be confused with any other, the great extent of the overlapping expansions giving it a very striking appearance.

*Formation and locality.*—Stones River group (Vanuxemia bed), Minneapolis, Minnesota, and Dixon, Illinois.

*Collections.*—Geological and Natural History Survey of Minnesota (about 22 specimens); E. O. Ulrich (6 specimens).

*Museum Register*, Nos. 653, 5110, 8724.

## Conradella triangularis, *n. sp.*

PLATE LXVII, FIGS. 19–22.

Shell usually from 15 to 18 mm. in diameter, compressed discoid, consisting of about three volutions; whorls carinate, slightly higher than wide, triangular-obcordate in section, gently convex on the sides, widest and angular below where the surface sinks abruptly into the umbilicus. Surface very rough, the zigzag or serrated lamellæ crossing the whorls almost directly, from 0.5 to 1 mm. apart, each with eight or nine folds between the dorsal keel and the edge of the umbilicus; at the latter the lamellæ generally turn somewhat abruptly forward. Usually the folds are arranged so as to present obscurely the appearances of revolving ridges. At other times they may alternate in adjacent series. The angularity of the ventral part of the sides of the volutions varies somewhat, the margin of the umbilicus being in many cases very sharp, while in others it would be more truly described as abruptly rounded. In casts of the interior, of course, the angle is never so distinct as in the shell itself.

Most collectors of northwestern fossils have identified this species with the New York Trenton *C. compressa* Conrad, sp. They are, however, quite distinct, the whorls in the New York shell being wider and more uniformly convex on the sides, the umbilicus not at all sharply defined, and the transverse imbrications more distant. Compared with all the known species of the genus, excepting the next, which see, none seems to us so near as *C. dyeri* Hall sp., a variety of which occurs in the Trenton of Minnesota. Still, *C. triangularis* is distinguished readily enough from that species, as well as from all the others, by the more distinctly angular character of the umbilical edge. Besides *C. dyeri* is a smaller shell, with rounder volutions, and more sharply raised keel, while the transverse imbrications are more crowded and the appearance of revolving ridges much stronger.

*Formation and locality.*—Vanuxemia bed of the Stones River group, Minneapolis, Minnesota, Janesville and Beloit, Wisconsin, and Dixon, Illinois; also at Lebanon, Tennessee.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register,* Nos. 7292, 7309.

## Conradella grandis, *n. sp.* (*Ulrich.*)

PLATE LXII, FIG. 67; PLATE LXVII, FIGS. 16–18.

This species is closely related to *C. triangularis* but reaches a much greater size, the greatest diameter of one of the specimens being fully 30 mm. Then the transverse section of the whorls, which also increase more rapidly in size, is a little different, the dorsal slopes being more convex, the sides less angular, and the transverse diameter relatively greater, the latter exceeding the vertical diameter by one-sixth, whereas the two dimensions are equal, or the hight the greater, in *C. triangularis.* Furthermore, the folds of the surface imbrications are fewer in number, there being only five or six on each of the dorsal slopes to eight or nine in that species. Then the revolving ridges are more distinct, and the keel is more abrupt, especially on interior casts of *C. grandis*, the latter exhibiting distinctly a broad furrow on each side of the keel. The slit extends quite half around the last whorl.

*Formation and locality.*—"Glade limestone" of the Stones River group, Lebanon, Tennessee, where the types (three specimens) were collected by Prof. J. M. Safford, and sent to one of the authors for description.

### CONRADELLA DYERI *Hall.*

PLATE LXVII, FIGS. 30—33.

*Cyrtolites dyeri* HALL, 1871, Advance sheets, 24th Rept. Regents N. Y. St. Cab., and reissue of same, 1872, p. 230, pl. VIII, figs. 7, 8. MEEK, 1873, Pal. Ohio, vol. i, p. 149, pl. XIII, figs. 2*a*, *b*, *c*, (not 2*d* and *e*, these representing *C. elegans* Miller). MILLER, 1874, Cincinnati Quart. Jour. Sci., vol. i. p. 309.

Shell small, 10 to 13 mm. in diameter, laterally compressed, consisting of two and a half or three volutions, the outer embracing the next within for about one-third of its hight. Whorls cordiform in section, broadest and sharply rounded below, sharply and abruptly carinate dorsally, rounded on the sides the curvature increasing downward from the keel; hight and width of volutions, including the carina, about equal, or the former slightly the greater. Umbilicus about equalling the dorso-ventral diameter of the last turn at the aperture. Surface marked by numerous closely and regularly arranged transverse lamellæ, the raised edges of which are curved abruptly backward at regular intervals and have a general retral direction from the umbilicus to the keel. The recurved intervals being more prominent than the longer straight portions, and occurring at regular intervals, they cause the surface to appear as having revolving ribs. On the ventral half of the volutions the lower sides of the loops sometimes coalesce and form really continuous revolving lines. Ten of the loops on each side is the usual number for the last whorl, but two extra ones are sometimes distinguishable near the aperture of larger examples. Of the transverse lamellæ the average number on the back of the last volution in 2 mm. is seven or eight. The keel is prominent, rounded on the summit, and, so far as observed, without a trace of lunulæ, although some of the specimens before us are in a beautiful state of preservation. The slit has the usual length (i. e., nearly a half volution).

We have two specimens of a variety or a closely related species from the Trenton of Minnesota which we propose provisionally to designate as

### Variety CELLULOSA, *n. var.*

PLATE LXVII, FIGS. 27–29.

They are both only about 9 mm. in diameter, and differ from the typical form of the species in having much less of a keel and in the peculiar modification of the surface markings. The lamellæ, namely, generally unite with each other in such a manner that a cellular rather than striated surface results. When slightly weathered the connected sides of the successive loops may appear like delicate longitudinal plates. It seems to be a rule that the loops are oblique and joined to each other only on one side, the other being open. Again it may appear that the longitudinal line is independent and runs directly through the loops. The transverse lamellæ are unusually crowded, the average on the last volution being from eight to ten in 2 mm.

The surface markings of *C. dyeri* have never been correctly illustrated. On the accompanying plates we show that the "revolving ridges" are as a rule not ridges at all, but only an appearance due to the elevation and longitudinal arrangement of the closely following loops of the transverse lamellæ. When continuous revolving lines are formed it is only through coalescence of one or both sides of the loops of succeeding lamellæ.

Compared with the preceding species *C. dyeri* is distinguished at once by its smaller size and unusually crowded surface markings.

*Formation and locality.*—The typical form occurs in the Richmond group at Richmond and Versailles, Indiana; Oxford, Clarksville, Freeport and Waynesville, Ohio; near Maysville, Kentucky, and Spring Valley, Minnesota. Variety *cellulosa* was found in the Clitambonites bed of the Trenton group at St. Paul and Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich.

### CONRADELLA BELLULA, *n. sp.* (*Ulrich.*)

PLATE LXVII. FIGS. 23–26.

This species in most respects occupies an intermediate position between *C. dyeri* Hall and *C. elegans* Miller. From the former it is distinguished by its lesser thickness (compare figures 24 and 31 on plate LXVII) less crowded lamellæ, and by having numerous well marked lunulæ on the slit-band. From *C. elegans* it differs in having more slender whorls and less coarsely marked surface.

The specimen figured seems to be complete. If this is the case, then we have another feature in which *C. bellula* differs from both of the species with which we have compared it. Namely, a slit extending only about a fourth, instead of half around the circumference of the last turn.

*Formation and locality.*—Lower half of the Loraine group, Covington, Kentucky.

*Collection.*—E. O. Ulrich.

## CONRADELLA ELEGANS *Miller.*

PLATE LXVII, FIGS. 12—15.

*Cyrtolites dyeri* (part.), MEEK, 1873, Pal. Ohio, vol. i, p. 149, plate XIII, figs. *2d*, *2e*.
*Cyrtolites elegans*, MILLER, 1874, Cincinnati Quart. Jour. Sci., vol. i, p. 310.

This species is closely related to and about of the same size as *C. dyeri* Hall, but we cannot say that we ever found it difficult to distinguish. In the first place the transverse lamellæ are less crowded—sometimes they are more than twice as far apart as in that species; next the undulations or loops of each are not so deep and fewer, there being only five or six to a side as against ten in *C. dyeri;* then it is only in rare instances that even the most obscure appearance of revolving ridges is observable; finally, the whorls are a trifle higher, while the slit-band bears distinct and closely arranged lunulæ. The last is probably to be regarded as the most important of the differences mentioned. The *C. triangularis* of the Stones River group, though of a similar type, is readily distinguished by its larger size, rougher surface, oftener and more deeply undulated lamellæ, and angular umbilical edges. *C. grandis* is perhaps nearer than any other, but it grows so much larger that there is little danger of confusion between them. For comparisons with *C. bellula* see that description.

*Formation and locality.*—As yet this pretty shell is known only from the shaly limestones of the Loraine group, at Cincinnati, Ohio and localities in the immediate vicinity of that city.

*Collection.*—E. O. Ulrich.

## CONRADELLA IMBRICATA *Meek* and *Worthen.*

PLATE LXVII, FIG. 11.

*Cyrtolites imbricatus* MEEK and WORTHEN, 1868, Geol. Surv. Ill., vol. iii, p. 340, pl. IV, fig. 12.

A good figure of this species has not yet been published, and as it is an interesting form and one that may be expected to occur in Minnesota, we have decided to illustrate a specimen that a careful comparison with the original type proves to belong to the same species. This specimen is from the same locality as the type and differs from it only in being smaller. The greatest diameter of the type is about 22 mm.; in our specimen 15.5 mm.

The chief peculiarity of *C. imbricata* lies in the fact that the sides of the whorls are the most prominent and somewhat angularly bent just beneath the middle and flattened in the umbilicus, giving a subrhomboidal or *Cyrtolites*-like transverse section instead of the rounded or cordiform section prevailing among the other species of the genus. In all other respects the species agrees very well with *C. triangularis* U. & S. and *C. elegans* Miller. Still, the transverse lamellæ are more irregularly undulating and wider apart than in either of those forms.

Meek and Worthen make a statement to which we must object. Namely, that the inner volutions are "nearly half embraced by the last turn." This is true of only the anterior part of the last volution of their type, and we are inclined to believe that it is due to oblique pressure to which the specimen has been subjected. On the rest of the type, as in the whole of the specimen now illustrated, the embracing extends only to the base of the carina.

*Formation and locality.*—In strata regarded as belonging to the Trenton group, Alexander county, Illinois. The same layers contain *Rhynchotrema inæquivalvis* Castelnau (*R. increbescens* Hall) and *Nematopora delicatula* Ulrich.

*Collections.*—Illinois State Museum; E O. Ulrich.

## Genus OXYDISCUS, Koken.

*Bellerophon*, *Cyrtolites*, *Porcellia* and *Euomphalus* (part.) of authors.
*Tropidodiscus* of MEEK, 1866, and WAAGEN, 1880, not Steininger, 1855.
*Oxydiscus*, KOKEN, 1889, N. Jahrb. f. Mineralogie, etc., Beilageband vi, p. 390.

For generic characters see page 852.

This group recommends itself to us as not only a convenient but a natural generic division of the *Bellerophontacea*. Sowerby, Billings and Conrad placed three of the species under *Bellerophon*, from which they are distinguished by their lenticular form, compressed and sharply carinate volutions, scarcely, if at all, expanded aperture, and by their thin lips and the total absence of any callosity. Lindström and Miller placed four of the species with *Cyrtolites*, a genus that is widely different in all respects excepting the general form. As to *Porcellia*, Koken has shown, and we can bear evidence for the general correctness of his observations, that that genus represents a totally different type of structure. Finally, the reference of two of the species to *Euomphalus* rests probably upon nothing more than an error of observation and judgment.

Koken excludes all those species from the genus in which even a suspicion of a slit-band occurs. This we think is drawing the line too close and somewhat inconsequent. He admits into *Bellerophon* (sens. strict.) species in which the slit-band is represented by a single keel only. And he is probably correct in this, since in not only closely related species but in one and the same species (e. g., *B. troosti* Safford) a true slit-band may occur occasionally, while the usual form has merely a keel.

Besides the species listed on page 852 there are three more American, or rather Canadian, species that may belong to *Oxydiscus*. These were described by Billings as *Bellerophon macer*, *B. palinurus*, and *B. argo*, the first from the Calciferous formation, the second from the Quebec group, the third from the Black River group. Of the three forms, the first is the most likely to belong here, but in the absence of any positive knowledge respecting their essential generic features, it is best to leave them provisionally where they are placed by Mr. Billings.

Respecting the systematic position of *Oxydiscus*, we are somewhat in doubt. The absence of any sort of revolving lines is against the inclusion of the genus with the *Bucaniidæ*. On the other hand such a position is strongly indicated by the absence of labial callosities and more particularly by the large umbilicus and long apertural slit. The latter occurs most certainly in the Lower Silurian species next described, and as these species agree verly closely in all respects with the Upper Silurian and Devonian types of the genus, we have assumed that the slit is one of the prime characteristics of the genus. Now, if this view proves to be correct we cannot be far wrong in placing *Oxydiscus* in the immediate vicinity of *Conradella*. The only difference of any consequence between these genera are that, while the surface of the volutions of the latter are crossed by imbricating, wavy lamellæ, which are not turned backward on the dorsum to form an angular sinus where they meet at the keel, the whorls of the former are crossed simply by fine lines of growth, turning backward very strongly in nearing the dorsal keel, their junction here indicating a narrow, V-shaped excision in the outer lip.

### OXYDISCUS SUBACUTUS, *n. sp.* (*Ulrich.*)

PLATE LXII, FIGS. 62–65; PLATE LXXXII, FIGS. 23–25.

Shell lenticular; dorsum acutely carinated; greatest diameter from 15 mm. to 28 mm.; greatest thickness or width nearly one-half the diameter. Volutions three and one-half to four and one-half, thickest near the umbilicus, from which the surface ascends first with a gently convex, then with a concave slope to the sharp periphery; each volution embracing between one-third and one-half of the preceding one; umbilicus exposing all the whorls; its width somewhat less than one-third of the diameter of the shell; edge of umbilicus abrupt, subangular; aperture obcordate, indented below by the sharp dorsum of the preceding whorl; margin of aperture thin, in a side view with a strong backward sweep; slit long, very narrow. Surface marked by fine and rather indistinct lines of growth.

This species agrees perhaps as well as any with the Devonian types of the genus. Of Silurian forms only *O. cristatus* Safford and *O. disculus* Billings need be compared. The Candian species will be found to be more compressed, and to have the edge of the umbilicus less abrupt. For comparisons with Safford's species see next description.

*Formation and locality.*—Upper beds of the Trenton group near Danville, Kentucky, where more than twenty specimens were obtained. We have reason to believe that the same species occurs also in Tennessee and in the Fusispira bed in Minnesota.

*Collection.*—E. O. Ulrich.

### OXYDISCUS CRISTATUS *Safford.*

PLATE LXXXII, FIGS. 26—28.

*Cyrtolites cristatus* SAFFORD, 1869, Geol. of Tenn., p. 289.

Through the kindness of Prof. J. M. Safford we have before us the types of his *Cyrtolites cristatus.* These show conclusively that the species is an *Oxydiscus,* closely related to *O. subacutus* Ulrich, yet not strictly identical. The Tennessee species is uniformly larger, the greatest diameter in four specimens varying between 30 and 38 mm. More important differences are (1) that the whorls are one less in number in mature examples, (2) that they increase more rapidly in size, (3) that they embrace each other in a lesser degree, the amount being in no case more than a sixth of the hight of a whorl, while the last may become entirely free, without, however, any appreciable diminution in the depth of the sharp furrow, which, farther inward, receives the keel of the preceding whorl. In consequence of the peculiarities mentioned, the umbilicus is relatively somewhat larger. Finally, the shell substance is comparatively thicker on the ventral side, and the keel more distinct than in the Kentucky species. Taken all in all, we do not see how we can do otherwise than regard *O. subacutus* as distinct from *O. cristatus.*

*Formation and locality.*—From Safford's "Middle Nashville," which we regard as representing an upper member of the Trenton group, at Nashville and in Jackson county, Tennessee.

*Collections.*—J. M. Safford; E. O. Ulrich.

## Genus BELLEROPHON, Montfort.

*Bellerophon,* MONTFORT, 1808, Conchiliologie Systematique, vol. i, p. 51. WAAGEN, 1880, Pal. Indica, ser. 13, pt. 2, pp. 130 and 133.
*Bellerophon* (part.), HALL, LINDSTRÖM, and most authors prior to 1880.
*Waagenia,* de Koninck, 1882, Ann. Soc. Geol. de Belgique, p. 14.
*Waageniella,* BAYLE, 1883. Proposed instead of WAAGENIA which was preoccupied.

For generic characters and list of species see page 853.

Adopting this genus in the restricted sense proposed by Waagen, we have an easily recognized and still large group of Paleozoic shells. The numerous species are of a remarkably uniform type, distinguished at once from *Protowarthia* by its slit-band and different apertural emargination; from *Bucania* and allied genera by the total absence of revolving surface lines. Within its own family, the *Bellerophontidæ*, *Bellerophon* has not the revolving sculpture of *Bucanopsis*, nor the extremely expanded aperture of *Patellostium*, nor the revolving folds of the inner lip which characterize *Euphemus*, while neither *Mogulia* nor *Warthia* have a distinct slit-band.

The principal distinctive features of the genus are: (1) the absence of all kinds of sculpture save the more or less strongly developed lines of growth, (2) the small or entirely closed umbilicus, (3) the moderate expansion of the aperture, (4) a more or less strong callosity on the inner lip, and (5) a well developed, generally raised, slit-band terminating anteriorly in a short median emargination or slit in the outer lip.

The genus might be divided into several subordinate groups none of them, however, seeming of more than doubtful utility. One, *Waagenella*, including a few Carboniferous species, is distinguished by a definite callosity in the umbilical region. Regarding the *Bellerophon contortus* group of Koken, we have already distinguished it as a separate genus under the new name *Megalomphala* (see p. 850), this type belonging in our opinion to the *Bucaniidæ* rather than the *Bellerophontidæ*.

Ten of the fifteen American Lower Silurian species retained as true bellerophons are figured and described in this report, giving a very good idea of the genus as represented in this part of the Paleozoic rocks. Most of them are described for the first time and all are more or less closely and obviously related.

### Bellerophon troosti (*D'Orbigny*) *Safford.*

PLATE LXIV, FIGS. 1–5.

*Bellerophon troosti* D'Orbigny, 1840, Cephalopoda, p. 206; as figured by Safford, 1869, Geol. of Tenn., pl. G, figs. 4*a*—4*d*.

Shell beneath the medium size, rarely exceeding 17 mm. in diameter; somewhat transverse, the width of the aperture being greater than the hight; whorls rather broad, inflated, though somewhat depressed on each side of the prominent dorsal carina; on the sides they are strongly convex, rounding into the small but deep and constantly developed umbilicus. In the adult shell the carina is rounded, but in young specimens the summit is flat or slightly excavated, forming a distinct slit-band on which lunulæ are either not preserved or were originally very faint. Aperture greatly expanded laterally, outer lip sharp and thin, with a deep and rather narrow subrectangular central emargination; inner lip thickened and much expanded laterally and horizontally, the inner edge forming a thick low biconcave ridge with a rounded central prominence; the latter constricted within the mouth and continuing inwardly as a distinct ridge; latero-ventral angles turned backward, in some cases partly overhanging the umbilicus. Surface marked by growth lines only. They are more or less distinct, though on the whole fine. They are also somewhat irregular, being generally arranged in bundles, which, especially near the aperture of adult shells, may produce obscure undulations of the surface. The course of the striæ from the umbilicus to the dorsal carina is very little curved and nearly at right angles with the carina. However, just before joining the latter, they bend sharply backward. Hight of one of the largest of the Kentucky specimens 16 mm.; greatest width of the aperture 19 mm.; width of whorl just in front of edge of inner lip 7 mm. In Tennessee the species often attains a hight of 20 mm.

We have before us an excellent series of silicified shells of this species and can testify to the unusual constancy of its specific characters. Considering this persistence we might be justified in separating the following form as a distinct species, but after considerable reflection we have concluded that such a course would not now be warranted. We propose then that it be known as

### Variety BURGINENSIS, *n. var.* (*Ulrich.*)

PLATE LXIV, FIG. 6.

This variety grew to be a litttle larger than the typical form (22 mm. in hight), has a proportionally less expanded mouth (the greatest diameter of the shell is about the same as the width of the aperture), more slowly enlarging volutions, and a larger umbilicus. On the best specimen the dorsal carina besides has the characters of a true slit-band and near the aperture it exhibits distinct lunulæ.

*B. troosti* is one of a number of closely related Lower Silurian species. The group is well represented in the Trenton of Minnesota, but that *B. troosti* itself occurs here is as yet very doubtful. *B. similis* is very much like it, and before we found specimens showing the mouth and lines of growth, we unhesitatingly referred the casts of the interior to this species. Still, it is possible that *B. troosti* is really represented among the casts now assigned to *B. similis.*

*Formation and locality.*—The typical form is not uncommon in the Trenton group at Nashville and Hartsville, Tennessee, and Danville, Frankfort and other localities in central Kentucky. Var. *burginensis* occurs with the typical form near Burgin and Danville, Kentucky. The species is limited to a vertical range of a few feet in the upper half of the group.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

### BELLEROPHON CLAUSUS, *n. sp.* (*Ulrich.*)

PLATE LXIV, FIGS. 7—10.

In the general form of the shell and the course of the lines of growth, this species resembles *B. troosti* very closely. Carefully compared we find that the new species differs in several important respects. First the umbilicus is entirely closed, next the lines of growth are more regular and sharper, then the slit-band is more truly a band though on the whole less prominent, while the lunulæ are sharply defined. Finally, the inner lip is scarcely as broad though its inner margin is heavier, while the prominence of the central boss is emphasized by a deep and large depression on each side of it. We know of no other species with which *B. clausus* need be compared, excepting two or three of those next described.

*Formation and locality.*—Trenton group, Frankfort, Kentucky, and near Nashville, Tennessee.
*Collection.*—E. O. Ulrich.

### Bellerophon bilineatus, *n. sp.* (*Ulrich.*)

PLATE LXIV, FIGS. 19–21.

Very much like *B. troosti*, only smaller, narrower across the aperture, with fine and sharper, as well as more regular, lines of growth, and much less prominent slit-band. The latter is concave, lies between two sharp lines and is crossed by rather distinct lunulæ. The posterior curve of the lines of growth on the dorsum also is broader, while the inner portion of the lower lip is much less thickened. The last difference is even more conspicuous when we compare the species with *B. clausus*, and this, coupled with the fact that the umbilicus is closed in that species and rather large in *B. bilineatus*, renders confusion with that form quite improbable.

*Formation and locality.*—Upper portion of the Trenton group, near Danville, Kentucky.
*Collection.*—E. O. Ulrich.

### Bellerophon subglobulus, *n. sp.* (*Ulrich.*)

PLATE LXIV, FIGS. 17 and 18.

This also resembles *B. troosti* very closely, but good testiferous examples may be distinguished without much trouble. The surface striæ, though their direction with respect to the dorsal keel is nearly the same as in *B. troosti* (the retral curve on the back is somewhat wider), are more regular, sharper and thread-like. Comparing other characters it is found that the volutions are more ventricose and more uniformly rounded, causing the shell as a whole to be more globular, the keel is less prominent and thinner, the aperture is more rounded and less expanded transversely, and the callosity of the inner lip not so great—probably much less. (In all of our specimens of this species the mouth is obscured by an incrustation of siliceous material so that we cannot tell exactly about the callosity of the inner lip.) *B. subglobulus* is distinguished from *B. clausus* by similar differences, while the presence of a small umbilicus adds another, the umbilicus being closed in that species. In *B. bilineatus* the umbilicus is larger and the slit-band concave instead of rounded.

*Formation and locality.*—Black River limestone, Mercer county, Kentucky.

*Collection.*—E. O. Ulrich.

### Bellerophon platystoma *Meek* and *Worthen*.

PLATE LXIV, FIGS. 22–30.

*Bellerophon* (*Bucania?*) *platystoma* M. & W., 1868, Geol. Surv. Ill., vol. iii, p. 312, pl. III, figs. 8*a*, *b*.

Shell exceeding medium size for the genus, composed of about three volutions, which increase rather slowly in size until near the aperture where the last one is suddenly and greatly expanded laterally; whorls embracing very little, subtriangular in cross-section, with the dorsum strongly carinate; surface descending on each side from the keel, first with a concave then a nearly flat slope, toward the edge of the umbilicus into which it turns very abruptly; umbilicus open, rather large, about one-fourth as wide as the greatest diameter of the shell; aperture somewhat triangular-reniform, the hight a little greater than half the width, the width exceeding by nearly a fifth the greatest diameter of the shell; outer lip thin, broadly sinuate, the center of bottom of sinus prolonged into a narrow slit; inner lip apparently with but a very little developed callosity. Lines of growth sharp, rather regular, curving backward gently between the umbilicus and carina. The latter, on which we have not observed any well defined slit-band, is very prominent and almost sharp on casts of the exterior, but on casts of the interior it is not distinguishable from the general regularity of the dorsum.

We are quite confident of the specific identity of the Minnesota shells above described and the original types of *B. platystoma*, the latter having been examined by us. In Minnesota we have two varieties of the species, one, agreeing exactly with Meek and Worthen types, occurring in the Fusispira bed, the other, which is much smaller, its greatest diameter but rarely exceeding 20 mm., being a common fossil of the Clitambonites bed.

*B. platystoma* is closely related to *B. similis*, but may be distinguished readily enough by the different transverse section of its volutions, this being subtriangular while in the new species it is semicircular rather than triangular. When, as is often the case, the expanded aperture is broken away, the remaining whorls of *B. platystoma* remind one greatly of *Crytolites*. Similarly imperfect examples of *B. similis*, however, are scarcely distinguishable from *B. troosti*. None of the other species known are closely related, nor have we experienced any difficulty in separating *B. platystoma* from them.

*Formation and locality.*—The original types are from the Trenton (Galena) group at Galena and Dixon, Illinois. In Minnesota the small form is common in the Clitambonites bed at localities in Goodhue county, while the larger or typical form is not rare in the Fusispira bed at Kenyon, Holden P. O., Wykoff, Weisbachs' dam, and other localites.

*Collections.*—Geological and Natural History Survey of Minnesota; W. H. Scofield; E. O. Ulrich; Dr. C. H. Robbins.

*Museum Register*, Nos. 6765, 7399, 7449, 7463.

## Bellerophon similis, *n. sp.*

PLATE LXIV, FIGS. 31–39.

This species is represented by about thirty casts of the interior and exterior, showing a decided constancy in its specific peculiarities. The form of the carinated volutions, indeed the general aspect of the whole shell in its usual state of preservation, is so much as in *B. troosti* that at first sight it may seem to be identical with that Kentucky and Tennessee species. A closer examination and better specimens, however, will soon prove them to be quite distinct. In the first place, the surface striations, instead of passing from each side almost straight across the back of the volutions to the carina, curve strongly backward, thereby forming a deep though wide-angled sinus in the outer lip. Next the striæ are coarser, sublamellose, more regular and not arranged in bundles as in *B. troosti.* Further, the keel grows more prominent toward the aperture and the umbilicus is larger, though this is probably due entirely to the lesser thickness of the test. Finally, the aperture is of a different shape, less expanded laterally and less contracted by the callosity of the inner lip. The callosity is much less and forms no transverse ridge at the inner part of the lip.

*B. similis* occupies an intermediate position between *B. troosti* and *B. platystoma* Meek and Worthen, the section of the volutions being as in the former, while all the other characters are more nearly like those of the latter. With ordinary care good specimens of *B. similis* and *B. platystoma* are not difficult to separate. *B. similis* has more rapidly enlarging and relatively fuller volutions, the dorsal part of the transverse section, if we exclude the carina, being almost semicircular, while in *B. platystoma* the slope on each side of the prominent keel is decidedly flattened. This difference in the transverse sections of the whorls we have found to be very reliable and of itself sufficient for the separation of the two forms excepting in a few cases in which the specimens were either poorly preserved or badly crushed.

It remains to be mentioned that several specimens show very faintly a number of wide revolving bands. Whether these are structural or merely accidental has not been determined. Possibly they indicate color bands.

*Formation and locality.*—Clitambonites and Fusispira beds of the Trenton group, Wykoff, Kenyon, and various localities in Goodhue county, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, No. 8725.

### Bellerophon recurvus, *n. sp.* (*Ulrich.*)

PLATE LXIV. FIGS. 11–13.

This species is closely related to and in some respects intermediate in position between *B. clausus* and *B. similis.* The lines of growth curve backward as in the latter, while the umbilicus is entirely closed as in the former. Compared with *B. clausus* we find that the lines of growth curve backward much more strongly in approaching the dorsal carina, and the outer lip consequently has a much deeper sinus, while the callosity of the inner lip is not so great. The aperture, as nearly as we can make it out, must be very much as in *B. troosti* (pl. LXIV, fig. 3), not so much expanded laterally perhaps. The absence of an umbilicus will distinguish the species at once from *B. similis.* None of the other known Lower Silurian species of the genus are as closely related as the two with which we have compared *B. recurvus.* Further remarks are, therefore, unnecessary, particularly since it is our wish that the student should rely chiefly upon the illustrations in seeking to identify the species of this difficult group of fossils.

*Formation and locality.*—So far known only from the Loraine group at Cincinnati, Ohio, where a few specimens were found near the tops of the hills.

*Collection.*—E. O. Ulrich.

### Bellerophon subangularis, *n. sp.* (*Ulrich.*)

PLATE LXIV. FIGS. 14–16.

Having no umbilicus, this species is related to *B. clausus* and *B. recurvus,* but it is distinguished at once from both by its subangular dorsum, and relatively narrower and somewhat triangular aperture. Its surface markings are rather distinct and regular; on the dorsal slopes they sweep backward gently to the carina.

*Formation and locality.*—Richmond group, Richmond, Indiana.

*Collection.*—E. O. Ulrich.

### Bellerophon mohri *Miller.*

PLATE LXIV. FIGS. 44 and 45.

Shell large, last volution with the aperture abruptly and greatly expanded laterally; inner volutions of moderate size, appearing rather closely involute, having only a small umbilicus, with the slope on each side of the carinated dorsum slightly flattened; aperture somewhat semicircular in outline, much wider than high, its width comparing with the hight of the entire shell about as seven to ten; outer lip thin, the small V-shaped central emargination prolonged backward into a rather long narrow slit, which as growth continues forms the slit-band; inner lip thick, greatly expanded, extending below almost to the periphery of the outer volution; concave on each side of the latter, the inner edge thick and with a rounded central swelling which continues inwardly as a rounded ridge; inner aperture subtriangular, the inner or lateral angles rather sharp, the outer more obtuse. Surface marked by strong, regular, thread-like lines of growth, of which, on an average specimen, twelve to fourteen occur in 5 mm. The course of the striæ from the umbilicus to the slit-band is gently curved in the central half, but more strongly at each end. Slit-band very rarely preserved; when perfect it surmounts a low ridge, is of moderate width, concave, bordered on each side by a thin sharp line, and covered by more or less unequal lunulæ. In casts of the interior the umbilicus is much larger, sharply defined and very abrupt, the ventral side of the volutions appearing to be almost flat and the section of the outer one triangular.

This fine species is related to *B. platystoma* and *B. similis*, but has a thicker shell than either of the Trenton species. This shows itself especially in the much stronger development of the inner lip, and in the smaller umbilicus. As casts of the interior, in which condition all three of these species are most commonly met with, *B. mohri* may be distinguished from the others by the impression of the callosity of the inner lip which causes the umbilical cavity to appear as drawn out narrowly above. The volutions besides enlarge more rapidly, and the umbilicus, especially when compared with *B. similis*, is deeper and much more sharply defined.

Good testiferous specimens are very rare, many being distorted by pressure, and in most of them the greater part of the aperture is broken away, and the surface markings obscured by weathering or maceration. The majority, however, preserve a large part of the expanded inner lip.

*Formation and locality.*—Not uncommon in the upper part of the Richmond group of the Cincinnati period at Richmond, Indiana. We have it also from Lincoln county, Kentucky.

*Collection.*—E. O. Ulrich.

### Bellerophon capax, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 50 and 51; PLATE LXIV, FIGS. 40–43.

This species agrees closely with *B. mohri*, but on comparison proves to differ in a greater or lesser degree in nearly every feature. First, the volutions enlarge more rapidly, second, they are more ventricose, third, the umbilicus in casts is a trifle smaller and more rounded at the edge, fourth, the outline of the aperture is less narrowly rounded on the sides, and fifth, the cross-section of the outer volution of casts is nearer semicircular than triangular. The shell is larger, the volutions increase in size much faster, the umbilicus is smaller, and the inner lip much heavier than in *B. platystoma* and *B. similis*. When the aperture is imperfect, specimens of this species sometimes look very much as though they might be a larger variety of *Protowarthia granostriata*. Yet this is most certainly not the case, since the species possesses a slit-band and the aperture of a true *Bellerophon*. When neither of these features is preserved, then it is distinguished from the *Protowarthia* by its open umbilicus and larger size.

*Formation and locality.*—Lower part of the Loraine group and upper part of the Utica group at several localities in the vicinity of Cincinnati, Ohio.

*Collection.*—E. O. Ulrich (7 specimens).

## Genus BUCANOPSIS, n. gen.

*Bellerophon* (part.), HALL, MEEK, DE KONINCK, MCCOY, D'ORBIGNY, and other authors prior to 1880. LINDSTRÖM, 1884, Silurian Gastropoda of Gotland.

*Bucania* (part.), WAAGEN, 1880, Palæontologica Indica, ser. 13, pt. 2, pp. 130 and 150. KOKEN, 1889, N. Jahrbuch f. Mineralogie, etc., Beilageband vi, p. 379.

?*Euphemus* (part.), MCCOY, 1844, Synopsis Carb. Foss. Ireland, p. 25.

For generic characters see page 853.

The greater part of the species which we propose to classify under this generic name were originally described as of *Bellerophon*, an arrangement that was quite satisfactory to paleontologists till 1880 when Waagen proposed to separate them on account of their spiral surface sculpture. In this we think he was fully justified, because extensive studies of the *Bellerophontacea* prove conclusively that the surface markings deserve a high rank among the characters that are available to the systematist who seeks to subdivide the group into natural and convenient generic sections. But, as we shall show in discussing that genus, both he and Koken, who adopts Waagen's proposition, are wrong in extending the application of Hall's *Bucania* to all the spirally striated bellerophontids. *Bucania* must be restricted to species of the type of *B. sulcatina*, which is quite different in other respects from the Devonian and later Paleozoic shells that make up the bulk of the species referred by them to Hall's genus. The surface markings even are not exactly the same in the two groups, they being straight and parallel with the direction of the whorls in *Bucanopsis* while in true *Bucania* they are wrinkled, interrupted and more or less oblique in direction.

It seems very clear to us that *Bucanopsis* was developed from *Bellerophon* and not from *Bucania*. Every character of the genus, excepting the revolving lines, corresponds with the former and is more or less different from the latter. A comparison of the figures of species described in this work alone can scarcely fail to convince students that this is really a fact, and the same must continue to grow more obvious when they extend their comparisons to Upper Silurian, Devonian and Carboniferous *Bellerophontidæ*.

*Bucanopsis,* if we include in it, as we must provisionally do, all the Paleozoic spirally striated shells which agree in other respects with *Bellerophon,* may not be an entirely natural genus. By this we mean that many of the later forms are probably not descended from the Trenton type of the genus. We think it possible that *Bucanopsis*-like species were evolved from *Bellerophon* not only in Lower Silurian times but at later periods as well. Again it is not unreasonable to suppose that certain developmental lines, originating in some period preceding the Trenton, may have resulted in forms that we cannot now separate satisfactorily from *Bucanopsis.*

The last possibility is suggested by Koken's remarks on the development of the shells which he erroneously places into Meek's genus *Bucanella* (see this work pages 849, 876 and 882). If he is correct in regarding *Bellerophon substriatus* Krause, and several Devonian species mentioned by him, as having descended from his Lower Silurian *B. esthona,* then the possibility is strengthened into probability; for *B. esthona* most certainly came from quite a different stock than that which produced *Bucanopsis carinifera,* while the supposed Devonian descendants are scarcely distinguishable from *Bucanopsis,* and only by the slightly greater width of their slit-bands. However, we are strongly inclined to doubt that Koken's views on the question under consideration are justified by the facts. In our opinion, *B. esthona,* as well as a corresponding American form, is quite distinct from most if not all of the others with which he connects it, and it probably represents an undescribed genus with relations nearer *Tetranota* and *Bucania* than *Bucanopsis.** On a preceding page we propose the name *Kokenia* for this new genus, and on plate LXIV figure the only known American species of this type (*K. costalis,* page 882).

*B. substriatus* Krause strikes us as a form that may have been developed from a species of *Tetranota* like *T. wisconsinensis.* The characters known, it is true, are insufficient to establish its affinities, yet if it could be proved that the inner whorls retain only a trace of latero-dorsal ridges, we would overlook its somewhat different surface markings and place the species with little or no hesitation under *Tetranota.* But to show the difficulty of correctly estimating the generic affinities of many of the bellerophontids from figures and descriptions above, we may say that so far nothing has been published of *B. substriata* that might be considered as thoroughly antagonistic to the view that would consider it as a modification of the Lower Silurian *Protowarthia,* in which delicate revolving lines are also often present. The broad apertural sinus reminds one strongly of *Protowarthia,* and when it comes to the tripartite character of the shell, which character in connection with another about to be considered led Koken to place these species with *Bucanella, B. substriatus*

* It is to be mentioned that Koken very properly places *B. esthona* in the immediate vicinity of *Bucania* or, as we call it, *Tetranota bidorsata.*

resembles *Protowarthia granistriata* more closely in this respect than either *Bucanella trilobata* Conrad sp., or *Kokenia esthona.*

The longitudinal striation, unusual width and elevation of the slit-band, the last feature producing an obscure tripartite character to the shell, seem to be the principal characters upon which Koken bases his conception of *Bucanella* as distinct from *Bucania*, which with him included *Bucanopsis.* These features he finds in his *B. esthona*, Krause's *B. substriatus* and in several other Silurian and Devonian shells which he assumes to be related to species upon which Meek founded *Bucanella.* This assumption, however, is totally unwarranted, and in the absence of sufficient evidence to prove his point Koken should not have charged Meek with an incorrect description.

The elevation of the slit-band in the group of species under consideration is probably not of much consequence, though usually present. Its unusual width, however, may be of importance but we see no way of utilizing it at present. The extension of the revolving lines over the slit-band also seems to us to be of little value. We came to this conclusion because they may be present in one and absent in the other of two closely related species. For instance, in *Bucanopsis textilis* Hall (not De Koninck sp.), of the Warsaw or St. Louis group, the slit-band seems always to be without revolving lines, but in an undescribed form recurring in the Chester group of Kentucky, and which can scarcely be distinguished, such lines are clearly present. We find them also in *B. leda* Hall, while they are absent in the closely related *B. lyra* Hall. Then they are developed again in some of the Carboniferous species, notably *B. marcouiana* Geinitz, *B. ellipticus* McChesney, and *B. montfortianus* Norwood and Pratten, the last belonging to the *Bellerophon patulus* group of species. It seems to us, therefore, unreasonable to accord any more than specific importance to the presence or absence of these lines.

There is another assertion made by Koken to which we must take exception. He says that *B. esthona* is "obviously a combination of the characters of the so-called *Euphemus* and *Bucania.*" This observation is so totally at variance with our own opinion that we are almost at a loss to answer it except with a simple contradiction. He is most assuredly far from the truth if he means to imply that the revolving ridges of *Euphemus*, which we cannot for a moment doubt are really folds of an extension of the inner lip, are in any way comparable with the spirally ribbed external surface sculpture of *Bucania* and *Bucanopsis.*

BUCANOPSIS CARINIFERA, *n. sp.* (*Ulrich.*)

PLATE LXII, FIGS. 56–61.

Shell less than medium size, the hight varying in thirty-five specimens between 7 mm. and 15 mm.; width of aperture nearly or quite equal to the hight. Volutions two or two and one-half, rather closely coiled, embracing to a little more than one-half, with a strong, prominent, flat-topped dorsal keel, from which the surface descends in a wide concave slope; sides rounding somewhat narrowly into the small open umbilicus; section of volutions broadly cordate. Aperture broad, somewhat triangular-ovate in outline; outer lip thin, with a moderately deep V-shaped central emargination; inner lip thick, very wide, reflected laterally, extending downward over the preceding volution whose keel shows through very distinctly. Surface with fine straight revolving striæ, alternating somewhat in strength; transverse or growth lines, excepting an occasional wrinkle, usually very faint, but on the larger specimens they become much stronger and incline to be irregular. Slit-band flat, smooth so far as known.

This, the type and only known Lower Silurian representative of the proposed genus *Bucanopsis*, reminds one somewhat of the European *B. substriatus* Krauss, but the dorsal carina is much more prominent and the slit-band narrower than in that rather doubtful Upper Silurian species. None of the Gotland species of the genus have the dorsum carinated. Of Lower Silurian *Bellerophontidæ*, *Bellerophon troosti* and *B. platystoma* are somewhat similar, but as the former has more rounded volutions and the latter quite a differently shaped aperture, there is little likelihood of confusion between them even as casts. Being true bellerophons they have of course no revolving lines, while the carina is never so prominent as in *Bucanopsis carinifera.*

We have about fifty specimens of what we take to be the same species from the Loraine group at Cincinnati, Ohio. They are, however, smaller than the Trenton form, the hight being in most cases less than 7 mm. and in only one as much as 10 mm. Not one of them exhibits even a trace of surface markings although preserving the shell, or rather a replacement of the same in crystalline calcite. But the absence of surface markings on these specimens should not be considered as proof that they were originally without them, since they are wanting also on all the other *Gastropoda* occurring in association with them. Among these other forms are well known species of *Lophospira* and *Cyrtolites ornatus*, the surfaces of which under more favorable conditions are always distinctly sculptured.

*Formation and locality.*—Upper part of Trenton group, near Danville, Kentucky; Loraine group of the Cincinnati period, Cincinnati, Ohio.

*Collection.*—E. O. Ulrich.

## Genus CARINAROPSIS, Hall.

*Carinaropsis*, HALL, 1847, Pal. New York, vol. i, p. 183.
*Phragmostoma*, HALL, 1861, Fourteenth Rept. N. Y. St. Cab. Nat. Hist., p. 94; not Waagen, 1880, Pal. Indica, ser. 13, pt. 2, p. 131.

For generic characters see page 857.

This is a well-marked genus, and one that we find it difficult to place satisfactorily in our scheme of classification. Taking the small inner volution alone, we are reminded sometimes of *Cyrtolites*, at other times of *Oxydicus*, but the whole shell with its greatly expanded and peculiarly constructed aperture, is so widely different from these genera that, with our present knowledge, we cannot think even for a moment of seriously comparing them. There are perhaps better reasons for bringing the genus into connection with *Bellerophon*, there being in reality scarcely a single—if indeed any—feature of *Carinaropsis* that is not also present in some form or other in species of that genus. Thus, picking out the more essential characters of *Carinaropsis*, an expanded aperture is frequently present in *Bellerophon*, though the inner volution or volutions are never minute as in *Carinaropsis*, the inner lip is often thickened within into a blunt ridge (e. g. *B. troosti*) but the ridge is never developed into a projecting wide plate; then the volutions are often carinated, though but rarely, if ever, so distinctly as the smaller volution of *Carinaropsis.* Finally, the shells of both genera have a slit-band and a sinus in the outer lip. Though their features on the whole are the same in kind, they still differ so greatly in development that, especially when resemblances in very different directions are considered, we are more than satisfied that *Carinaropsis* represents a distinct family.

We have already alluded (see page 857) to certain striking agreements in structure existing between *Carinaropsis* and *Pterotheca*, a genus of Silurian shells that all authorities now place with the *Pteropoda.* In both of these genera the aperture is broadly expanded, a septum is developed, and the back is carinated, in each case more strongly in *Pterotheca* than in *Carinaropsis.* But while in the latter the shell forms as much as two volutions, in the former it is merely arcuate, the curvature in no case amounting to a single volution. Though the differences between the two genera are doubtless important, are we not so far justified in claiming that *Pterotheca* is not farther removed from *Carinaropsis* than this genus is from *Bellerophon?* We say "so far" because *Pterotheca* possesses one character that is not represented in *Carinaropsis* nor in any true member of the *Bellerophontacea.* Namely the apical extremity of *Pterotheca* is divided by two small vertical septa into three portions of which the central one is longer and somewhat wider than the lateral ones.

Granting for the present that *Pterotheca* is a pteropod, we look in vain among the other types of that sub-class of shells for anything corresponding to the trifid apex of *Pterotheca*. We conclude, therefore, that the peculiarity is of generic importance only, and consequently not a serious objection to an arrangement which, in following the suggestion of the other characters, would bring *Carinaropsis* and *Pterotheca* within the limits of the same order and family. According to our opinion this family will prove to belong to the *Docoglossa* and not to the *Pteropoda*.

### CARINAROPSIS CUNULÆ *Hall.*

PLATE LXII, FIGS. 10—13.

*Carinaropsis* (*Phragmostoma*) *cunulæ* HALL, 1861, Fourteenth Rept. N. Y. St. Cab. Nat. Hist., p. 94.

Shell 20 mm. to 25 mm. in width, the length of the largest specimens about 20 mm., the hight of the same about 10 mm.; consisting of two or two and one-half volutions, the last abruptly expanded. Dorsum angular, or slightly carinated on the small volution, the angle becoming gradually more and more obtuse toward the deeply emarginated anterior edge, where it may be quite obsolete and in some specimens replaced by a broad flattened slit-band. Umbilicus small but distinct and deep. Aperture broadly subovate, insinuated in front and somewhat truncated behind; posterior lip reflected. Septum broad, extending about two-fifths across the aperture from the edge of the posterior lip, nearly twice as wide as long, its anterior edge somewhat thickened and slightly arched; behind the edge, which is nearer the plane of the apertural margin than usual, the outer surface is moderately concave. Inner surface of septum distinctly carinate, with a slight continuation of the same feature on the outer side. Inner aperture subtriangular or semi-elliptical, closed by a nearly flat operculum. Surface marked by fine lines and more or less obscure varices of growth.

This species differs from *C. cymbula* Hall in having the first volutions larger and projecting farther beyond the posterior lip, which again is more abruptly deflected, but the best difference lies in the septum whose outer surface is much less excavated in this species.

*Formation and locality.*—Upper part of Trenton group, Nashville, Tennessee, and Boyle county, Kentucky.

*Collection.*—E. O. Ulrich.

### CARINAROPSIS CYMBULA *Hall.*

PLATE LXII, FIGS. 1—4.

*Carinaropsis* (*Phragmostoma*) *cymbula* HALL, 1861, Fourteenth Rept. N. Y. St. Cab. Nat. Hist., p. 94.
*Phragmostoma natator* (in error for *cymbula*) HALL, 1862, Fifteenth Rept. idem., pl. VI, figs. 12—14.

Volutions one and a half or two, the first very minute; posterior margin of aperture not reflected, causing an unusual depth between the lip and the edge of the septum; edge of septum scarcely thickened, the whole outer surface of septum nearly smooth. In other respects like *C. cunulæ*. The great excavation of the septum is the principal peculiarity of the species.

*Formation and locality.*—Top of the Trenton group, near Danville, Kentucky. The original types of the species are said to have come from the Hudson River group, but this is probably an error.

*Collection.*—E. O. Ulrich.

CARINAROPSIS PHALERA *Sardeson.*

PLATE LXII, FIGS. 14—18.

*Carinaropsis* (or *Bellerophon*) *phalera* SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, no. 3, p. 336.

This form is very near *C. cunulæ* Hall, the only differences that we can now see being the apertural margin which is less reflected and scarcely truncated posteriorly, giving a more nearly circular outline and greater depth to the concavity of the septum. Mr. Sardeson mentions "indistinct radiating folds on the dorsal surface" of one of his specimens (a cast), but we have failed to notice anything of the kind.

*Formation and locality.*—Black River group, Rhinidictya and Ctenodonta beds, St. Paul, Minneapolis Chatfield, Minnesota.

*Collections.*—E. O. Ulrich; original types in the cabinet of the geological department of the University of Minnesota.

CARINAROPSIS ACUTA, *n. sp.*

PLATE LXII, FIGS. 6—9.

Shell very delicate, the largest about 27 mm. in length, but the majority of the specimens before us, perhaps because of imperfection, are only from 3 to 11 mm. in length. Volutions about three, the inner ones very small, greatly compressed, and very sharp on the dorsum, the last expanding very rapidly. As the dorsal angle becomes gradually less acute and the rate of expansion of the volutions increases, the aperture changes from triangular to subcircular. Septum comparatively short, the edge much within the plane of the apertural margins. Posterior lip not reflected. Surface, so far as observed, quite smooth.

This differs from the preceding species in the greater compression and much sharper dorsal angulation of the inner whorls, and in the much shorter septum.

*Formation and locality.*—Black River shales, Rhinidictya and Ctenodonta beds, Cannon Falls, and near Fountain, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7534.

CARINAROPSIS MINIMA, *n. sp.*

PLATE LXII, FIG. 19.

Shell very small for the genus, the width of the aperture about 8 mm. in a specimen having a length of 6 mm. and a concavity of about 4.3 mm. Dorsum only moderately acute at first and becoming gradually quite obtuse. Surface with several comparatively strong lines or wrinkles of growth.

Of this species we have seen only the small specimen figured on plate LXII. At first we thought it might be an immature example of *C. phalera*, but a more careful comparison proved conclusively that so great an expansion of the aperture could not have occurred in the young of that species. Indeed, the expansion of the aperture is a sign of maturity in this genus, and that this condition has been reached by the specimen in question is further indicated by the strength of the lines of growth which mark its surface where the latter is in good preservation. If these indications are trustworthy then the species will be distinguished very readily from all the others known of the genus by its small size.

*Formation and locality.*—Black River group (Ctenodonta bed) near Cannon Falls, Minnesota.
*Collection.*—E. O. Ulrich.

CARINAROPSIS EXPLANATA, *n. sp.* (*Ulrich.*)

PLATE LXII, FIG. 5.

Shell large, volutions apparently less than two, the first very small, the next greatly expanded; hight only about one-third of the width; umbilicus very small; dorsum angular. Aperture not well preserved, apparently transversely subelliptical, and somewhat broadly sinuate in front; posterior lip little if at all reflected. Septum large, curved inward, the inner edge about 18 mm. long in a specimen 38 mm. wide. Surface of casts with obscure varices of growth.

The width is relatively greater than in any of the other species. The outer surface of the septum is less deeply concave and its anterior edge farther within the plane of the apertural margin than in *C. cymbula*, which it resembles perhaps more closely than the others.

*Formation and locality.*—Upper part of the Trenton group, Covington, Kentucky.
*Collection.*—E. O. Ulrich.

## Subclass PROSOBRANCHIATA.

## Order PECTINIBRANCHIATA.

### Suborder EOTOMACEA.

This proposed suborder is made up chiefly of four families of shells that are perhaps the most important of all to the paleontologist, namely, the *Raphistomidæ*, *Pleurotomariidæ*, *Euomphalidæ* and *Trochidæ.* Besides these it should include other families, as for instance the *Fissurellidæ* and *Haliotidæ*, which were most probably derived from the *Pleurotomariidæ*, provisionally also the *Maclureidæ* because of their evident relations to the *Euomphalidæ.* Then we include also the *Turbinidæ* because their early Paleozoic prototypes can be shown to have very close relations with unquestionable members of the group, while of their recent representatives it is well known that they are not greatly different from the *Trochidæ.*

We find it most difficult to designate the characters of the shell which may fairly be said to be peculiarly characteristic of the group. Perhaps such characters do not exist,—at any rate we shall not now attempt to point them out. For the present it must suffice to say that the suborder rests principally upon observations which we regard as proving the common origin of the four families first mentioned. These observations will appear in the course of our remarks on the families known to have representatives in the Lower Silurian rocks of Minnesota.

### Family RAPHISTOMIDÆ, n. fam.

This family includes shells which we regard as the best known representatives of the original stock from which the *Euomphalidæ*, *Pleurotomariidæ* and *Trochidæ* were almost simultaneously evolved. The position of the majority of the forms is intermediate between the first two families, leaning toward the second rather than the first, while the rest compare better with types that we place as early representatives of the last family, particularly with certain of the Upper Silurian shells which Lindström refers to the recent genus *Trochus.*

The most persistent character of the *Raphistomidæ* is one that at first may seem almost trivial, but because of its persistency it is justly entitled to rank as important. Namely, the lines of growth on the upper side of the whorls, which of course correspond in direction with the outline of the upper lip of the aperture, though directed on the whole backward, are curved sigmoidally, thus causing a usually very slight sinus in the outer part. The curvature is never strong and is perhaps best developed in *Raphistoma* in which the point at which the change in direction of the curve occurs is usually marked by a slight seam-like line or interruption. In *Raphistomina* and *Euomphalopterus* the sigmoid character of the curve is always distinguishable but there is no intermediate interruption.

A true slit-band does not occur in any of the *Raphistomidæ*, yet it would be quite reasonable to consider the angular or lamellar periphery of the whorls as its representative. Or it may be that the slightly sinuate outer parts of the lines of growth on the upper side of the whorls are homologous with the lunulæ crossing the band of true *Pleurotomariidæ*. Still, the evidence at hand is insufficient to establish either view. For the present then we have two well marked differences between the shells of the two families that may be utilized even should the suggested homologies admit of demonstration. The first of these differences lies in the absence of an apertural slit and the resulting slit-band, while the second may be expressed by saying that the retral sweep of the lines of growth in the *Pleurotomariidæ* is never diminished but, on the contrary, is nearly always increased just before reaching the band, while in the *Raphistomidæ* it is decreased and often overcome entirely on the peripheral carina. In cases like *Euomphalopterus alatus*, in which the carina is extremely developed, the second curve is again overcome by a third which is strongly retral. The last, it seems to us, has no further significance than the preservation from injury of the anterior outer angle of the carina which would have been exceedingly liable to breakage if the second curve had continued.

We place here in all five genera. The position of the first three we regard as unquestionable, the fourth, *Omospira*, differs very decidedly from the rest in the rounded form of its volutions and relatively high spire, while the fifth, *Scalites*, is doubtful because there is yet much to learn respecting its most important characteristics. If the last should prove to have the really essential features of the family then its systematic position would most likely be between *Raphistoma* and *Omospira*. All of these genera have heretofore been placed with the *Pleurotomariidæ*. For general remarks on them, farther than those about to follow, the reader is referred to our discussion of that family on a subsequent page.

Raphistoma, Hall, 1847.* Shell sublenticular or plano-convex, the spire flat, the sutures close; volutions triangular in section, sharply angular and generally thin at the periphery; there is neither a slit nor a band; umbilicus varying in size but nearly always present; aperture turned backward slightly so as to form a shallow notch at the outer angle; lines of growth only; on the flattened upper surface these are slightly sigmoid and usually interrupted by a raised line between the two

* Pal. New York, vol. i, p. 28.

curves; passing over the acute edge they turn strongly forward and finally back again into the umbilicus. Types, *R. staminea* and *planistriata* Hall.

RAPHISTOMINA, n. gen. Shell lenticular to depressed conical, umbilicated; volutions sharply angular and carinate at the periphery, the carina projecting over the but slightly impressed sutures; aperture very little oblique, subrhomboidal; upper lip directed backward with a gently sigmoid curve, the sutural half convex, the outer half concave, the extreme outer angle slightly hooked; outline of lower lip varying from concave to convex, in the latter being almost parallel with the upper; lines of growth moderately distinct, not interrupted on the upper side of the whorls. Type, *Raphistoma lapicida* Salter.

EUOMPHALOPTERUS, F. Roemer, 1876.* Shell trochoid or subturbinate, broadly umbilicated, consisting of six or seven volutions rounded in section internally; carina thin, very wide, placed between the middle and the base of the whorls, enclosing numerous small tubular spaces running obliquely forward and outward and somewhat at variance with the lines of growth, and opening along its outer edge; aperture rounded, very oblique, the lower lip deeply and broadly sinuate; the lines of growth make a sigmoid curve between the umbilicus and the outer edge of the carina, the extent of the outer curve varying with the species and depending upon the width of the carina; on the upper side of the whorls they are curved less strongly and on the inner part in an opposite direction from that observed on the base, the result being that in a species like *E. undulans* Lindström sp., in which the carina is comparatively narrow, the anterior edge of the aperture, as viewed from above, is a gentle sigmoid, while in a widely carinated form like *E. alatus* the edge is biconvex, being recurved at the outer extremity. Type, *E. alatus* Wahlenberg sp.

OMOSPIRA, n. gen. Shell somewhat elongate turbinate, subturriculate; volutions seven or eight, ventricose, obliquely flattened in the upper part by an obtuse shoulder-like angulation; the latter, which may or may not constitute the periphery of the whorls, forms the outer margin of a wide band-like space in which the lines of growth, which first curve strongly backward in their course from the suture line, are turned in the opposite direction; a short distance before reaching the angle the curve is sharpened; as in *Raphistoma* the junction between the two curves is marked by a thin line, while beneath the outer angle the lines of growth are turned somewhat gently forward. Aperture somewhat quadrate-triangular, its hight slightly greater than the width, narrowly rounded but not effuse below; columellar lip rather straight, not thick, usually reflexed so as to hide a minute umbilical perforation. Surface markings consisting of fine lines of growth only. Type, *O. laticincta*, n. sp. (Ulrich.)

* Leth. Geogn., Ed. 4, pt. 1, pl. XIV, fig. 9.

? Scalites, Emmons. Shell turbinate, spire only moderately high; whorls flat above rising step-like one above the other, sharply angular at the periphery, produced below; no umbilicus; aperture subtriangular, apparently drawn out below; columellar lip rather thick, slightly twisted. Surface markings and form of outer lip unknown; probably as in *Omospira* and *Raphistoma*. Type, *S. angulatus* Emmons.

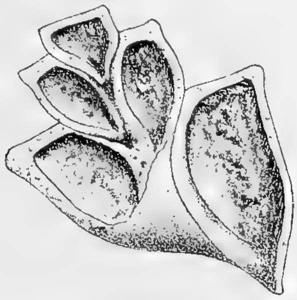

Fig. 4.—*Scalites angulatus* Emmons, Chazy limestone, Chazy, New York. View of a weathered specimen, imbedded in stone, showing part of the upper whorls in section and the umbilical region and slightly twisted columellar lip. Received from Prof. H. M. Seeley and now in the collection of E. O. Ulrich.

The accompanying figure shows nearly all we could learn of this genus and species. The general form reminds one of certain species of *Lophospira*, but we are certain that the angular periphery of the whorls does not carry a band as in that genus. Unfortunately, neither the original types nor, so far as known, any of the specimens discovered since, afford any positive knowledge concerning the form of the outer lip and surface markings. Although we believe that these characters will prove to be essentially as in the preceding genera of this family, we must admit that the question is complicated by the marked resemblance which *S. angulatus* bears to *Holopea supraplana*. For the present then the name *Scalites* should be restricted to the species to which it was originally applied.

Of these five genera *Euomphalopterus* is the most recent, being perhaps entirely an Upper Silurian type. The others with a few doubtful exceptions, are confined to Lower Silurian deposits. *Raphistoma* begins with several species in the Chazy and continues to the top of the Cincinnati period; *Raphistomina* is known in the Trenton, Black River and Calciferous formations, and we have reason to believe that the type reaches as far back as the Cambrian; while *Omospira* comprises Black River and Trenton species and perhaps a single Upper Silurian form. *Raphistomina* strikes us as the most primitive of the four Lower Silurian types and we feel reasonably satisfied that the others were evolved from it. *Raphistoma* was produced by flattening the spire, and by the anterior prolongation of the central portion of the lower lip, the latter modification causing the hook of *Raphistomina* to be replaced by a notch in the upper side of the outer angle of the aperture. *Euomphalopterus* differs chiefly in its more rounded volutions, and excessively developed carina. The lower lip also has become more strongly and constantly sinuate, causing a more oblique aperture. The evolutional modifications, it will be noticed, are almost exactly opposite in the two cases. As to *Omospira*, it was most probably derived from *Raphistoma*, or from some unknown allied type. The relations and differences existing between *Raphistoma*, *Raphistomina* and *Euomphalopterus* are clearly shown by the figures in the accompanying cut:

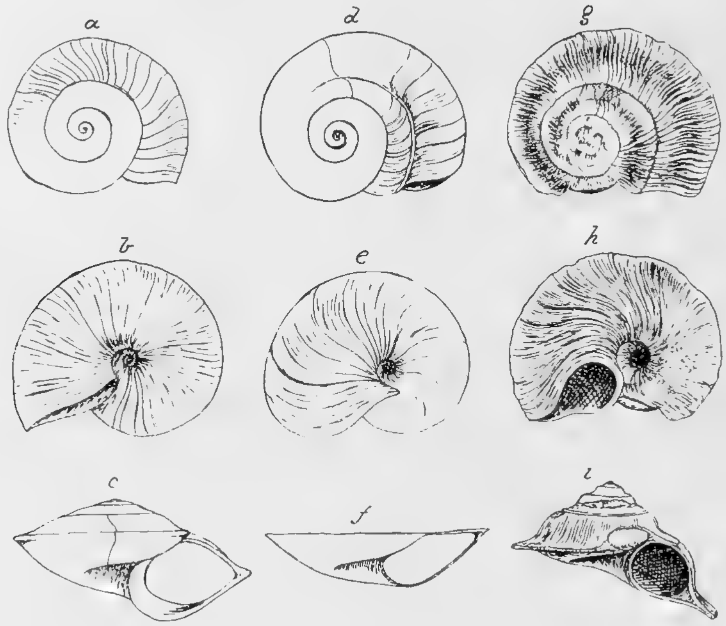


FIG. 5.—Sketches illustrating the character of *Raphistomina*, *Raphistoma* and *Euomphalopterus*. *a*, *b*, *c*, three views of *Raphistomina lapicida* Salter sp.; *d*, *e*, *f*, similar views, × 2, of *Raphistoma peracutum*, a depressed but otherwise very typical species of the genus; *g*, *h*, *i*, similar views of *Euomphalopterus alatus* var. *obsoletus*, n. var. The last is from the Niagara group near Waldron, Indiana, and is the only American representative of this peculiar genus known. It differs from the European varieties of the species chiefly in wanting the ridge which surrounds the umbilical cavity in those forms. The umbilicus in our variety is also a trifle narrower than usual.

*Raphistoma*, Hall, that long misunderstood and much debated genus, is now for the first time since 1847 correctly interpreted, limited and placed. Justice demands that Prof. James Hall, the author of the name, should be credited with having given a diagnosis that is strictly correct and sufficiently detailed to satisfy even the present requirements. He noticed and says distinctly that his *Raphistoma* has no band, and this fact of itself should have been accepted as fully justifying a separation from *Pleurotomaria*. Instead we find that authors have generally regarded his genus as indistingishable from *Scalites* Conrad, and both as synonyms of *Pleurotomaria*. Salter,* it is true, gives *Raphistoma*, together with his *Helicotoma* and Vanuxem's *Ophileta*, the rank of subgenera under *Scalites* (which he refers to the *Ianthinidæ*), and distinguished them from *Pleurotomaria* because of the absence of the spiral band. However, as we will show later on, *Helicotoma* and *Ophileta* are

*Canadian Organic Remains, dec. 1, p. 10, 1859.

euomphaloids and therefore quite different genetically from *Raphistoma*, while *Scalites* is not sufficiently known to be placed satisfactorily.

It is not worth while to review the literature of the genus that appeared during the time included between the years 1859 and 1890. It will suffice to say that the name gradually attained a somewhat precarious standing among American paleontologists as a convenient designation for lenticuliar shells which in other respects were supposed to be of the type of *Pleurotomaria.* Taking Miller's list of species referred to *Raphistoma** as a fair example of the use to which the genus had attained in recent years, it is evident that it is truly an incongruous assemblage. Of the nineteen species probably only the three originally referred to the genus really belong there. The others belong mostly to our new pleurotomarian genera *Eotomaria* and *Liospira*, and to *Raphistomina*, while several are too ill known to justify a definite arrangement under any genus.

In 1890† Koken endeavored to establish *Raphistoma* and to show its relations to *Pleurotomaria* on the one side and *Euomphalus* on the other. His effort has not proved entirely successful because he failed to grasp fully the essential peculiarities of the type species, *R. staminea.*‡ Unfortunately we cannot follow his arguments as closely as we would like, hence we are not quite certain that our objections to his statements are always fully justified. The main point, however, is that he holds to *Raphistoma* as a good genus. According to our views he should have gone a step farther and removed the genus entirely from the *Pleurotomariidæ.* The absence of a true slit-band alone seems to us fatal to a reference of *Raphistoma* to that family, and it is surely so when coupled with the rather obvious relations in which the genus stands with *Eccyliopterus* and *Eccyliomphalus* on the one hand and *Helictoma* on the other. Still, we are inclined to believe that Koken has overestimated the closeness of the line of the development which he seeks to establish between *Raphistoma* and *Eccyliopterus.*

Koken's observations are based chiefly upon European specimens which he has identified with *Raphistoma* in accordance, as he believes, with Hall's description of the genus in the first paleontological volume of the New York Survey. He starts with Schlotheim's *Euomphalus qualteriatus* which he regards as the European representative of our *R. staminea.* Considering the great variety of shells that have been referred to the species *qualteriatus*, it is to be regretted that Koken did not

* North Amer. Geol. and Pal., p. 424, 1889.

† N. Jahrb. f. Mineralogie, etc., Beilagebd. vi, p. 315.

‡ It is customary to cite *Maclurea striata* Emmons, as the type of *Raphistoma*, probably because the description of that species is the first to follow the generic description. From Hall's remarks under *R. staminea* (*op. cit.*, p. 29) it is quite evident that this is a mistake, for he says distinctly that "the generic character" was but "obscurely indicated upon" the *striata.* Besides, neither Emmous nor Hall refer to the character in their descriptions of the species, while the latter is very particular in showing its presence in *R. staminea* and *R. planistria*, going so far even as to use a wood-cut because it was not sufficiently brought out on the plate.

publish good figures of the form that alone is entitled to bear the name. Under the circumstances we are unable to decide whether it is a true *Raphistoma*. But we will concede for the present that it is. The second species is a new one which he calls *R. schmidti* and compares with the American *R. striatum.* This strikes us as not a true *Raphistoma,* the striæ upon the upper sides of the whorls curving backward too strongly and being neither interrupted nor sigmoidally curved. The figure (*op. cit.,* pl. XI, fig. 7) represents the shell as preserved on the inner volutions only, but a small peripheral rim or "collar" is rather distinctly indicated so that the species may be an undeveloped and closely coiled *Eccyliopterus* or an unusual type of *Helicotoma.* The remaining species constituting the supposed phylum (*Euomphalus marginale* Eichwald, *Raphistoma spirillum* Koken, *Pleurotomaria replicata* Lindström, and *Eccyliopterus alatus* Roemer, sp.) are doubtless all good species of *Eccyliopterus* and not *Raphistoma* at all.

In constructing the line Koken seems to assume that the other characters are equal, and then to depend upon the gradual sinking of the spire and on the increasing freedom of the whorls. Neither of these conditions, however, appears to us of material consequence in the case, both pertaining strictly to the *Eccyliopterus* end of the line and neither occurring ever in any true *Raphistoma.* Further, we doubt very much that *Raphistoma* and *Eccyliopterus* represent different stages of one and the same line of development, nor have we met with any evidence that might cause us to believe that the distinction between the two is ever likely to become arbitrary or artificial ("eine künstliche"). Finally, according to our opinion, the validity of *Eccyliopterus* will be determined not so much by its relations to *Raphistoma* as by its connection with *Ophileta* and *Helicotoma* and possibly *Eccyliomphalus.**

We find that *Eccyliopterus* is very closely related to the latter genera, only one so far constant peculiarity separating it in either case. The feature alluded to is the prominent thin plate into which the notch-keel is produced and which surmounts the top of the whorls like a high "collar." On seeing a shell like the Calciferous *Eccyliomphalus volutatus* Whitfield, which, from a careful study of a series of specimens recently sent us by Prof. H. M. Seely, we have determined to be a true *Eccyliopterus,* the first impression would naturally be that the genus is a very near relation to *Eccyliomphalus.* And so it may be, yet, if for a moment we leave out of sight the fact that its whorls are widely disconnected, and consider only the other characters, it will soon become obvious that the balance of agreements lies on the side of *Ophileta* rather than *Eccyliomphalus.* The whorls of *E. volutatus* are flattened on the lower side, although casts of the interior are rounded here, the shell

*When we say *Eccyliomphalus* we are to be understood as referring to shells of the type *E. intortus* and *canadensis* of Billings and *E. undulatus* Hall, which with other species form a distinct and natural group that it is presumed will include also Portlock's original types of the genus. At any rate, they are so nearly like them that, without more certain knowledge respecting Portlock's species, it is not safe to separate them.

being thickened at the outer and inner corners. This agrees with *Ophileta*, as does also the form of the aperture, and the course of the lines of growth. Finally, the position and character of the "collar" is certainly much more like the notch-keel of *Ophileta* than the more obtuse keel or angulation which marks the position of the rather broad and more shallow upper sinus in *Eccyliomphalus.*

Loosely coiled or disconnected whorls we do not consider as an essential characteristic of *Eccyliopterus.* All the species may perhaps exhibit a proneness to assume such a condition but it is certainly not very apparent in any of the American species. Of the latter, *E. volutatus* Whitfield sp., (see plate LXXIV) is the only one known to us having all the whorls separate, and it is doubtless closely related to the European *E. alatus* Roemer sp., the type of the genus. Then we have *E. triangulus* Whitfield sp., also from the Calciferous at Providence island and Fort Cassin, Vermont, which is exceedingly like the Swedish *E. replicata* Lindström sp., especially when it has the inner whorls in contact. The next species, our *E. beloitensis*, is from the Stones River group. It, like the preceding, has a representative in Europe, being apparently very similar to *E. marginalis* Eichwald sp. All the whorls are in contact in this species excepting occasionally the apertural portion in old examples. The fourth American species is the *Ophileta ottawaensis* of Billings, from the Trenton of Canada, while the fifth and, so far as known, the last is the *Ophileta owenana* of Meek and Worthen, casts of which are not uncommon in the Trenton group of Minnesota and Illinois. In both the whorls are always in contact. From the foregoing statements it is evident that, in the development of the genus from the Calciferous on, the evolute or free character of the whorls became gradually less and finally was lost entirely. All the other characters, however, are maintained with rare persistency.

If *Eccyliopterus* and *Raphistoma* are sections of the same line of development, then the evidence of their geological distribution indicates the former as the parent stock and not the latter, since *Raphistoma* occurs so far as known first in the Chazy when *Eccyliopterus*, which enjoyed its greatest development in the Calciferous formation, had already begun its decline. We do not wish to deny that much may be said in favor of such a derivation of *Raphistoma*, still we are confident that the modifications required are more difficult to prove and altogether less rational than in the view which derives the genus from *Raphistomina.* Billings has described a number of low-spired Calciferous and Quebec species among which we expect to find links connecting the last genus with the Chazy *Raphistoma.* His *Pleurotomaria hortensia* and *Pl. harpya* promise the required conditions.

In *Raphistoma* the spire of the upper side varies from flat to gently convex, but so far as we have observed, it is never sunken; the keel forms the periphery and is directed outward instead of upward; the umbilicus is always smaller, and the section of the whorls consequently different; finally, there is always an interruption or peculiar bend in the backward sweep of the surface striæ on the flat upper side of the whorls, the like of which we have never seen in any *Eccyliopterus*. The last peculiarity we have observed in only three other groups of species that have been referred to the *Pleurotomariidæ*, namely, the Upper Silurian *Euomphalopterus*, Roemer, a good genus that will include the majority if not all of Lindström's section *alatæ* of *Pleurotomaria*; our *Raphistomina*, founded upon Lower Silurian shells of the type of *Raphistoma lapicida* Salter; and our *Omospira*, which differs from *Raphistoma* chiefly in forming a high spire and in having much less angular whorls.

For the present we must take a decided stand against the view held by many paleontologists and definitely expressed by Koken (*op. cit.*, p. 315) that the developmental series in which *Raphistoma* was continued ended in unquestionable pleurotomarians. On the contrary so far as our observation permits of judgment, *Raphistoma* is a sharply limited type, in no case taking on pleurotomarian characters, and one that is entirely restricted in its geological range to the rocks lying beneath the base of the Upper Silurian. As may be seen from our *R. richmondense*, which is from the uppermost division of the Cincinnati period and the most recent species of the genus known, the generic type underwent exceedingly little modification from the first to the last. Nor have the changes been in any respect toward the *Pleurotomariidæ*. We admit, however, that a more complete knowledge of the Calciferous *Gastropoda* is necessary before it will be possible to reach perfectly satisfactory conclusions respecting the origin and development of *Raphistomina* and *Raphistoma* and their true relations to the equally ancient euomphaloid and pleurotomarian genera *Eccyliopterus* and *Helicotoma*, and *Liospira*, *Euconia*, *Eotomaria* and *Lophospira*. All these genera represent, in a measure, contemporaneous lines of development, often exhibiting very nearly parallel, or at any rate similar, series of modifications. But this does not necessarily imply that they pass into each other, not that there is any very close relationship amongst them. They may have merely given expression to characteristics and tendencies which they inherited in common from a remote ancestor.

If genetic relations exist between the *Raphistomidæ* and *Pleurotomariidæ*, and this is a condition that we believe will some day be demonstrated, then the faint sinus in the outer part of the upper lip may prove to be an undeveloped or incipient representation of the much narrower and deeper apertural notch of the early pleurotomarians. In that case Koken's view of the carina of *Euomphalopterus* (*op. cit.*, page 318) which he gives in opposition to Lindström, who regards it as homologous with the slit-band of the *Pleurotomariidæ*, would be correct in so far as the shells are concerned which we regard as *Pleurotomariidæ*. But he is certainly in error when he denies homology between the carina of the group of *Pl. alata* (*i. e. Euomplalopterus*) and of *Raphistoma* and *Raphistomina* on the one hand, and the "collar" of *Eccyliopterus* on the other. On later pages of his valuable work (438, 439) Koken compares the genus *Euomphalopterus* with *Delphinula* and particularly with the so-called *Solarium caillaudianum* of d'Orbigny, a Mesozoic shell. The agreement of the latter with *E. alatus* is exceedingly close, and we are quite willing to admit the justice of his comparisons because they accord so well with our view that the *Trochidæ* and *Onustidæ* were derived, like *Euomphalopterus*, from descendants of *Raphistomina*.

In his most exemplary work on the "Silurian Gastropoda of Gotland" Lindström describes and most beautifully illustrates a large number of shells which he refers to *Trochus*. A comparison of the figures, excepting *T. profundus* and *T. cavus*, is calculated to give the impression that the whole assemblage represents numerous and very diverse specific modifications of a single generic type. And yet it is possible to pick out several groups that may be brought into very plausible connection with widely different Lower Silurian types. Thus, the group of which *T. lundgreni* is the central form, with *T. astraliformis* and perhaps *T. stuxbergi* and *T. gothlandicus* on one side and *T. incisus* on the other, we regard with much confidence as derived from *Raphistomina; T. wisbyensis, T. lamellosus, T. fulminatus* and *T. dalli* remind one in all respects, excepting that their apertures are more oblique, of some of the smaller species of *Trochonema* figured in this work; finally we are so greatly impressed with the similarity between *T. mollis* and our *Cyclonema transversum*, that we can scarcely concede that they are not genetically related.

Now, with respect to these Gothlandic *Trochus*-like shells, the closeness of the resemblance existing between them may be explained in two different ways. The first, starting from the almost demonstrable assumption that the *Trochidæ* and *Turbinidæ* have been derived from an early type of *Raphistomina*, considers them as a great display of varietal or specific modifications of a single type, the varieties severally taking on more or less of the distinctive features of previously established lines that had their origin in the same ancestral stock. According to the second explanation the groups of species mentioned in the preceding paragraph are actual descendants respectively of *Raphistomina*, *Trochonema* and *Cyclonema*, which, because they lived under the same conditions, or for some other unknown cause, assumed similar characters with their neighbors, the gradual convergence of characteristics resulting in a series of forms that to many may seem almost inseparable. Both of these explanations are theoretically correct, and although we are inclined to accept the second as the most rational, it is not at all improbable that the truth lies between them.

## RAPHISTOMA, Hall.

*Raphistoma*, HALL, 1847, Pal. New York, vol. i, p. 28.
*Raphistoma* (part.) and *Pleurotomaria* (part.), of many authors.

For the generic characters and a full discussion of the relations of this genus the reader is referred to the preceding remarks on the family. (See pages 931, 934.)

Of the nineteen species referred to this genus in the last edition of Miller's catalogue, perhaps only *R. stamineum* and *R. planistria*, with its variety *parvum*, really belong here. The majority of the remainder must be classed as doubtful, since we do not know whether they have a slit-band or not. Some may belong to *Raphistomina*, as does *R. lapicida* Salter, or to *Liospira*, as do *R. americanam* Billings sp. (= *lenticulare* Emmons) and *R. subtilistriatum* Hall sp. *R. niagarense* Whitfield certainly is not a *Raphistoma*. It seems to be congeneric with Meek and Worthen's *Platyostoma trigonostoma*. Two good species of the genus were described by Billings as *Pleurotomaria calyx* and *Pl. crevieri*, both from the Canadian Chazy. To these we add the two following new species.

### RAPHISTOMA PERACUTUM, *n. sp.*

PLATE LXVIII, FIGS. 1–6.

Shell small, not known to exceed 12 mm. in diameter, consisting of three or three and one-half whorls, flat above, rounded below; periphery very sharp and thin; umbilicus equalling a little more than a fourth of the greatest diameter, its edge narrowly rounded; hight of shell very slightly exceeding a fourth of the width. Surface marked on the flat upper side with very fine subequal striæ sweeping on the whole rather strongly backward from the suture. About a third of the width of a whorl from the suture the striæ are interrupted by a delicate revolving line. Between the latter and the extreme edge of the peripheral carina the striæ make a distinct sigmoid curve. Below the periphery the surface is marked with similar striæ, which, in descending, curve first forward and then almost directly toward the center of the umbilicus.

In this species the hight is relatively less, and the peripheral edge consequently thinner, than in any previously described species of this genus. It is the only gastropod known to us as occurring in the Lower Silurian rocks of Minnesota having a perfectly flat spire.

*Formation and locality.*—Black River group, Ctenodonta bed, Goodhue county, Minnesota. Rather rare.

*Collections.*—E. O. Ulrich; W. H. Scofield.

RAPHISTOMA RICHMONDENSIS, *n. sp.* (*Ulrich.*

PLATE LXVIII, FIGS. 7–9.

Shell 15 to 20 mm. in diameter, the spire almost flat, the hight between one-third and two-sevenths of the width; volutions four, very slightly convex on the upper side, *i. e.* within the outer edge which forms a thin elevated rim; umbilicus very small in casts, apparently closed in shells. Surface striæ fine and subequal on upper side, making the usual sigmoid curve, the change in curves occurring near the middle of the whorls. Just before reaching the peripheral rim the striæ make another short backward turn. Beneath the periphery the striæ are more unequal. At first they turn forward then more directly inward.

This species resembles the Chazy *R. calyx* Billings, but is smaller and relatively wider. In *R. crevieri,* of the same author and formation, the edge is blunter, and the lines of growth curve more strongly forward beneath it. *R. peracutum* has an umbilicus and differs in several other respects. A very similar species, differing only in that it has a small umbilicus, occurs in the Stones River group in Tennessee.

*Formation and locality.*—Richmond group, Richmond, Indiana. Good specimens rare.

*Collection.*—E. O. Ulrich.

## Genus RAPHISTOMINA, n. gen.

*Raphistoma* (part.) and *Pleurotomaria* (part.), of authors.

For generic characters and general remarks see pages 932 and 934 to 939.

As species of this genus are generally confounded with *Raphistoma,* it may be well to repeat the peculiarities upon which we base our separation. In *Raphistoma* the lines of growth on the lower side, which of course correspond with the outline of the lower lip, curve forward more or less strongly from from the peripheral edge. The outer half and more of the under lip therefore is convex, whereas in *Raphistomina* the corresponding portion is always concave. In species like *Raphistomina laurentina* Billings sp., this concavity is decided and extends over the whole anterior outline of lower lip. On the upper side of the whorls the striæ curve backward again in *Raphistoma* just before reaching the peripheral edge. This, together with the forward curve immediately beneath the edge, produces a small notch in the outer angle of the aperture. In *Raphistomina,* on the contrary, there is no notch, the angle being either rectangular or turned slightly forward, in some cases forming a beak-like projection. Comparing the upper and lower lips we find that in *Raphistoma* their outlines do not correspond, the lower being more prominent and simply convex in the outer two-thirds where the upper forms a sigmoid curve. In *Raphistomina,* however, the anterior outlines of the two lips are either equal, or the lower is more concave, the amount and extent of the sinuate portion varying with the species. Finally, the upper side of the shell is apparently never quite flat in *Raphistomina*, while this is generally the case in *Raphistoma*.

The shells of *Raphistomina* remind one in a general way very greatly of those of our new pleurotomarian genera *Liospira* and *Eotomaria*. Still, when the surface markings are preserved, no one is likely to have much trouble in separating them. A glance should be sufficient for those accustomed to handling fossil gastropods. The principal difference between these genera is that while *Raphistomina* has no slit-band, both of the other genera have, *Liospira* having it directly at the peripheral edge and *Eotomaria* immediately above it.

Besides the four species figured in this work, three of which are new, we have only one other species, *Pleurotomaria laurentina* Billings, which we can place here with certainty. However, we can scarcely doubt that some of the lenticular shells which, because they are insufficiently known, we must provisionally leave as doubtful forms of *Pleurotomaria* and *Raphistoma*, will eventually prove to belong to this genus.

### RAPHISTOMINA LAPICIDA *Salter*.

PLATE LXVIII. FIGS. 18–20.

*Raphistoma lapicida* SALTER, 1859, Can. Org. Rem., Decade 1, p. 12.

Shell discoidal, nearly equally convex above and beneath the acute peripheral carina, usually about 25 mm. in diameter and but little more than half as high. Umbilicus deep, rather narrow, not abrupt, its width equalling about a fifth of the diameter of the shell. Volutions about four, gently convex on both the upper and lower sides except near the peripheral carina, where, especially upon the upper side, the surface is rather distinctly concave. Excepting the last whorl, which sometimes descends a little beneath the edge of the preceding, the spire slopes with very little interruption at the sutures. The lines of growth are as usual somewhat stronger below than above. As a rule they are irregular and unequal. On the upper side they are turned backward from the suture but not very strongly, nor is the sigmoid curve which they make a conspicuous feature. Still, the retral sweep is sufficiently overcome in the concave region near the edge to cause them to intersect the latter at nearly a right angle. On the lower side their course from the edge to the umbilical cavity is nearly a straight line, a slight anterior curve just before they descend into the umbilicus causing a faint sinus in the outer half. Aperture transverse, acutely ovate, the outer extremity or angle turned slightly forward in a view from below. Inner lip curved, slightly reflexed.

The above description is based chiefly upon a number of silicified shells from Tennessee which we owe to the kindness of Prof. J. M. Safford. These differ, so far as we can see, from the Canadian types of the species only in having the upper side of the volutions a trifle more convex. *R. laurentina* Billings sp., from the Calciferous of Canada, is closely related but is readily distinguished by the much deeper and wider sinus in the outline of its lower lip.

*Formation and locality.*—The original types are from the Black River limestone at Allumette island, in the Ottawa river, Canada. The Tennessee specimens come from an equivalent horizon near Lebanon. If the species occurs in Minnesota it will probably be found in the Ctenodonta bed.

### RAPHISTOMINA DENTICULATA, *n. sp.* (*Ulrich.*)

PLATE LXVIII, FIGS. 21—23.

This species is very closely allied to *R. lapicida* Salter, yet there should be little trouble in distinguishing good specimens. Carefully compared we find that in the new species the umbilicus is much narrower, the hight of the shell relatively greater, the sutures deeper because the edge of the whorls projects somewhat over the top of the succeeding volution, the aperture is a little more oblique and the periphery of the whorls less acute. Further, there is to be observed, especially on casts of the interior, an obscure ridge running parallel with but some distance beneath the peripheral carina. Finally, the peripheral edge is minutely toothed, a character that does not occur on the even better preserved examples of *R. lapicida* seen by us. At present we know of no other species with which it need be compared.

*Formation and locality.*—Top of the Black River group, Mercer county, Kentucky.

*Collection.*—E. O. Ulrich.

### RAPHISTOMINA MODESTA, *n. sp.* (*Ulrich.*)

PLATE LXVIII, FIGS. 14—17.

Differs from *R. lapicida,* which it resembles more closely than any other known, in being smaller (12 to 15 mm. in diameter), in having a proportionally smaller umbilicus, and in its surface markings. On the upper side, which is also a little more depressed, the lines of growth are very faint, while the peripheral edge turns rather distinctly upward. On the lower side the lines of growth are likewise obscure except in the peripheral half of the last whorl, where they appear as rather coarse undulations of which the best specimen has about seven in 5 mm. The course of the lines on this side, which of course corresponds with the outline of the lower lip, is more convex anteriorly than in *R. lapicida.* (Compare figs. 16 and 18 on plate LXVIII). *R. denticulata* is a larger shell, has a higher spire and deeper sutures.

*Formation and locality.*—Lower division of the Stones River group (Safford's Central limestone), near Murfreesboro, Tennessee. It is here associated with a broadly umbilicated and much larger species, apparently of this genus, of which, unfortunately, we have so far failed to secure satisfactory examples. Several other discoidal shells occur at this locality rendering great caution a necessity in discriminating between them.

*Collection.*—E. O. Ulrich.

### Raphistomina rugata, *n. sp.*

PLATE LXVIII, FIGS. 10–13.

This pretty species differs in at least two respects from all of the foregoing species. First, the surface markings are relatively stronger, second, the umbilicus is more sharply outlined. As usual the surface markings are faint in the umbilicus and near the suture line, and much stronger in the peripheral portion of the shell. The umbilicus is rather larger than the average, its diameter equalling about a fourth of the entire width of the shell. Another peculiarity is that the upper surface of the whorls is almost flat from the but slightly impressed suture line to the edge; nor is there more than a barely perceptible concavity beneath the edge. Often the whole upper surface of the shell is perfectly flat, giving it more of the usual appearance of a *Raphistoma* than a *Raphistomina.* The spire is always lower than in any of its congeners, and in no observed case higher than in fig. 12.

*Formation and locality.*—Clitambonites bed of the Trenton group at various localities in Goodhue county, Minnesota.

*Collections.*—E. O. Ulrich; W. H. Scofield.

## Genus OMOSPIRA, n. gen. (Ulrich.)

*Murchisonia* (part.), Hall, Salter and Billings.

For generic characters see page 932.

We are anything but satisfied respecting the systematic position of this genus. If *Scalites*, Emmons, could be proved to possess the essential characteristics of the *Raphistomidæ,* then we would have an undeniable link between *Omospira* and *Raphistoma*. In the absence of such a link, the general resemblance which *Omospira* bears to certain *Pleurotomariidæ*, like *Hormotoma bellicincta* and *Eotomaria elevata*, gives us not a little trouble to explain away in a convincing manner. Still, there are two features about the sinus in the upper lip and the band-like space resulting from it in the growth of the shell that are anything but indicative of pleurotomarian affinities. First, the great width of the band, and second, the oblique,—perhaps it would be better to say the outwardly increasing,—curvature of the lines crossing it. In all true *Pleurotomariidæ* the lunulæ or lines crossing the slit-band, providing the latter does not lie, as in *Liospira micula*, partly over the peripheral edge, form a uniform curve in passing from one to the opposite border of the band. (See fig. 13, plate LXIX). As may be seen in fig. 65 on plate LXX, this is not the case in *Omospira*, the lines in this case crossing obliquely and increasing in curvature downward. The lines on the band, furthermore, are of the same character as those above the band, only curved in the opposite direction, the two portions united forming a sigmoid curve as in *Raphistomina;* and their continuity is interrupted when the change in direction occurs by a raised line, as is frequently the case in *Raphistoma.* Is it fair to explain the conditions observed in *Omospira* by supposing that they have resulted, first, through the elevation of the spire and the consequent reduction of peripheral carina and hightening of the volutions, and second, either by a mere approximation toward the prevailing character of the *Gastropoda* with which they are chiefly associated, or by following the more prevalent tendency which they, as *Raphistomidæ*, inherited, like the *Pleurotomariidæ*, from their common ancestor? For the present we must confess that we have allowed such theoretical reasons as the foregoing to dominate our placement of the genus.

To whatever position *Omospira* may be ultimately assigned, the validity of the genus is not likely to be seriously affected. If it really belongs to the *Raphistomidæ*, then it will stand as a type obviously distinct from the other genera of the family, because of its high spire and comparatively rounded volutions. If, on the contrary, it proves to be one of the *Pleurotomariidæ*, then it will be readily distinguished by the peculiarities of the band mentioned in the preceding paragraph. The high position of the band would also serve in the latter association.

As to the specific representation of the genus, we know of only two species that can be referred here positively, namely, the type *O. laticincta* and *Murchisonia alexandra* Billings (*M. ventricosa* Salter, not Hall). Possibly Hall's *M. ventricosa* also belongs here, but Whitfield says it is a *Lophospira.*

### OMOSPIRA LATICINCTA, *n. sp.* (*Ulrich.*)

PLATE LXX, FIGS. 64 and 65.

Shell 50-60 mm. high; greatest width about three-fifths of the hight; apical angle varying between 49° and 55°, the angle formed by the first three or four whorls usually about five degrees more. Volutions about seven in number, obliquely flattened above, ventricose below, their sides almost vertical, the upper turns more rounded than the last three. Sometimes the flattened upper portion is more nearly horizontal than in the specimen illustrated. Aperture subtriangular, somewhat higher than wide, the outer lip thin and curving gradually inward from the shoulder-like upper angle to the narrowly rounded base; inner lip only moderately thick, nearly straight, and generally reflexed in its upper part over a minute umbilicus, more or less completely closing the latter in all save one of the specimens before us. Surface marked with fine, regular, equal, raised lines of growth. These curve rather strongly backward on the flattened upper portion of the whorls until they approach the shoulder-like angulation, when they turn sharply forward. About midway between the suture line and the outer angle, the growth lines are interrupted by a sharply elevated revolving line, causing the outer half of the upper slope to resemble an unusually wide slit-band. Beneath the angle the lines descend with a gentle forward curve to the base of the whorl.

This fine species is readily distinguished from *O. alexandra* Billings sp., by its higher and more angular whorls.

*Formation and locality.*—Top of Stones River group or base of the Black River group, near Lebanon, Tennessee.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

### OMOSPIRA ALEXANDRA *Billings.*

PLATE LXX, FIGS. 66 and 67.

*Murchisonia ventricosa* SALTER, 1859, Can. Org. Rem., Decade 1, p. 23. (Not *Murchisonia ventricosa* Hall, 1847.

*Murchisonia alexandra* BILLINGS, 1865, Pal. Foss., vol. i, p. 172.

This species has the same general characteristics as the preceding, yet may be distinguished at once by its more depressed and more rounded volutions. Its apical angle also is narrower, being between 40° and 45°, while the aperture is more rounded. There is not a sign of an umbilical perforation.

The cast of the interior figured as possibly of this species may in reality belong to something quite different. At any rate, it is the only fossil from the northwestern states which we could say probably represents this species.

*Formation and locality.*—Base of the Trenton group or at the top of the Black River group, in Mercer county, Kentucky. The types are from the latter horizon at Allumette island in the Ottawa river, Canada.

*Collection.*—E. O. Ulrich.

## Family PLEUROTOMARIIDÆ, d'Orbigny.

This large and most important family of fossil shells has given systematists not a little trouble to classify. The great number and variety of the species has occasioned many attempts to arrange them in convenient generic and subgeneric groups, sometimes happily, but in most cases the result proved neither convenient nor successfully defensible when subjected to the test of genetic relationship. As usual many of the subdivisions as drawn by authors were necessarily wrecked through the prevailing ignorance concerning the structural peculiarities and lines of development exhibited by the Paleozoic types, the early Paleozoic especially.

Each year the absolute necessity of extending our systematic paleontological studies backward as far as possible becomes more and more obvious. The rapid changes which took place among the early representatives of all classes of animals and the consequent relative ease with which the lines of evolution may be traced, gives them an importance in biology that is scarcely to be overestimated. For the *Gastropoda* the Lower Silurian species, because the class is but sparingly represented in the Cambrian, are the most likely to throw light upon the genetic relations of the succeeding forms, and are therefore deserving of the most careful investigation. Concerning the *Pleurotomariidæ*, the facts brought out in an extended study, of the Paleozoic species chiefly, have led us to conclusions that, while not greatly different from those published by Koken, who has adopted methods more nearly in accordance with our own than any previous observer, are still sufficiently original to cause great changes in the views and nomenclature heretofore in vogue. We have gone into the subject more extensively than the present work demanded or perhaps even justified, but the knowledge gained, if it cannot all bear fruit immediately, is still not in vain, since it will doubtless prove of use in our future work. We have most carefully considered the published papers of authors who have dealt with Paleozoic *Pleurotomariidæ*, particularly those of De Koninck, Sandberger, Lindström, Œhlert and Koken, and it would please us greatly to enter into a detailed account of their various views. But as this would require more space than we have at our disposal and would moreover be out of place in a work of this kind, we are obliged to postpone it to some more fitting occasion. Incidentally, however, we shall frequently refer to them, especially when our opinions happen to differ.

We believe it is admitted generally that the essential feature of the *Pleurotomariidæ,* and the peculiarity relied upon chiefly in distinguishing the family from other spiral shells, excepting of course the symmetrically enrolled bellerophontids and certain *Euomphalalidæ*, *Fissurellidæ*, *Turritellidæ* and *Cerithiidæ*, is a definitely limited narrow band, terminating anteriorly in the bottom of a more or less deep sinus of the outer lip merely, or in a long, open and sometimes periodically closed slit. The long parallel-edged slit occurs, as far as known to us, in but two Lower Silurian species (*Schizolopha* of this work), and is comparatively rare among the Upper Silurian and Devonian forms; but with the Carboniferous species it is common, while among the more recent forms it is nearly always present.

Of all the characters of the family, the peculiarities of the slit and band furnish us with the most reliable grounds upon which to base our generic divisions. According to these the family might be divided primarily into two principal groups, the first having a sinus only in the outer lip, the second a long parallel-sided slit or a series of openings. These groups are again divisible, according to the character of the slit-band, each into two similar groups, one having the band convex, the other concave. Such an arrangement might at first appear convenient, yet a careful study will soon reveal that it would be quite arbitrary, therefore unnatural, and in the end not even convenient. This is so obvious that it is quite unnecessary to cite proving instances. Still, there is an element of truth in the first of these suggested divisions, for it would separate what we may call the archaic from the more recent stages in the development of the family.

We have already referred to the almost total absence in the Lower Silurian *Pleurotomariidæ* of the long parallel-edged slit which occurs so generally among the more recent types of the family. This difference has not received the attention from paleontologists that it deserves, for surely it must indicate a structural difference in the animals. Lindström barely alludes to it, while Koken, much to our surprise, takes no notice of it whatever. Unfortunately, the presence or absence of the slit is not positively determinable except when the aperture is entirely preserved, the band behind the slit presenting, so far as we can say, no evidence that might lead the observer to suspect either the one or the other condition.

The slit which should be carefully distinguished from the apertural notch, which is more or less widely V-shaped and does not extend backward any farther than the bottom of the sinus formed by the lines of growth, seems to be a later phase in the evolution of the majority of the lines of development that can be traced from the Lower Silurian into subsequent periods. Its development appears to be the result of a tendency to which the whole family, rather than any particular generic line, is subject. As we have already said it is almost entirely absent in the Lower Silurian *Pleurotomariidæ*, in the majority of which the lines of growth, and, therefore, the outer edges of the lip, sweep backward toward the band more strongly than in the prevailing types of subsequent ages. We might then assume that the slit was represented in those ancient times by a deep notch, and that the presence of the latter in many Devonian and Carboniferous forms is merely a retention of a primordial character after its real cause or purpose had been removed or satisfied by the development of a long slit. However, before such a view can be accepted we must account for the extreme shallowness of the apertural sinus in such slit-less species as are comprised in the *Bicincta* section of *Lophospira*, which, as far as our present knowledge goes, existed in numerous species from the Chazy to the close of the Upper Silurian. Now, *Shizolopha textilis*, which has a long slit, was almost certainly developed from some member of the *Bicincta* section, so that the suggested explanation of the development of the slit cannot apply here and is rendered highly improbable in any case.

In one group of *Pleurotomariidæ*, i. e. *Hormotoma*, we have good evidence showing a gradual development of the slit. In all the Lower and Upper Silurian species of this genus a deep V-shaped apertural notch is present, but no slit. In, however, what we consider to be Devonian representatives of the same type of shell (e. g. *Murchisonia desiderata* and *maia* Hall) we observe that the bottom of the notch is prolonged into a short slit, but the backward sweep of the edges of the outer lip forming the notch is quite as pronounced as in the earlier species which have no slit. From this and the preceding case, therefore, it is evident that the slit did not take the place of a deep notch but that it is really an additional and distinct feature.

The length of the slit varies greatly in different members of the family. On the whole the length is considerably greater in Mezozoic than in Paleozoic species. In the latter the length has not been observed to exceed three-eighths of the circumference of the last whorl. In the Devonian *Pl. sulcomarginata* it is about one-fourth, likewise in the *Pl. turbiniformis* group (*Euconospira*), the *Pl. tabulata* or *Worthenia* group and the majority of the Carboniferous species. In *Schizolopha* it is a trifle longer, while in the Niagara *Pl. labrosa* group (*Phanerotrema* Fischer) it equals about one-third. In *Pl. sphærulata* it is about one-seventh, and in *Murchisonia maia* Hall not over an eighth, while in the *Pl. carbonaria* group it is even shorter and possibly absent entirely. Among Mesozoic and more recent forms, particularly *Leptomaria* and *Chelotia*, the length often exceeds one-half and may reach fully two-thirds of the last whorl. It is interesting to note that, as far as we now know, the slit which furthermore seems to have been developed almost suddenly, is longer in the earliest species known to possess one than in any of the later Paleozoic forms.

The band which is left behind by the gradual closing of the slit presents considerable variety in position and structure. As a rule, especially among Paleozoic species, it lies on the peripheral part of the whorls. When the volutions are angular it commonly forms the summit of the principal angle, as in *Lophospira* and *Worthenia*. In conical shells, like those of the group of *Pl. turbiniformis*, it forms a narrow vertical band at the extreme periphery of the whorls. In other conical shells, like *Pl. etna* Billings, it lies at the base of the flat slope, the lower edge of the band in such cases forming the periphery. In certain Mesozoic and recent types (*Pyrgotrochus*, *Perotrochus* and *Entemnotrochus* of Fischer) in which the shell is similarly conical, the band lies considerably above the angular periphery, but it never occupies such a position in any of the angulated Paleozoic types, being in these placed always very near or entirely upon the angle. Occasionally, as in the Carboniferous group of *Pl. brazoensis*, it lies in a broad peripheral concavity, beneath the principal carina.

What we conceive to be the most primitive type of slit-band occurs in the Lower Silurian *Lophospira*. In this genus it occupies, or rather forms, the summit of a more or less prominent peripheral ridge, above and beneath which the lines of growth curve backward in directions corresponding to the outline of the apertural notch. The band itself may be simply a blunt edge, upon which the growth lines make their turn; but more commonly it is defined on each side by a delicate raised line, which separates the lunulæ of the band from the surface striations. The markings of the band are always different from that of the rest of the surface, being as a rule more regular, while the arched transverse lines or lunulæ may be stronger or weaker, and farther apart or closer than the lines of growth either above or beneath the band. Occasionally, as in *Lophospira tubulosa* and *L. imbricata* Lindström sp., and our *L. notabilis*, the lunulæ are widely separated and strongly imbricating; sometimes, as in *L. bicincta*, they are much finer and very closely arranged; frequently they consist of simple elevated lines; in other cases they have a median excision (*Pleurotomaria limata* Lindström), or they are crossed by one (*Pl. ohioensis* James) or two (*Pl. scutulata* Lindström) median lines; or the central line may be developed into a thin undulating plate (*Lophospira serrulata* Salter sp.) or into a row of nodes (*Pl.* [*Worthenia*] *tabulata* Conrad). In short, the marking of the band in the members of the family is of great variety, but as a rule we cannot say that the various types are of much assistance in determining the generic or subgeneric position of the species.

Although we can already see some possible exceptions, we think that provisionally it is advisable to regard species having a concave band as generically distinct from those in which the band is convex. We have very carefully examined a large number of species, and so far the separation on this difference has resulted in a very much more satisfactory classification than any we have yet had. Considering the form of the band, as far as its being concave or flat on the one hand and more or less convex on the other is concerned, as a leading test of relationship, we bring together many forms that have hitherto been separated, while many others that had been associated are widely separated.

As generally understood heretofore, particularly among American and Canadian paleontologists, the two principal Paleozoic genera of the family are *Pleurotomaria*, De France, and *Murchisonia*, d'Archiac and Verneuil, the former embracing the species with a low spire and relatively few volutions, the latter those forming a high shell of numerous whorls. As viewed by us this broad separation or arrangement of the species according to the hight of the spire results in a most artificial classification, since it causes the separation of shells that comparative studies prove to be closely related genetically, while others are associated that have only very remote affinities for each other.* Besides it leaves a large number of intermediate forms which may be placed with equal propriety into either genus. But this is not all, for we believe with other authors that, as now constituted, these genera embrace material more than sufficiently various to admit of defining a comparatively large number of valid generic groups,—valid in the sense that they are relatively as important groups of species as are ordinarily considered to be of generic value.

Now, what are the characters upon which we propose to base these genera? First, upon the presence or absence and relative length of a true slit, as distinguished from a mere apertural notch; second, the characters of the slit-band, among which its outline, as exhibited in transverse section, is the most important; third, the width of, and the position of the band and slit or notch with respect to the hight of the volutions; fourth, the form of the volutions, with respect to angularity and roundness; fifth, the form of the entire shell; sixth, the character and depth of the suture; seventh, the form and outline of the aperture as shown by the lines of growth; and eighth, the changes in the character of the volutions from the embryonic to the mature stages. Corroborative and subordinate characters are furnished by surface markings, the apical angle, the relative size of the last volution, the presence or absence of an umbilicus, and minor peculiarities of the aperture, the notch, the slit and the band. The relative importance of these characters is not always the same, but they are sufficiently reliable for present requirements.

### SYNOPSIS OF GENERIC AND SUBORDINATE GROUPS OF PALEOZOIC PLEUROTOMARIIDÆ.†

I. LOPHOSPIRA, Whitfield, 1886.‡ Shells with more or less elevated spires; whorls closely coiled throughout or only in the upper part, the last often exhibiting a tendency to become disconnected; whorls angular on the periphery and bearing from one to five distinct carinæ; central or peripheral keel strongest and most prominent, carrying the band, which is obtusely rounded, or more or less distinctly trilineate, with the median line heavier and more prominent than the other two; axis rarely, if ever, solid; an umbilicus, usually of very small size, nearly always present. Inner lip generally thickened, often slightly twisted, turning around the umbilicus so as to form a kind of hollow pillar. Outer lip more or less deeply notched, but the center of the notch, which lies at the peripheral angle, is never prolonged into a slit. Surface markings parallel with the apertural edge; occasionally cancellated by fine spiral lines. Types, *Murchinsonia bicincta* Hall and *M. serrulata* Salter (=*M. helicteres* Whitfield, not Salter.)

*To appreciate the subordinateness of the value of differences in the hights of the spire within moderate limits, a comparison of the figures of species of *Lophospira* described in this work should suffice. We pass by almost imperceptible gradations from species like *L. ampla* and *L. notabilis*, in which the apical angle is 80 and 90 degrees, to others, like *L. bowdeni* Safford sp., in which the angle is of sometimes less than 25 degrees. And, so far as we can see, there is not the remotest chance for a generic separation between the first and the last of the species mentioned.

†Remarks on genera of which species are described in this work will be found on succeeding pages.

‡Bull. Amer. Mus. Nat. Hist., vol. i, p. 312.

II. Schizolopha, n. gen. (Ulrich.) In every respect like *Lophospira* excepting that the apertural notch is prolonged into a long parallel-edged slit. Type, *S. textilis*, n. sp. (Ulrich.)

III. Phanerotrema, Fischer, 1885.* Shell turbinate, whorls few in number, flattened above, the last large and high, the others rising step-like; spire short; slit long, region of band salient; aperture subquadrate, inner lip thick; lines of growth nearly vertical beneath the band, above it turning more decidedly forward; strong revolving lines occur especially on the lower and outer parts of the whorls. Type, *P. labrosa* Hall.

This Upper Silurian genus seems to have been derived from the *Trochonemoides* section of *Lophospira*, our *L. trochonemoides* and *L. knoxvillensis* being very similar in general form and having almost exactly the same kind of aperture. The band, though salient also in those species, is somewhat different, the central line being, as it should be in *Lophospira*, considerably stronger and more prominent than the bordering lines. Still, in our opinion, the peculiarities of the *labrosa* type of band were produced by an extreme development of the bordering lines, the space between the elevated edges being gently convex. Aside from the band, *Phanerotrema* is distinguished from all the Lower Silurian *Pleurotomariidæ*, except *Schizolopha*, by its long slit, and from the excepted genus by its relatively smaller spire, much larger last volution, peculiar band, and strong revolving lines. Further, it seems very clear that, although both types originated in *Lophospira* and deviated from the general character of that type in similar directions, their immediate ancestors represent widely different sections of that genus, and constitute distinct lines of development. Of the two species of *Schizolopha*, *S. textilis* evidently came from the *Bicincta* section, while *S. mooresi* accords more nearly with the *Perangulata* section. As to *Phanerotrema*, we have already said that it was most probably derived from the *Trochonemoides* section.

*Phanerotrema* includes besides the type species, *Pl. occidens* Hall, and a Gothlandic shell which Lindström erroneously identified with Hall's *labrosa*. The genus appears to be sparingly represented in the Devonian of Europe, but we know of none in American deposits of that age. Two of our Carboniferous species, however, *Pl. grayvillensis* Norwood and Pratten, and *Pl. marcouiana* Geinitz, appear to have all the essential characters of *Phanerotrema*, and we expect to find that they are actual continuations of the same generic type.

IV. Worthenia, De Koninck, 1883. Shell conical, tabulate, the general aspect much as in *Lophospira;* whorls angular on the periphery, the latter carrying the band; slit extending backward from the mouth between one-fourth and one-third of

*Manual de Conchyliologie, p. 851.

the circumference of the last whorl; band narrow, convex, the lunulæ not much curved, very strong and prominent at regular intervals, giving the band a crenulated or toothed appearance; columellar lip scarcely callous, reflected and forming a sort of false umbilicus; surface ornamented with spiral ridges; lines of growth moderately curved backward on the upper side of the whorls, nearly vertical beneath the band. Type, *Pl. munsteriana* De Koninck.

This genus is represented by three good species in the Carboniferous deposits of America, viz.: *Pl. tabulata* Conrad, *Pl. subscalaris* Meek and Worthen, and *Pl. speciosa* M. and W. We have before us a small undescribed species from the Devonian of Ohio that probably belongs here. The Worthenias remind one greatly of certain Lower Silurian types of *Lophospira*, particularly of the *Bicincta* section and *L. knoxvillensis*, and it is highly probable that they will be traced back to some member of that genus. We think further that they will be brought into connection with the Upper Silurian Phanerotremas. For the present they are readily distinguished from the latter by their higher spire, more gradually increasing volutions, and different band. From *Lophospira* they are separated by the denticulate band, strong spiral ornamentation and in having a true slit.

V. Liospira, n. gen. Shell sublenticular, the spire low, depressed conical, almost smooth, the sutures very close, scarcely distinguishable; volutions subrhomboidal in section, flat, gently convex or slightly concave above, sharply rounded at the periphery, convex below, and not infrequently angular at the edge of the umbilicus. The latter is usually present but may be filled entirely by an extension from the inner lip, in other cases it may be open during the younger stages only. Aperture deeply notched; band scarcely distinguishable as such, wide, situated on the narrow outer edge of the whorls though chiefly upon the upper side. Surface markings very delicate, rarely preserved, consisting generally of exceedingly fine transverse lines bending strongly backward on the apical side to the peripheral band over which they continue with little interruption to sweep sharply forward again on the lower side. Faint revolving lines occasionally observed. Types, *Pleurotomaria micula* Hall, *Pl. americana* Billings.

VI. Euconia, n. gen. (Ulrich.) Shell subtrochiform, regularly conical, base nearly flat, suture shallow; umbilicus usually of large size; mouth subquadrate, the inner lip but little reflected and scarcely thickened, the outer with a wide notch but no slit, the upper projecting beyond the lower; whorls numerous, enlarging very gradually, sharply angular at the lower edge; band not sharply defined, of moderate width, lying entirely upon the upper side of the peripheral edge; on the upper side of the whorls the lines of growth are fine and strongly curved backward from the suture to the band; on the lower side, where they are usually somewhat stronger, they pass almost directly across the whorl, a short backward curve occurring only just before they reach the periphery. Types, *Pl. etna* and *ramsayi* Billings.

At least two other species, the *Pl. amphitrite* Billings and *Pl. beekmanensis* Whitfield, are known to belong to this generic type. A possible fifth species (it may be the same as Billings' *etna*) occurs at Ft. Cassin, Vermont. With the exception of the species *amphitrite*, which may be a Chazy fossil, all these forms occur in the Calciferous formation, so that the genus represents one of the earliest fixed types of the family. Though fixed, in the sense that the known species adhere very strictly to the characters mentioned in the generic diagnosis, the type was evidently of short duration. We have very carefully examined the *Pleurotomariidæ* found in succeeding geological divisions but have failed entirely to discover any that might reasonably be viewed as descendants of *Euconia;* nor do we know anything positive about their ancestors. We are therefore obliged to consider the genus as a rapidly evolved, short and abruptly terminated branch from the stock which produced also *Liospira* on the one side and *Eotomaria* on the other. *Euconia* is distinguished from all of the Lower Silurian *Pleurotomariidæ* by the regularly conical spire and flat base, and the very slight curvature of the lines of growth on the under side of the whorls. These features are all reproduced in the Carboniferous group of shells which we propose to distinguish as *Euconospira,* but they have another character, namely, a long open slit, which is absent in *Euconia* and of itselt demands a separation. The surface of the Carboniferous shells differs also in being spirally lined.

VII. Eotomaria, n. gen. Shell depressed-conical, sometimes sublenticular; base more or less convex, its bulk usually nearly equal to the apical part; umbilicus very small or wanting; volutions not very numerous, sometimes slightly turriculate or strongly angular near the mid-hight; aperture oblique, subquadrate, the inner lip slightly reflected or merely thickened, the outer deeply notched at the peripheral angle; no slit; band of moderate width, concave, sharply defined, oblique or horizontal, lying upon the apical side of the periphery. The surface markings consist of fine lines of growth only. These curve backward more or less strongly toward the band on both the upper and lower sides of the whorls. Type, *E. sublævis,* n. sp. (Ulrich.)

VIII. Clathrospira, n. gen. Shell in all respects like *Eotomaria* except that the band is nearly vertical and situated upon the periphery of the whorls, and the surface beautifully cancellated. Type, *Pl. subconica* Hall.

IX. Bembexia, Œhlert, 1887.* Shell depressed subconical, imperforate, volutions angular; band distinct, concave, vertical or oblique, situated on the periphery,

* Extr. Bull. Soc. d'Etu. Scientif. d'Angers, p. 24.

submedian on the last whorl; slit about one-fourth volution in length; aperture moderately oblique, the edge of the upper lip sweeping backward rather strongly, the lower broadly concave in the middle, the inner lip generally somewhat thickened and reflected. Surface with rather strong lines of growth; on one or both sides of the band often a more or less well-defined smooth space. Type, *Bembexia larteti* Munier-Chalmas sp.

We have adopted this name for the group which in America is typified by the well-known Hamilton species, *Pl. sulcomarginata* Conrad, and includes also *Pl. planidorsalis*, *Pl. adjutor*, and *Pl. nitella*, described by Hall from the same formation, and *Pl. shumardi* Meek and Worthen, and *Pl. elegantula* Hall, two Lower Carboniferous shells, the first from the Keokuk, the second from the St. Louis. Excluding the spirally striated forms, whose relations to the group under consideration we cannot consider as established, *Bembexia*, as here defined, corresponds very nearly with Koken's "*Pleurotomariæ interruptæ*." The group, whether viewed as a genus or a subgenus is immaterial, seems to be a perfectly natural one. Provisionally we would give it an intermediate position between the Silurian *Eotomaria* and the Carboniferous *Euconospira*, the tendency of variation exhibited by the species being toward the latter, while their general expression reminds one of the former.

X. Mourlonia, De Koninck, 1883. Shell conical or somewhat discoidal, umbilicated. Band forming the periphery of the whorls, extremely prominent, thin, flange-like. On the upper side of whorls lines of growth curve backward without interruption from the suture line to the extreme outer edge; on the lower side first forward, then in a broad curve backward, and finally forward again as they turn into the umbilicus. Surface with revolving lines or not. Type, *Pl. limata* Lindström (*Pl. carinata* Sowerby).

This type of shell is represented in American deposits by *Murchisonia worthenana*, a rather high species described by Miller from the Niagara limestone at Chicago. As now understood the principal peculiarity of *Mourlonia*, when compared with true *Pleurotomariidæ*, lies in the excessive development of the bounding plates of the slit-band. This particular feature reminds one of *Euomphalopterus*, Roemer, and it is possible that *Mourlonia* is really allied to that remarkable genus. Still, they are readily distinguished by the sigmoid instead of uniform curve of the lines of growth on the upper side of the whorls in *Euomphalopterus*. Despite the resemblances we are firmly convinced that the genesis of the two types is quite different.

XI. Euconospira, n. gen. (Ulrich.) Shell almost regularly conical, the base nearly flat, sometimes a little convex but oftener slightly concave; not perforated, though a small umbilical depression is always present; whorls rather numerous, the first three or four, so far as observed, less flattened on the upper or visible slope than the following turns; aperture oblique, the width much greater than the hight, the inner lip scarcely thickened, the lower border, beginning at the inner extremity, first convex then broadly concave and finally convex again when the edge turns rather sharply backward to the slit which lies in the peripheral angle; upper margin sweeping backward very strongly from the suture; length of slit equalling between a third and a fourth of the last volution; band narrow, slightly truncating the pheriphery, visible on all the volutions, concave, lying between sharply elevated lines. Excepting the first three or four whorls, the surface is cancellated by fine spiral lines crossing the lines of growth. Types, *Pl. turbiniformis* Meek and Worthen, and *Pl. missouriensis* Swallow.

The deriviation of this genus is doubtful. There are two widely distinct Devonian groups of species from either of which it may have been evolved. With the evidence at hand, one derivation seems as plausible as the other, so we find ourselves unable to decide for either. The first brings the *Euconospiræ* from the *Pl. lucina* group, in which the slit-band and surface markings are similar while the form of the shell and of the volutions is very different. If this is the stock from which the genus under consideration sprang, the first change consisted probably in the gradual flattening of the dorsal surface of the whorls. In *Pl. filitexta, Pl. ella* and *Pl. hebe,* all species of the Hamilton group described by Hall, the necessary conditions are supplied in increasing ratio. The next step is furnished by Meek's Waverly species, *Pl. textiligera,* in which the apical side of the shell agrees exactly with the *Euconospiræ.* The basal portion, however, is very different, being ventricose instead of flat. Now, if we could find a shell having the convexity of the base considerably reduced, we might say that the chain connecting *Pl. lucina* and *Euconospira turbiniformis* is reasonably complete.

The second line of development would begin in, say *Pl. sulcomarginata* Conrad of the Hamilton, and include *Pl. nitella* Hall, of the same formation, *Pl. shumardi* Meek and Worthen, of the Keokuk, and *Pl. elegantula* Hall, of the St. Louis. The last species, though still too full at the base, nevertheless approaches very nearly to the form pertaining to the *Euconospiræ.* The principal feature lacking is the spiral sculpture, which is wanting in all of the *sulcomarginata* or *Bembexia* group. This difficulty, however, is lessened by the fact that the spiral lines are wanting also on the first volutions of at least two species of *Euconospira.* These early turns, furthermore, are slightly rounded on the dorsal surface, thus strongly indicating that the type was evolved from another in which the whorls were more rounded and without spiral markings. Taking all these points into consideration, the balance of agreement seems to be in favor of the second rather than the first line of development.

*Euconospira* is most probably related to the Mesozoic group of species which Fischer has distinguished by the name *Pyrgotrochus,* with *Pl. bitorquata* Deslongchamps, as the type. The latter differs from our genus principally in having the band near the middle of the dorsal side of the whorls instead of at the basal edge. The presence of a long slit distinguished the genus from *Euconia, Eotomaria* and *Clathrospira.*

XII. Trepospira, n. gen. Shell sublenticular to depressed conical; base convex; without umbilicus; whorls, six or seven, the first two or three very small, rounded, prominent and smooth, the next two flat and coiled more or less nearly in the same plane, the rest sloping according to the apical angle of the shell; aperture transverse, subrhomboidal, the upper lip projecting beyond the lower, the outline curving strongly backward to the slit; edge of lower lip strongly convex in the middle; inner lip rather thin but continuing into a concave callosity which is spread over the umbilical region; slit very short, scarcely extending beyond the notch formed by the converging lips; band rather wide, slightly concave, smooth, visible on the last whorl only, so situated that its lower edge forms the peripheral angle of the volution; beginning with the fourth turn the sutural edge bears a row of nodes covering the band of the preceding whorl. The rest of the surface is nearly smooth, the lines of growth being nearly always obscure. Type, *Pl. sphærulata* Conrad.

In its most essential characters—form of shell, nearly smooth surface, short slit, and direction of lines of growth on the lower side—this genus resembles the Lower Silurian *Liospira* very closely. Still, we are fully satisfied that *Trepospira* is not a continuation of that early type. In coming to this conclusion we rely principally upon the character of the embryonic whorls. These, as stated, are rounded and smooth, wherefore we should look for the ancestors of the type among shells having similar whorls. The required conditions, it seems to us, are furnished by *Pl. rotalia* Hall, of the Hamilton group. In this species we see a callus filling the umbilicus, a nearly smooth surface, strongly curved lines of growth on the lower side of the whorls, the band hidden on the upper turns by overlap of the thickened and plicated sutural edge. Excepting the last, which is somewhat compressed and, therefore, obtusely angular, the whorls may properly be called rounded. Now, it is not a great step from *Pl. rotalia* to the small Upper Silurian shell which Lindström calls *Pl. helicina* in his great work on the Gothland *Gastropoda,* and more recently, because the name was preoccupied, *Pl. kokeni.* The latter has neatly rounded whorls, an open umbilicus and the band a trifle too high, but in all other respects the agreement with *Pl. rotalia* is sufficiently exact to indicate close genetic relations between them. As to the umbilicus, this is not of much consequence, especially since *Pl. kokeni* has a ridge-like thickening of the shell around the umbilicus which may well represent the callus found in *Pl. rotalia* and typical species of *Trepospira*. From what line *Pl. kokeni* was derived, we are not prepared to decide, though inclined to regard *Liospira* as the most likely. Should that prove to be true, then *Trepospira* would furnish us an interesting case of reversion. Similar reversions are shown or noticed in other parts of this work.

Descendants of the *Trepospira* type are to be looked for among the Mesozoic pleurotomarian shells which are commonly referred to Deslongchamps' *Cryptænia*. The Triassic *Pl. radians* Wissman certainly resembles *T. depressa* very closely, but Koken's figure and description prove it to have a more inflated ("pear-shaped") embryonic whorl, and, if we understand him correctly, it has, like *Pl. heliciformis*, the type of *Cryptænia*, a narrow and long slit, which would exclude it from *Trepospira*. According to the figures which we have seen, *Pl. polita* Goldfuss (Lias), which also is usually referred to *Cryptænia*, agrees better with *Trepospira* so far as the position and width of the band and depth of the slit is concerned, but in the rounded form of its volutions, and, more importantly, in the direction of the lines of growth between the band and the umbilical callus, it differs widely.

Besides the type, we place here the closely related *Pl. depressa* Cox, *Pl. illinoisensis* Worthen, *Raphistoma junior* De Koninck, and possibly *R. radians* of the same author, all Carboniferous species. Perhaps it would be well to include the Hamilton *Pl. rotalia* Hall.

XIII. Seelya, n. gen. (Ulrich.) Shell turbinate, consisting of from five to seven rapidly enlarging rounded or ventricose whorls, coarsely though usually not very deeply grooved spirally; apertural sinus shallow, broadly >shaped, slit wanting, band distinct, rather wide, more or less prominent, concave, nearly central on the last volution, infra-median on the upper turns; axis minutely perforated, the inner lip usually thin and reflected so as to form a hollow columella; aperture slightly produced below. Type, *S. ventricosa*, n. sp. (Ulrich.)

XIV. Plethospira, n. gen. (Ulrich.) Rather short, turbinate shells, consisting of four or five rapidly enlarging ventricose whorls, the last produced below and greatly exceeding in hight the rest of the spire; band wide, submedian in position on the last whorl, flat or slightly concave, vertical, margined on each side by a raised line; apertural sinus not very deep, slit wanting; surface marked with lines and wrinkles of growth only; these are only moderately arched, especially upon the lower half of the volutions where, excepting near the band, they are nearly vertical. Type, *Holopea cassina* Whitfield. Range, Lower Silurian.

XV. Hormotoma, Salter, 1859.* Shell elongate, beaded, practically imperforate, composed of rather numerous (eight to fourteen) rounded or subangular whorls; aperture acuminate subovate, narrow and more or less prolonged below; outer lip with a broad and deep >shaped notch and no slit; band median or submedian, generally obscure, of moderate width, flat or slightly concave, in the perfect condition margined on each side by a delicate raised line; surface marked with lines of growth only; these are never very sharp and always sweep backward very strongly, from below especially, to the band. Type, *H. salteri* Ulrich [=*M.* (*H.*) *gracilis* Salter, not Hall].

XVI. Cœlocaulus, Œhlert, 1887.† Similar to *Hormotoma* but the shells are longer, and composed of more numerous depressed whorls. Axis perforate, the umbilicus small but extending quite to the apex. Aperture rounded, not produced below; inner lip thin. Type, *Murchisonia* (*Cœlocaulus*) *davidsoni* Œhlert.

XVII. Turritoma, n. gen. (Ulrich.) High shells, consisting of numerous whorls; whorls somewhat flattened, convex above, slightly concave in the middle, and most prominent in the lower part where the band is situated; other features apparently as in *Hormotoma*. Type, *Murchisonia acrea* Billings. Range, Lower and Upper Silurian.

This is a well marked group of species and readily distinguished form *Hormotoma* (to which the group is related) by the flattened instead of uniformly rounded volutions, and by the lower position of the band. For the present the new genus will include the following species: *Murchisonia ada* Billings, Calciferous; *M. acrea* Billings, Quebec; *M. laphami* Hall, Niagara; *M. boylei* Nicholson, *M. constricta* Whiteaves, Guelph; and *M. cava* Lindström, Upper Silurian of Gotland.

XVIII. Solenospira, n. gen. (Ulrich.) Small shells usually, forming a high and very slowly enlarging spire, consisting of numerous, generally depressed volutions; near the middle of each whorl and occupying nearly a fourth of its hight, the spiral band forms a deep channel between two salient thin ridges; the flat or convex slopes above and beneath the band may be free of ridges, or there may be a third above and a fourth below, or there may be, including those bordering the band, as many as five or even six on each whorl. Outer lip with a broad >shaped sinus but no linear slit. Type, *Eunema pagoda* Salter.

*Doubtful and insufficiently known generic and minor groups of Paelozoic species usually referred to Pleurotomaria and Murchisonia.*

Murchisonia, d'Archiac and Verneuil, 1841. (Bull. Soc. Géol. France, vol. 12, p. 154.) We prefer not to give a description of this genus at this time, because

* Canadian Organic Remains, Decade I, p. 18.
† Extr. Bull. Soc. d'Etud. Scientif. d'Angers, p. 20.

of doubt respecting the proper selection of the essential from the non-essential among the exceedingly diverse characters exhibited by the original type of the genus, *M. coronata* Goldfuss and its numerous varieties. We will say positively, however, that none of the preceding genera can properly be united with *Murchisonia*. Indeed, we are anything but satisfied that *M. coronata* is a true member the *Pleurotomariidæ*, and it appears that Koken felt more doubt on this point than he expressed in the remark (op. cit., p. 367) that "the method of growth, the rapid enlargement of the first volutions and other peculiarities remind of the *Pyramidellidæ*." On the same page he says also, in speaking of *M. coronata* and varieties, "it is just this type that impresses me as though it did not belong with the other Silurian, Devonian and Carboniferous species that are called *Murchisonia*." With a few exceptions, we have seen specimens of all the American species which have been described as of *Murchisonia*, and are quite prepared to maintain that strictly speaking the genus is not represented among them. The continued use of the genus for American species therefore is not justified except as a provisional receptacle for those which, because of insufficient knowledge of their characters, cannot yet be referred to their proper positions.

We had intended to add remarks on De Koninck's *Ptychomphalus*, *Gosseletia*, *Pithodea*, *Agnesia*, *Rhineoderma* and *Baylea*, and Œhlert's *Gyroma*, *Platyloron* and *Stenoloron*, (all proposed since 1880 as divisions under *Pleurotomaria*), but a lack of space makes it necessary that their consideration be postponed to some future opportunity. It may be well, however, to state here that each of these divisions embraces species genetically distinct from those in the others and that, while they will have to be redefined and their contents revised, none is likely to prove entirely useless in the classification of the future. As to *Pleurotomaria*, De France, if the genus is confined between reasonable limits, it is not recognizable among the Paleozoic species known to us, nor are the sections *Talantodiscus*, *Pyrgotrochus*, *Perotrochus* and *Entemnotrochus*, proposed by Fischer in 1885. The same is to be said of *Chelotia*, Bayle, and *Cryptænia* and *Leptomaria*, of Deslongchamps, which are variously recognized as sections, subgenera, or as distinct genera.

### Genus LOPHOSPIRA, Whitfield.

*Lophospira*, WHITFIELD, 1886, Amer. Mus. Nat. Hist., vol. i, p. 312.
*Murchisonia* and *Pleurotomaria*, of authors.

For generic characters see page ——.

As here understood and described this excellent genus constitutes perhaps the most important of all occurring in the Lower Silurian. The species are numerous, some have comparatively an extended geological range, and most of them are to be counted among the common fossils at the localities where they occur. Moreover, in our opinion, the species are comparatively constant and therefore easily distinguished, although in practice among collectors no group of species has been more persistently thrown together as of one or two species than has the majority of the numerous types which on the following pages we endeavor to distinguish in such a manner that any one having good material at his command may without much trouble recognize them.

As far as known *Lophospira* ranges from the Calciferous to the Hamilton group, in other words from the base of the Lower Silurian or Ordovician to the middle of the Devonian system. However, by far the greatest development of the genus occurred in the various groups of the Trenton period. That the genus extended through the Devonian into the Carboniferous rocks is, to say the least, doubtful. We come to this conclusion despite the fact that the Worthenias of the Coal Measures (see p. 952) so greatly resemble the average Lower Silurian types of the genus that it is difficult to escape the conviction that they are direct descendants of them. *Worthenia,* though sufficiently distinguished by having an apertural slit, might readily have acquired this difference through gradual development, but we know absolutely of no intermediate later Devonian and Sub-Carboniferous *Lophospira*-like shells from which they might have been derived. For the present therefore, especially after considering that the apex of the shell of *Worthenia* is blunt and the embryonic whorls rounded, we incline to the view that the Carboniferous genus was evolved from some low-spired round-whorled shell like those which Œhlert proposes to distinguish as *Gyroma.* Excepting the initial cell or turn, which we have not seen, the apical whorls of *Lophospira* are not materially different from those following.

Many of the species now referred to this genus have heretofore been placed, according to the hight of the spire and the whim of the author, under either *Murchisonia or Pleurotomaria.* No genus is better calculated to show the unreliability, as a generic character, of the hight of the spire. This fact is we believe strikingly shown by the figures on plates LXXII and LXXIII. Take for instance various species of the *Bicincta* section, beginning with *L. humilis* Ulrich, the spire of which is so low that according to methods prevailing heretofore no one would have hesitated in placing it as a *Pleurotomaria.* From this it is certainly not a great step to reach *L. bicincta* Hall which Lindström calls a *Pleurotomaria,* while American authors generally have referred it to *Murchisonia.* Next we have *L. concinnula* U. and S. and *L. fillmorensis* U. and S., in which the spire is higher, and finally *L. procera* Ulrich in which it is very much higher than in *L. humilis.* Fully as great or greater differences in the hight of the spire are to be observed in the *Perangulata* section. Beginning with forms like *L. ampla* Ulrich and *L. multigruma* Miller, in which the apical angle varies from 70 to more than 90 degrees, we pass by numerous and easy gradations to *L. bowdeni* Safford, in which the angle is sometimes as narrow as 25 degrees. While the hight of the spire only rarely deserves to be counted among the generic characters, we believe it is, within reasonable limits, usually an excellent specific character.

Concerning the systematic position of the genus, we may say with considerable confidence that it is the oldest of the many types strictly belonging to the family *Pleurotomariidæ.* We say this not so much because the genus goes far back in geological time, for, according to known facts, several other types are equally ancient, but because it shares characters with types belonging to other families which, like the *Pleurotomariidæ*, originated somewhere in the interval between the Calciferous and the Upper Cambrian. Thus the simplicity of the band and apertural notch allies the genus with the *Euomphalidæ.* A striking resemblance, indicating, we believe, also close relationship, obtains between certain species of *Trochonema* and *Lophospira notabilis, L. knoxvillensis* and *L. trochonemoides.* This relation of *Trochonema* to the notched pleurotomarian and euomphalid genera is shown not only by the species of *Lophospira* just mentioned, but is indicated quite as strongly by such undeniable Trochonemas as *T. retrorsa* and *T. bellula.* The latter have an apertural notch at the end of the supra-peripheral angle, causing the lines of growth to curve backward toward the angle from both above and below. Only one feature remains to distinguish the *Trochonemoides* section of *Lophospira* from *T. retrorsa* and its allies, and that is, that while the Lophospiras have a distinct band, the Trochonemas have none, the lines of growth curving backward to and then over the angle without interruption in the latter.

*Lophospira* is divisible into four sections, and two of these into several subsections as follows:

A. *Perangulata section:*—Apertural notch >shaped, deep and wide, the lines of growth sweeping backward strongly from both above and below to the peripheral band.

1. *Perangulata subsection:*—Shells not very high, whorls five to eight, strongly angular. Species: *L. perangulata* Hall, *L. sorocula* Billings sp., *L. modesta* Billings sp., *L. medialis* U. and S., *L. decursa* Ulr., *L. pulchella* U. and S., *L. saffordi* Ulr., *L. abnormis* Ulr., *L. centralis* Ulr., *L. oweni* U. and S., *L. ampla* Ulr., *L. peracuta* U. and S., *L. elevata* U. and S., *L. multigruma* Miller sp., *L. tropidophora* Meek sp., *L. sumner-*

*ensis* Safford sp., *L. perlamellosa* Ulr., *L. perforata* U. and S., *L. spironema* U. and S. *L. tennistriata* Ulr., *L. conradana* U. and S., *L. gothlandica* Ulr.*

2. *Bowdeni subsection:*—High shells, eight to twelve whorls, less angular than in preceding subsection. Species: *L. bowdeni* Safford sp., *L. producta* Ulr., *L. augustina* Billings sp., ?*L. major* Hall sp., *L. macrospira* Hall sp.

3. *Cicelia subsection:*—Differs from 1 in having a much higher spire, and from 2 in having more numerous and more sharply angular volutions. Species: *L. cicelia* Billings sp., *L. estella* Billings sp., *L. extenuata* Hall sp.

4. *Serrulata subsection:*—Distinguished from 1 by the plate-like extension and wavy character of the central part of the peripheral carina. Only known species: *L. serrulata* Salter sp.

B. *Bicincta section:*—Lines of growth curving very slightly, or not at all, backward to the peripheral keel, the apertural notch being very shallow.

1. *Bicincta subsection:*—Surface markings fine, generally quite regular, sharply elevated and closely arranged. Species: *L. bicincta* Hall sp., *L. quadrisulcata* U. and S., *L. obliqua* U. and S., *L. humilis* Ulr., *L. concinnula* U. and S., *L. fillmorensis* U. and S., *L. aspera* Billings sp.

2. *Tubulosa subsection:*—Similar to preceding, but surface markings much stronger, lamellose and imbricating, particularly on the band. Species: *L. tubulosa* Lindström sp., *L. laqueata* Lindström sp., both from the Upper Silurian of Gothland.

3. *Imbricata subsection:*—Relatively high small shells, with coarsely lamellar imbricating lines of growth; the latter turn backward on the basal portion of the whorl very soon after leaving the peripheral band, the aperture being unusually oblique. Species: *Murchisonia imbricata, munda, tortuosa, cochleata* and perhaps *cancellata,* all Upper Silurian of Gothland and described by Lindström. Unknown in America except by an undescribed species in the Clinton iron ore of New York.

4. *Holmi subsection:*—Lines of growth fine and equal as in the *Bicincta* subsection but with a direction as in the preceding. Only known species: *Pleurotomaria holmi* Lindström (Gothland.)

5. *Helicteres subsection:*—Agrees in all respects with the *Bicincta* subsection excepting that the last whorl or two is free. Only known species: *L. helicteres* Salter sp.†

C. *Robusta section:*—Shells rather short, whorls comparatively rounded, ventricose, scarcely angular even at the peripheral band, which is distinctly trilineate.

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*The name *Lophospira gothlandica* is proposed for the shell which Lindström describes from the Upper Silurian strata of the island of Gothland as a species of *Pleurotomaria* under Hall's specific name *bicincta*. It is beautifully illustrated on plate VIII of his great work on the "Silurian Gastropoda of Gotland." The figures, together with specimens received from Dr. Lindström, prove it to be quite distinct from the American *bicincta*.

†*Murchisonia soluta* and *M. tropidophora* of Whiteaves, from the Guelph of Canada, for which the subgenus *Loxoplocus* is proposed by Fischer (Manual Conch., p. 847; 1885,) may belong to this subsection, but in the absence of reliable information respecting the characters of the peripheral band and apertural sinus, we prefer to leave them unclassified.

Surface, the basal half chiefly, usually with large though not very prominent revolving ribs. Lines of growth recurving moderately toward the peripheral band, indicating a wide but not very deep sinus in the outer lip. Species: *Pleurotomaria ohioensis* James, *Pl. robusta* and var. *lævissima* Lindström, *Pl. trilix* Hall.

D. *Trochonemoides section:*—In all respects like *Trochonema* save that the supra-peripheral keel bears a distinct band. Differs from ordinary types of *Lophospira* in the relatively depressed form, large umbilicus, thick shell and oblique mouth. Species: *L. trochonemoides* Ulr., *L. knoxvillensis* Ulr., *L. notabilis* Ulr.

### Lophospira bicincta *Hall.*

PLATE LXXII, FIGS. 1–5.

*Murchisonia bicincta* Hall, 1847, Pal. N. Y., vol. i, p. 177, pl. xxxviii, figs. 5*a*–5*f*, (?5*g* and 5*h*.)
*Murchisonia milleri* Hall, 1877, 1st Ed. Miller's Amer. Pal. Fossils, p. 244.

Hight 15 to 30 mm.; apical angle 59° to 63°, usually about 60°. Volutions five or six, subangular; last one ventricose below, tricarinate, the upper ones bicarinate the lower carina being hidden by the suture; central or peripheral angle margined on either side by a sharp elevated line, with a narrow groove between, the angle, therefore, being composed of three lines of which the central one is a little stronger and more prominent than the lateral ones; lower carina thin, abruptly raised, the space between it and the peripheral angle scarcely concave and almost perpendicular; upper carina sharp, rather strong, removed a little more than a third of the biconcave upper slope of the volution from the suture; aperture somewhat obliquely subelliptical, higher than wide, narrow below, subangular at the lower inner corner; inner lip but little thickened, slightly twisted, never completely covering the minute umbilicus; outer lip very slightly sinuate. Surface marked by fine sharp subequal striæ, curving backward very gently from the suture to the peripheral band; beneath the latter they pass in a vertical direction to the lower carina which scarcely interrupts their course to the umbilicus, near which only a slight backward curve is noticeable. On the most perfect specimen seen all the transverse lines present the appearance of being minutely papillose or toothed, while the central line of the peripheral band is crossed by straight lines of which there are nearly twice as many in a given space as of those coming from above and below.

The most marked and important feature of this species is the exceeding shallowness of the sinus or notch in the outer lip. It is true Prof. Hall mentions an abrupt retral and forward curve of the surface striæ at the mesial band, but if we accept his fig, 5*e* as correct, it is evident that this statement is quite at variance with his illustrations. We prefer to accept the evidence of the cited figure upon the point in question rather than the description, especially since it is not at all improbable that the idea of an abrupt retral curve of the striæ was received from some similar associated but distinct shell. That he united more than one species or variety under the name *bicincta* is shown, provided the form has been correctly drawn, by his figures 5*g* and *h*. In the first, representing the fossil of the natural size, no upper carina is shown; nor is the peripheral angle trilineate. The second represents a part of the last whorl magnified and shows not only one, but two carinæ on the lower half. Perhaps these figures are not entirely trustworthy.

Although very frequently quoted, we thought it best to restrict the synonomy of the species to the original description, because we found it almost impossible to decide in most instances whether an author had the true *bicincta* before him or not. With collectors the practice prevails to a large extent to identify almost any set of Lower Silurian *Lophospira* with the *bicincta*, and we have seen no less than ten distinct species in collections bearing the one label "*Murchisonia bicincta* Hall." Salter's *M. bicincta* (Can. Org. Rem., Dec. 1, p. 19; 1859) clearly belongs to the next species or variety (*L. obliqua*) while Meek and Worthen's (Geol. Sur. Ill., vol iii, p. 317; 1868) we describe as another new species under the name *L. perforata*. Then the Upper Silurian shell from the island of Gothland, which Lindström identifies with this species (he calls it a *Pleurotomaria*) and describes and figures so beautifully in his classical work on the *Gastropoda* (Up. Sil. Gastropoda of Gotland, p. 106, pl. 8; 1884) is most certainly not the same as the American species. We have specimens of the Gothland shell before us and can say most emphatically that it has scarcely a single specific feature in common with *L. bicincta*. Comparing it with the other American species of *Lophospira*, we find that while it resembles *L. sumnerensis* Safford more than any of the others, it is still readily distinguished.

The essential characters of *L. bicincta*, as here identified and restricted, are (1) the ventricose whorls, (2) the sharp and regular lines of growth, and (3) the exceedingly shallow sinus in the outer lip and vertical direction of the surface striæ from the peripheral band downward.

*Formation and locality.*—Trenton period, Stones River group, not uncommon in the "Central limestone" at Murfreesboro, Tennessee, and rather rare in the Vanuxemia bed at Minneapolis, Minnesota, Dixon, Illinois, and Beloit, Wisconsin; Black River group, Mercer county, Kentucky; Trenton group, Middleville, New York; Clitambonites and Fusispira beds at several localities in Goodhue county, Minnesota; Cincinnati period, Richmond group, at Spring Valley and other localities in Fillmore county.

*Collection.*—E. O. Ulrich.

### LOPHOSPIRA OBLIQUA, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIGS. 6–8.

*Murchisonia bicincta* SALTER, 1859, Can. Org. Rem., Dec. 1, p. 19. (Not *M. bicincta* HALL, 1847.)

This form agrees in all respects with *L. bicincta* excepting that the surface striæ are less sharp and not so regular, and that instead of passing vertically downward from the peripheral band they cross the space between the central and lower carinæ somewhat obliquely, thus indicating a deeper sinus in the outer lip. Casts of the interior could not be distinguished excepting perhaps those which preserve the aperture entire, when the difference last mentioned may serve.

It is strange that two shells can be so very much alike and yet maintain certain almost minute characters so persistently as in this case. We have 42 specimens of the *obliqua* and there is never any doubt about them, the peculiarities mentioned being very constant.

*Formation and locality.*—Rare in the upper part of the Stones River group, at High Bridge, Kentucky; more common in the Black River and Trenton groups at various points in Mercer county, Kentucky.

*Collection.*—E. O. Ulrich.

### Lophospira concinnula, *n. sp.*

PLATE LXXII. FIGS. 16—19.

Hight usually 10 to 15 mm., in one case reaching 21 mm.; apical angle 52° to 59°. Volutions six or seven, angular, not ventricose; upper central and lower carinæ all strong. Lines of growth fine, sharp, thread-like, regular, almost vertical beneath the peripheral band, and but little curved backward above it. In the grooves between the lines there are numerous short connecting bars, producing a minutely cancellated appearance.

The peripheral band and surface markings, excepting the delicate connecting bars, are precisely as in *L. bicincta*, and we are satisfied that the new species is closely related to that shell, if indeed it is really not merely a variety of it. Still, the connecting bars are a feature deserving some recognition, and when we add that the volutions in *L. concinnula* increases less rapidly and that they are less ventricose and more angular, because of the greater prominence of the spiral carinæ, it seems to us that a specific distinction must be conceded.

We describe three other species, *L. pulchella*, *L. spironema* and *L. tenuistriata*, which, if the aperture is imperfect and the surface markings abraded, it would be quite impossible to distinguish from each other and from *L. concinnula*. With any part of the exterior layer of the shell preserved the difficulties vanish, the first named three forms having a deep sinus in the outer lip and, therefore, strongly recurved lines of growth, while in *L. concinnula* the retral curvature is, as in *L. bicincta*, very slight indeed. The character of the transverse striæ also is different, being stronger and sharper in *L. concinnula*. For other differences see descriptions of the species mentioned.

*Formation and locality.*— Black River group, Ctenodonta bed, Minneapolis and Cannon Falls, Minnesota.

*Collections.*—E. O. Ulrich (9 specimens); W. H. Scofield (1 specimen).

### Lophospira, fillmorensis, *n. sp.*

PLATE LXXII, FIGS. 20—24.

Hight 19 to 25 mm.; apical angle 53° to 56°; volutions about six. This form is represented by six casts of the interior and one macerated testiferous example. In its general aspect it, the cast especially, reminds one greatly of *L. concinnula* and it is not at all improbable that it is a later variety of that species. Still the testiferous example shows that on the exterior of the shell the spaces separating the upper and lower carinæ from the central one are more decidedly concave or groove-like. The surface markings also are different, consisting as near as can be made out, of transverse lines only. These furthermore are not sharp and equal but consist of more delicate lines with each third or fourth stronger than the others and sometimes distinguishable on the casts. The direction of the lines of growth is about the same in the two species. *L. bicincta* Hall has more ventricose whorls, less prominent keels and more equal and sharper surface striæ. For comparison with *L. perforata* see that species.

*Formation and locality.*—Trenton group, Fusispira bed, Wykoff and Fountain, Fillmore county, Minnesota.

*Collections.*—E. O. Ulrich; Dr. C. H. Robbins.

### Lophospira quadrisulcata, *n. sp.*

PLATE LXXII, FIGS. 10—11.

Hight 12 to 22 mm.; apical, angle 67° to 70°; volutions about six, the last large and ventricose below, quadrisulcate, its upper slope with a strong subcentral carina, dividing two distinctly concave spaces; peripheral angle thick, trilineate; beneath it a wide concave band, next a sharp carina, then a narrower groove and finally the convex base; umbilicus very small, generally bordered by an obscure ridge. Lines of growth sharp, thread-like, regular, just visible to the unaided eye, curving gently backward on the upper slope, more abruptly bent backward and then forward on the peripheral angle, and nearly vertical between the periphery and the umbilicus.

This beautiful shell, though closely related, is readily distinguished from *L. bicincta* Hall, and all other species now referred to *Lophospira*, by having a fourth carina and groove beneath the usual lower carina. The revolving grooves are also deeper, the carinæ being more prominent than in that species. The upper one besides is usually further removed from the suture. The lines of growth are precisely the same in the two shells excepting that on the trilineate peripheral band in *L. quadrisulcata* they are abruptly curved, while they are straight in *L. bicincta.*

*Formation and locality.*—Not uncommon in the Richmond group of the Cincinnati period at several localities in Fillmore county, Minnesota. The majority of the specimens were collected in a railroad cut about two miles east of Spring Valley.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield; U. S. National Museum.

*Museum Register*, No. 7384.

### Lophospira humilis, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIGS. 12—15.

Hight 7 mm. to 14 mm.; apical angle 80° to 90°. Related to *L. bicincta* Hall, but distinguished at once by its low spire and two carinæ instead of one on the upper slope of the whorls. One of these carinæ is close to the suture, the other about midway between the suture and the peripheral band.

*Formation and locality.*—Upper part of Trenton group, Mercer and Boyle counties, Kentucky, and Hartsville, Tennessee.

*Collection.*—E. O. Ulrich.

### Lophospira procera, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIG. 9.

Hight about 30 mm., width about 16 mm., apical angle 43° to 45°.

The surface markings show that this species belongs to the Bicincta subsection, the direction of the lines of growth on the concave space beneath the peripheral angle, though oblique, being approximately straight. The comparatively great hight of the shell distinguishes it from the other members of its subsection.

*Formation and locality.*—"Central limestone" of the Stones River group, Murfreesboro, Tennessee.

*Collection.*—E. O. Ulrich.

### Lophospira serrulata, *Salter.*

PLATE LXXII, FIGS. 51—55; PLATE LXXIII, FIG. 57.

*Murchisonia tricarinata* (Conrad) Hall, 1847, Pal. New York, vol. i, p. 178, pl. xxxviii, fig. 6c (not figs. 6*a* and 6*b*); Whitfield (part.) 1882, Geol. of Wis., vol. iv, p. 219.
*Murchisonia serrulata* Salter, 1859. Can. Org. Rem., decade 1, p. 20, pl. iv, fig. 1.
*Murchisonia helicteres* (part.) Whitfield, 1882, Geol. of Wis., vol. iv, p. 220, (not Salter, 1859, Can. Org. Rem., decade 1, p. 21, pl. iv, figs. 2—4.)

Hight 20 to 45 mm.; apical angle of upper volutions 56° to 62°. Volutions five to seven, closely coiled in the upper part of the spire but in fully grown individuals the last whorl descends very rapidly and becomes widely separated from the preceding one; volutions sharply and very prominently carinated on the periphery, the flange-like and obliquely undulated carina with a delicate line on each side of its base; carina frequently terminated by a series of spine-like prominences producing the serrated edge that has suggested the specific name. Sometimes the edge is merely wavy instead of toothed, while on the last or free whorl of old specimens the prominences are, if not wanting entirely, at least much more irregularly developed. In all the body whorl has four nearly equidistant sharp carinæ, one on the upper slope a third or a little more of its width distant from the suture, a third beneath the peripheral one already described, and a fourth marking the limits of the rather large umbilicus. The latter has a distinctly convex slope, while the space between the third and fourth keels is gently convex in the middle, those between the peripheral one and the third and first decidedly concave, and that between the summit of the first keel and the suture line more gently hollowed out. As long as the whorls are in contact the upper edge is sharp so that the suture is not excavated, but soon after the last turn becomes free this edge is lost, the whole upper surface, that is, above the first carina, becoming almost uniformly rounded. Aperture, excepting the angulation at the peripheral carina, subcircular; in a side view the outer lip is deeply notched at the principal carina and somewhat angularly produced at the extremities of the first and third keels. Surface marked with regular strong sharp equidistant lines of growth on the upper whorls, the striæ becoming more irregular and assuming an aged appearance on the free last turn. Their number in a given space varies, but the average at the first or upper carina is about three in 2 mm. The direction of the striæ, beginning at the suture, is first gently backward and then with a slight forward curve to the summit of the first carina. From here they sweep regularly and very decidedly backward to the peripheral keel, and beneath this forward again in a corresponding degree to the third carina on which they make a rectangular turn and proceed with less curvature than above to the fourth or umbilical keel. In the umbilicus, finally, the last backward direction continues until overcome by the curve when a transverse course is maintained until the circuit is completed on the upper side of the whorl.

In casts of the interior of young individuals all save the first three whorls, which are but rarely preserved, may preserve in a decided degree the angularity which marks the exterior, but in fully grown examples only the last whorl retains the angles and even here the peripheral carina only is distinct. (This is one of the points relied upon in distinguishing internal casts of this and the next species.)

We have very little doubt of the specific identity of this common shell of the Stones River group in Minnesota, Wisconsin and Illinois, with the *Murchisonia serrulata* described by Salter from the Black River group of Canada.* We grant that Salter neither mentions nor figures his species as having the last volution uncoiled, but this is readily explained if we assume, and his illustration justifies us in doing so, that he had only young or imperfect examples. We have numerous

* With the Canadian geologists this term includes the Birdseye or Stones River group.

specimens precisely like his in that respect. Two other features, however, shown in his illustrations are less easily reconciled with our specimens, and we confess that we can do so only by assuming that his drawings are not entirely trustworthy. We are loath to admit so much variation in at least one of the characters for we have found it to be remarkably constant in all other species. We refer namely to the direction of the lines of growth. These, we believe, do not bend sufficiently backward and forward in Salter's figures. In justification of our view we would point out the fact that his two figures (1 and 1*) are not exactly alike, so that it is not entirely unwarranted to assume that neither agrees exactly with the specimen. Then he represents the upper carina as nearer the suture than we have seen it, and farther from the peripheral angle than it should be if his description is correct is saying that the first and third keels are equally distant from the second.

As to *Murchisonia tricarinata* Hall, under which name Prof. Whitfield (*loc. cit.*) referred to young examples of both *L. serrulata* and *L. helicteres*, we have not the slightest doubt that Hall's fig. 6*c* was taken from an imperfect testiferous example of *L. serrulata.* This specimen, however, has four carinæ and is evidently distinct from the type represented by his figs. 6*a* and *b*. It was moreover only doubtfully referred to *tricarinata* by Hall himself. The validity of the species *tricarinata*, therefore, must be determined solely by the original description and type and not by Hall's second specimen which we have said is clearly referable to *L. serrulata* Salter. *L. serrulata* is the only species of the genus known to us having the flange-like peripheral keel serrated on the edge like a circular saw.* It is an excellent specific character, though unfortunately leaving no trace of its presence on casts of the interior. Still, the beds in which the species occurs in that condition are of such a nature that very often an excellent artificial cast of the exterior can be prepared from the natural mold enclosing the interior cast. The species is readily distinguished by other peculiarities, as may be seen by comparing it with other species described in this report. Some difficulty will probably be experienced in making a successful separation between it and the next species, *L. helicteres*, particularly when internal casts only are available. For comparisons see under that species.

*Formation and locality.*—Stones River group, in the Vanuxemia bed chiefly, at Minneapolis and St. Paul, Minnesota, Mineral Point, Janesville, Bellville and Beloit, Wisconsin, and Dixon, Illinois. Also in the Black River group (Upper Buff limestone) at Beloit, Wisconsin, and in central Tennessee (Carter's Creek limestone). In Canada the species occurs at Panquette's rapids in the Ottawa river in strata said to be of the age of the Black River group.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; Prof. J. M. Safford. *Museum Register*, No. 7283.

* Prof. Whitfield on two occasions credits other species with such keels, the first time in Geol. of Wis., vol. iv, p. 221, where he says it is occasionally or frequently met with in *Murchisonia* (*Lophospira*) *helicteres* and *M. tricarinata*; the second time in 1886, Bull. No. viii, Amer. Mus. Nat. Hist., p. 311, when he says it occurs in "Many of the specimens [of *Lophospira*] especially of *M. milleri*" [*L. bicincta.*] We are convinced that in both cases he refers to specimens of the form which we identify with *L. serrulata* Salter, since among the numerous specimens of *L. helicteres* and *L. bicincta* studied by us we have never observed even a semblance of such a keel.

LOPHOSPIRA HELICTERES *Salter*, var. WISCONSINENSIS, *n. var.*

PLATE LXXII. FIGS. 25–28.

*Murchisonia helicteres* SALTER, 1859, Can. Org. Rem., Dec. 1, p. 21, pl. IV, figs. 2--4.
*Murchisonia helicteres* et *tricarinata* (part.) WHITFIELD, 1882, Geol. of Wis., vol. iv, pp. 219 and 220.

Hight 28 to 68 mm.; apical angle of upper volutions 58° to 65°, of entire full grown shell 40° to 45°. Volutions five or six, of which the first three or four are closely coiled and the last one or two, or even three, are free and widely separated. The free whorls are marked on the exterior by five keels, the uppermost being the least distinct and representing the suture line; the second is stronger and in the upper part of the shell situated almost midway between the suture line and the peripheral angle, but after the whorls become free it is moved relatively much nearer the sutural edge; the third or peripheral carina is the strongest and most prominent, and bluntly or rounded flat, or even concave at the edge; above it the surface is decidedly concave, beneath it for the greater part to the fourth carina almost flat; the latter is situated about the same distance from the central keel as the second but is scarcely as strong; the fifth keel is relatively weak and situated on the base of the whorl. Surface with distinct, sharp, equidistant lines of growth averaging eight or nine in 5 mm. Their course from the suture to the peripheral angle is almost direct, as it is also from here to the basal keel. Near and on the peripheral keel a more or less abrupt retral curve occurs, indicating an unusually restricted notch in the outer lip of the aperture.

In casts of the interior the two upper carinæ appear as very near each other, yet distinguishable as far up the spire as the third or even the second volution. The peripheral angle, though gradually losing its prominence, may be recognized on all the whorls. The fourth is but rarely distinguishable, the fifth, never.

The above describes the main characters of the Wisconsin and Minnesota variety of this species. As may have been noticed, it differs in two respects from the typical Canadian form, namely, (1) the surface striæ are more regular and much less curved backward in consequence of which the insinuation in the outer lip of the aperture is relatively very small; second, they have a basal or umbilical keel (similar to the one in *L. serrulata*) which is wanting in the typical variety. The latter occurs not only in Canada but in central Kentucky as well, while the var. *wisconsinensis* is, so far as known, restricted to the northwestern area.

This fine *Lophospira*, though really widely different, greatly resembles, in the usual condition in which they occur, the preceding species, *L. serrulata*. Both are strongly carinated and have the last whorls free, while the surface striæ also are similar in being strong and sharp in both. Still, when the shells themselves, or good molds of their exterior surface, could be compared, we found little difficulty in separating them. In the first place, the free whorls of *L. serrulata* have only four carinæ, being entirely without the uppermost or sutural keel which occurs constantly in *L. helicteres.* Then the surface striæ in crossing the shell from keel to keel in the latter are directed very much less backward and forward than is the case in the former. The outer edge of the aperture is therefore quite different in the two species. (Compare figs. 26 and 55 on pl. LXXII.) With practice it is possible to distinguish them almost at a glance, and it is not by any means a hopeless task even when we have nothing but the casts of the interior. When the casts are entire at the aperture, *L. serrulata* is recognized by the projecting angles at the extremities of the first and third carinæ and the wide >shaped notch between them. When this test is not available then we must rely upon the relative distinctness of the carinæ on the upper whorls. They are recognizable much farther up on the spire in *L. helicteres* than in *L. serrulata,* providing, of course, the specimens are of equal size.

It is possible that the shell above described is the one which Conrad named *M. tricarinata,* but Halls figures of that species are so poor that we cannot be blamed if we have made a synonym.

*Formation and locality.*—Stones River group, Minneapolis and St. Paul, Minnesota; Mineral Point, Janesville and Beloit, Wisconsin; and Dixon, Illinois. The typical form is from the Black River group at Pauquette's rapids, Ottawa river, Canada. We have it also from a similar horizon in Mercer county, Kentucky. It is said to occur also in the Upper Buff limestone in Wisconsin.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register,* No. 6858, 7360.

### Lophospira perangulata *Hall.*

PLATE LXIII, FIGS. 1–7.

*Murchisonia perangulata* Hall, 1847, Pal. N. Y., vol. i, p. 41, pl. x, fig. 4; not p. 179, pl. xxxviii, figs. 7*a*, 7*b*; Salter, 1859, Can. Org. Rem., decade 1, p. 19, pl. iv, fig. 7.

Shell small, hight 10 to 20 mm.; apical angle usually about 52°, but varying between 50° and 57°. Volutions about six, the last inclining to become free, scarcely ventricose below, very gently concave above; peripheral band prominent, sharp, trilineate; lower carina distinct though not very prominent, sometimes very obscure on casts of the interior; upper slope without a carina, the gentle concavity extending to the suture. A small, abruptly defined umbilicus always present. Mouth subtriangular, slightly drawn out below. Surface markings consisting of two sets of strongly recurved lines of growth, one distant and sublamellose, the other much finer and closely arranged between the former.

We have every reason to believe that the shell above described is identical with the Birdseye type of the species, but it is not the same as the Trenton form which

Hall united with it. The latter, if correctly represented by Hall's figures (*loc. cit.*), is so different that we have no hesitation in pronouncing it a distinct species. So far as our experience is concerned, *L. perangulata* is an unusually constant species. Our figures represent extremes of variation as exhibited in a large number of specimens.

*Formation and locality.*—Stones River group, Watertown, New York; Murfreesboro, Tennessee; Mercer county, Kentucky; and, somewhat doubtfully, Minneapolis, Minnesota; Black River group, Panquette's rapid, Canada.

*Collection.*—E. O. Ulrich. (About 100 specimens.)

### LOPHOSPIRA ACUMINATA, *n. sp.* (or var. of PERANGULATA.)

PLATE LXXIII, FIG. 8.

Hight 10 mm. or less; apical angle about 42°. Volutions seven or eight, all contiguous; peripheral carina very prominent, trilineate, the central part of the band sharply angular; lower carina very strong, upper carina wanting; no umbilicus.

Resembles and perhaps is merely a later variety of *L. perangulata* Hall, yet readily enough distinguished by its more depressed and more numerous volutions, especially considering that it is a smaller shell. It differs further in being relatively higher, the apical angle being narrower, in the greater prominence of the carinæ, and in wanting the umbilicus which is so constantly present in Hall's species. A variety of *L. pulchella* is rather abundantly associated with this species at Spring Valley, Minnesota. It may be distinguished at once by its relatively strong upper keel, *L. acuminata* being without this keel.

*Formation and locality.*—Richmond group, Richmond, Indiana, Blanchester, Ohio; and near Spring Valley, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

***Museum Register,*** No. 7383.

### LOPHOSPIRA MEDIALIS, *n. sp.*

PLATE LXXIII, FIGS. 23–29.

Hight 12 to 22 mm.; apical angle 58° to 70°, the average about 63°. Volutions six or seven, all contiguous, somewhat depressed, rounded below; upper slope nearly flat, generally a little concave in the outer half and gently convex toward the suture, occasionally convex enough to form an obscure subsutural angulation; lower carina becoming less distinct with age, never strong, generally quite indistinct; between it and the prominent peripheral carina, which carries the rounded band, the outline is more or less concave; umbilicus small but always present. Surface markings rather strong, lamellose, strongly curved backward, often gathered into undulating groups near the umbilicus.

Nearly intermediate between *L. perangulata* Hall and *L. sororcula* Billings sp., having a small umbilicus and depressed volutions like the former and a hight of spire and general appearance more like the latter. The convexity or obscure angulation of the upper part of the volutions, as well as the lesser development of the lower carina, distinguishes it from both and suggests relationship with *L. oweni* and *L. ampla.*

*Formation and locality.*—Rare in the Trenton group of Minnesota, in the Clitambonites bed at St. Paul, and the Fusispira bed at Wykoff; common in the upper beds of the Trenton between Burgin and Danville and at other localities in Kentucky; occurs also in middle Tennessee and in Lincoln county, Missouri.

*Collection.*—E. O. Ulrich. (45 specimens.)

### Lophospira medialis, var. burginensis, *n. var.* (*Ulrich.*)

PLATE LXXIII, FIGS. 30 and 31.

Hight 10 to 14 mm., apical angle almost constantly 60°; volutions six.

Agrees in all respects with *M. medialis* excepting that the average size is less, and the lower carina much stronger and more prominent. The lower carina causes also a flattening of the base that does not occur in the typical variety.

Var. *burginensis,* having a small umbilicus, must still remain separate from the Quebec group *L. sororcula* Billings. It resembles very greatly also *L. pulchella,* but has a wider apical angle, while the subsutural or upper carina is never well defined as it is in that species. In *L. perangulata* the apical angle is somewhat narrower, the slope of the upper side of the whorls less steep, and the space between the peripheral and lower carinæ more nearly vertical and less concave.

*Formation and locality.*—Upper part of the Trenton group, Burgin, Danville, Lexington and other localities in Kentucky.

*Collection.*—E. O. Ulrich. (35 specimens.)

### Lophospira abnormis, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIGS. 36—40.

Hight 15 to 20 mm.; apical angle increasing with growth from 42° to 53°; volutions six or seven.

The size, surface markings, umbilicus and form of the volutions is almost exactly as in *L. medialis,* and if the last two whorls only were compared it would be most difficult to distinguish them. Still, a comparison of interior casts, the condition in which *L. abnormis* is usually found, will show that in the present species the umbilicus is less abrupt and the peripheral angle of the whorls more prominent and situated lower down, causing the upper slope to be slightly wider, higher and more convex. Besides the casts show an obscure revolving line or ridge close to the umbilicus which is not seen in *L. medialis.* But the peculiarity chiefly relied upon is the unusual fact that the apical angle of the first four or five whorls is only about 42°, while with the last turn the angle is increased to quite 53°; and taking only the last two volutions the angle is over 60°.

The marked increase in the apical angle distinguishes this species from all others now referred to *Lophospira.* Aside from this feature *L. perangulata* agrees nearly as well as *L. medialis.* Differing in the same manner as that species, the *perangulata* varies further in having constantly a carina beneath the peripheral one of which no sign is to be seen on *L. abnormis.*

*Formation and locality.*—Upper part of the Trenton group, Covington, Kentucky.

*Collection.*—E. O. Ulrich.

### Lophospira decursa, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIG. 10.

Hight 22 to 28 mm.; apical angle 40° to 44°. Volutions about six; peripheral carina situated unusually low, causing the slope of the upper side to be uncommly steep; upper slope flat or with a slight swelling near the suture; concave space between peripheral and lower carinæ relatively narrow; no umbilicus.

Near *L. perangulata*, but is a larger and relatively narrower shell, with the peripheral carina lower and the concave space beneath it narrower. The absence of an umbilicus is also distinctive.

*Formation and locality.*—Trenton group, Burgin, Kentucky.

*Collection.*—E. O. Ulrich.

### Lophospira producta, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIG. 21.

Hight about 42 mm.; greatest diameter 18 mm.; apical angle about 32°. Volutions about ten, strongly angular, rather high, the upper slope rather wide, concave to the suture except on the last whorl on which there is a slight thickening of the upper edge (not a carina) causing a slight deepening of the suture as we follow it down the spire; peripheral band prominent, rather thick, situated below the center of the exposed part of the upper whorls; lower carina well developed, exposed on all the volutions, its lower side forming the upper border of the suture line. Umbilicus open, comparatively large, the base of the shell rounding less abruptly into it than usual. Aperture rather high, straight upon the inner side, angular below; inner lip comparatively thin. Surface markings obscurely preserved in the specimen, apparently as in *L. perangulata.*

This species, considering that it is a close ally of *L. perangulata* and *L. elevata*, and therefore an undoubted *Lophospira*, is remarkable for the great elevation of the spire. It reminds decidedly of *L. bowdeni* Safford sp., but has a larger umbilicus, more angular volutions and a well developed lower carina, a feature that is scarcely distinguishable in that species. In our opinion *L. producta* has been developed from *L. perangulata*, while *L. bowdeni* probably had its origin in *L. oweni.*

*Formation and locality.*—Upper Trenton, Nashville, Tennessee.
*Collection.*—E. O. Ulrich.

### Lophospira conoidea, *n. sp.* (*Ulrich.*)

PLATE LXXIII. FIG. 22.

Hight about 40 mm.; apical angle 42°. Volutions about six, somewhat loosely coiled. Peripheral carina prominent, situated very low for the genus, just above the deep suture, the edge thick and flat rather than round. An angulation about the middle of the under side of the last whorl surrounds a slight depression which farther inward sinks rather suddenly into a deep umbilicus. Upper slope slightly concave in the lower half, convex in the upper. Lines of growth sweeping strongly backward to the peripheral band, consisting without regularity of stronger and weaker striæ.

This species is remarkable for the low position of the peripheral band. In this it has gone a step farther than *L. producta*, which we believe connects it with *L. decursa* and through that with *L. perangulata*.

*Formation and locality.*—The type specimen was found by Prof. J. M. Safford in the Trenton group at Nashville, Tennessee.

### Lophospira peracuta, *n. sp.*

PLATE LXXIII. FIGS. 15–17.

Hight 25 to 40 mm.; apical angle 58°. Volutions five or six; peripheral band rather sharp and very prominent; upper surface of volutions gently concave to the suture, without a trace of the carina; lower carina wanting; umbilicus small, aperture rounded below and upon the inner side; surface markings obscure, curving backward strongly.

In this species the peripheral angle is sharper and more prominent than in any other known to us. The mouth is shorter and rounder upon the inner side and the volutions project over each other in a greater degree than in *L. oweni*. The shell is much larger, and the peripheral angle more prominent than in *L. perangulata*. That species differs further in having a lower carina. *L. ampla* has a wider apical angle, a subsutural carina, and a differently shaped aperture. In *L. sumnerensis*

(Safford) the last volution is relatively much higher and the peripheral angle not nearly so prominent. In general the species may be said to occupy an intermediate position between *L. elevata* and *L. multigruma* Miller and Dyer.

*Formation and locality.*—The type specimen is from the Glade limestone of the Stones River group at Lebanon, Tennessee. We have several imperfect specimens from the Ctenodonta bed of the Black River group at St. Paul, Minnesota, which may belong to the same species.

*Collection.*—E. O. Ulrich.

## Lophospira elevata, *n. sp.*

PLATE LXXIII, FIGS. 11–14.

Hight 30 to 50 mm.; apical angle 52° to 54°. Volutions about six, contiguous but descending rapidly, an unusually large proportion of each exposed in the spire; peripheral carina moderately prominent, thick, situated about midway between the top and bottom of the whorl; beneath it a wide, slightly concave space, not very distinctly defined below by the obtuse lower angulation beyond which the surface turns rapidly inward to the small umbilicus; upper slope slightly concave to the suture, apparently never with a carina. Mouth very moderately drawn out below, the inner lip more or less curved and turned outward instead of being vertical as in most of the related species. Lines of growth rather obscure, curving strongly backwards to the peripheral band.

Very much like McCoy's *Murchisonia gyrogonia*, but if his figures are reliable then the two species must be quite distinct since the very slight retral curve in the lines of growth as shown in McCoy's illustration proves that his species belongs to the Bicincta section of *Lophospira*, while our *elevata* is an undoubted member of the Perangulata section. Compared with American species we find that the mouth is less produced below and, although the whorls are the same in number, the size of the shell much greater than in *L. perangulata*. The Tennessee species, *L. centralis*, is perhaps the nearest, yet we did not find much trouble in separating them. The apical angle is wider in that shell, the under side of the whorls more ventricose, the suture lines less oblique and the concave spaces over them narrower.

*Formation and locality.*—Five specimens from the Fusispira bed of the Trenton group at Decorah, Iowa, and Kenyon and Holden P. O., in Goodhue county, Minnesota. Several specimens from the upper part of the Trenton in Mercer county, Kentucky, are doubtfully referred here.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7370.

## Lophospira sumnerensis *Safford.*

PLATE LXXIII, FIGS. 18—20.

*Murchisonia sumnerensis* Safford, 1869, Geol. of Tenn., pl. G., figs. 1, *a-f*. (Not defined.)

Hight 18 to 42 mm., usually 25 to 30 mm.; apical angle 60° to 73°, usually 64° or 65°. Volutions four or five, the last very large, the upper surface deeply concave, the sutural edge slightly thickened but never carinate, the peripheral angle not very prominent; beneath it the sides are at first nearly vertical then broadly convex to the umbilicus which is entirely closed by the curved inner lip; the latter is thick and expanded; aperture unusually high, narrowly rounded below, more broadly convex upon the columellar side. Surface markings somewhat irregular, moderately distinct though never very sharp, curving strongly backward from both above and below to the peripheral band.

The unusual hight of the last volution and the absence of upper and lower carinæ are the principal peculiarities of this species. The species is probably not far removed from *L. elevata* and *L. peracuta*, but all three forms seem to us to be easily recognized. In the last the peripheral angle is much more prominent, the last volution not nearly so high, and the upper surface much less concave. In the second there is a well-marked broad concave band beneath the peripheral angle, while the volutions are more exsert, the upper ones exposing more of their sides. In *L. multigruma* (Miller) the apical angle is greater, the volutions not so high, the upper surface nearly flat and the peripheral band more prominent.

*Formation and locality.*—Upper beds of the Trenton group, Nashville, Tennessee, and Mercer and Boyle counties in Kentucky. A single cast of the interior from the Fusispira bed at Wykoff, Minnesota, probably belongs to this species.

*Collection.*—E. O. Ulrich.

## Lophospira multigruma *Miller.*

PLATE LXXII, FIGS. 36—39.

*Murchisonia multigruma* Miller, 1878, Jour. Cin. Soc. Nat. Hist., vol. i, p. 104.

Hight generally from 25 to 35 mm.; greatest width equalling from 75 to 80-100ths of the hight; apical angle 75° to 80°. Volutions five, uniangular; base produced, rounded; umbilicus closed; columellar lip thick and slightly twisted below. Surface markings curved strongly backward to the peripheral band, coarse and rather irregular on the base of the last whorl, much less distinct on the nearly flat upper slope. When perfect the lines of growth are somewhat lamellose.

This species is closely related to *L. sumnerensis* Safford, but is distinguished by a wider apical angle, more prominent peripheral band, plane instead of concave upper slopes, and more twisted and thicker columellar lip. Dr. Miller says further that the base of his shell is more produced than in Prof. Safford's species. This is probably a *lapsus* since the hight of the base, indeed of the whole last volution, surely is relatively greater in *L. sumnerensis* than in *L. multigruma*. Another closely allied species, it is perhaps even nearer than Prof. Safford's, is our *L. ampla*. The last, however, usually has a higher spire, but a more reliable and striking difference is furnished by the subsutural carina, which is wanting in *L. multigruma*.

*Formation and locality.*—Occurs in all three of the divisions of the Cincinnati period (Utica, Lorraine and Richmond groups), very rare in the lowest, at Covington, Kentucky, more frequently in the middle at Cincinnati, Ohio, and rather commonly in the upper beds at Richmond, Versailles and Madison, Indiana, Clarksville and Middletown, Ohio, and Maysville, Kentucky.

*Collection.*—E. O. Ulrich.

### Lophospira centralis, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIG. 9.

Hight 20 to 30 mm.; apical angle 60° or 61°. Volutions five or six, all contiguous, with a concave slope above, somewhat ventricose below the moderately prominent, thick, faintly trilineate peripheral band; immediately beneath the band a concave space bordered on the lower side by an obtuse carina which grows less distinct with age; no upper carina though occasionally a slight thickening may occur at the upper edge of the whorls; umbilicus small, abrupt, nearly covered by the inner lip. Aperture but little produced below, obliquely rounded-quadrate in outline. Surface markings somewhat irregular and rather strong, especially beneath the lower carina; above the latter they turn almost sharply backward to the peripheral band; and on the upper side the retral curve is very decided.

Closely related to *M. perangulata* Hall, but is a larger shell, has a wider apical angle, and more rapidly enlarging volutions. The species is regarded as intimately connected with *L. oweni* and *L. ampla*.

*Formation and locality.*—Lowest division (Central limestone) of the Stones River group, Murfreesboro, Tennessee.

*Collection.*—E. O. Ulrich. (7 specimens.)

### Lophospira conradana, *n. sp.*

PLATE LXXII, FIGS. 29–32.

*Murchisonia ventricosa*, Whitfield, 1882, Geol. of Wis., vol. iv, p. 218, pl. v, fig. 18.

Hight 21 to 31 mm.; greatest width about 7-10ths of the hight; apical angle 60° to 64°; volutions about six.

Of this species besides a single imperfect mold of the exterior we have seen only casts of the interior. In the former the upper whorls are rounded, but on the last two the periphery increases gradually in prominence until near the aperture it is sharply angular. The basal part of the last turn is decidedly ventricose, turning more or less abruptly into the deep though small umbilicus. On the flattened and nearly vertical sides, about midway between the peripheral angle and the basal outline, a faintly raised line (lower carina) is usually distinguishable. The suture is deep and the upper edge of the last whorl is flattened, and forms a shoulder-like prominence, between which and the peripheral angle the surface is strongly concave. Aperture obliquely subquadrate, rounded below. Surface markings only in rare cases leaving any traces upon the casts, consisting on the shell itself of lamellar lines of growth, .5 to 1.0 mm. apart, with much finer lines between them. They curve rather strongly backward from above and below to the peripheral angle.

Compared with species described in this report, *L. conradana* is distinguished by its strongly ventricose base. The general appearance of the shell might be considered to indicate close affinities with *L. bicincta* and *L. obliqua*, but the character and strong retral curve of the lines of growth prove that the species belongs to the *L. perangulata* section of the genus.

The Wisconsin specimen figured by Prof. Whitfield (*loc. cit.*) looks like an unusually large example of *L. conradana* that has been shortened by pressure, causing the apical angle to be abnormally wide. Still, the angle in the figure is only about 68°, while in his description Prof. Whitfield gives it at "about ninety degrees." Whatever the specimens described by him may turn out to be, we are satisfied that they are distinct from *L. ventricosa* Hall sp. In a more recent publication* Prof. Whitfield expresses himself as though he had arrived at a similar conclusion.

*Formation and locality.*—A frequent fossil of the Vanuxemia bed of the Stones River group at Minneapolis and St. Paul, Minnesota; occurs also, though rarely, in equivalent strata at Beloit, Wisconsin.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 5036.

### LOPHOSPIRA OWENI, *n. sp.*

PLATE LXXIII, FIGS. 41—45.

Hight, of Black River specimens, 25 to 36 mm., of Utica specimens, 18 to 27 mm.; apical angle 59° to 62°. Volutions six or seven, the first very minute, decidedly angular. Peripheral band prominent, thick and rounded, sometimes margined by a delicate line on each side. Upper slope concave, except near the suture where there is usually a broad rounded ridge or carina; this ridge, however, becomes quite obsolete on the sixth or seventh volution. Lower side sloping inward, scarcely ventricose, the outline being first concave, next convex, then straight or concave and finally convex again, there being a peculiar swelling just behind the minute

* Bull. Amer. Mus. Nat. Hist., vol. i, no. 8, p. 313, 1886.

umbilicus. The first convexity beneath the peripheral band represents the lower carina of *L. perangulata* and other species, and in young shells it is sharp enough to be called a carina, but as growth proceeds it becomes more and more obtuse. Aperture straight at the inner margin, and somewhat narrowly produced at the lower angle. Surface markings rarely preserved; whenever preserved they consist of rather distant, delicate, sublamellose striæ, with very fine lines between them, all curving backward strongly to the peripheral band.

This is a much larger shell than *L. perangulata*, yet has about the same number of volutions. The apical angle also is greater, while both the under and upper sides of the volutions are obviously different in several respects. *L. centralis* never has so strong a subsutural swelling, its peripheral band is less prominent, and the under side of the whorls more ventricose.

*Formation and locality.*—Rare in the Stones River group at High Bridge, Kentucky; not uncommon in the Black River group, especially in the Ctenodonta bed, at St. Paul, Minneapolis, Cannon Falls, Chatfield and Fountain, in Minnesota; also in Mercer county, Kentucky. As yet it is not known to occur in the Trenton proper, but a smaller yet otherwise indistinguishable form reappears in the Utica group at Cincinnati, Ohio, and localities in that vicinity. About 60 specimens.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, Nos. 7521, 6865.

## Lophospira ampla, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIGS. 52–54.

Hight, of Loraine group specimens, 20 to 32 mm., of Richmond group specimens, 22 to 50 mm.; apical angle 70° to 80°. Volutions about six, the last equalling about two-thirds of the total hight. Upper carina thick, near the suture, present on all volutions; lower carina nearly obsolete, represented by a broad swelling or low ridge, above which to the prominent peripheral band the surface is more or less concave. Inner lip very thick, almost or entirely covering the minute umbilicus, very broad and turned obliquely downward and forward in the basal half. Surface markings very strongly curved, unequal, on the whole not sharply defined.

Closely related to *L. oweni*, yet easily distinguished by the greatly thickened, broad and obliquely extended inner lip. The apical angle also is greater, and the lines of growth are more curved, especially at the base, while the upper carina does not fade away on the last volutions as in that species. The presence of this carina distinguishes it from the associated and otherwise similar *L. multigruma* Miller. *L. medialis*, which is usually much smaller, with the same number of volutions, a smaller apical angle and more distinct umbilicus, also has no such sutural carina.

*Formation and locality.*—Cincinnati period, Lorraine group, Cincinnati, Ohio, and Covington, Kentucky; Richmond group, Richmond, Indiana, and at several localities in Boyle and Lincoln counties, Kentucky.

*Collection*.—E. O. Ulrich. (17 specimens.)

## Lophospira pulchella, *n. sp.*

PLATE LXXIII, FIGS. 46—48.

Hight 8 to 15 mm.; apical angle 46° to 50° in the Richmond group variety and 50° to 56° in the Trenton types of the species; volutions angular, six in the latter and seven in the former. Peripheral band prominent, trilineate; upper or subsutural carina small and close to the suture, constantly present; lower carina obtuse, yet very distinctly defined by the concave band between it and the peripheral keel. Base of volutions somewhat flattened; umbilicus very small, closed entirely in the Richmond group variety. Growth lines as in *L. perangulata* and *L. medialis*, from both of which it is readily distinguished by the upper carina, those species being without that feature.

The development of an upper carina brings this species into closer relations with *L. oweni* and *L. saffordi* than it holds with the two species mentioned in the foregoing paragraph. The absence of the umbilical swelling and the small size of *L. pulchella* will of course suffice to distinguish it specifically from these. *L. spironema* and *L. tenuistriata* are exceedingly like it to the unassisted eye, but with the aid of a magnifier good specimens may be distinguished at once by their surface markings, the present species having lines of growth only, while both of the others have revolving lines as well. *L. pulchra* McCoy resembles this species very greatly, yet, relying on the accuracy of McCoy's illustrations, we see at once that his species is a member of the Bicincta section and not, as is the case with *L. pulchella*, of the Perangulata section. Indeed *L. pulchra* seems to be uncomfortably near certain varieties of *L. bicincta*.

*Formation and locality.*—Upper part of Trenton group, Burgin, Danville and Frankfort, Kentucky; Black River group, Ctenondonta bed, near Cannon Falls, Minnesota; Richmond group, Spring Valley, Minnesota. (Over 30 specimens.)

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7383.

## Lophospira saffordi, *n. sp.* (*Ulrich.*)

Hight 23 to 33 mm.; apical angle 59° to 65°. Volutions seven, very angular, the peripheral band unusually prominent, upper and lower keels both distinct; upper carina removed a third of the width of the upper slope from the suture; surface of whorl lying between the three keels decidedly concave; umbilicus small, rather abrupt, the surface between it and the lower carina either flat or slightly concave. Aperture quadrate, or it might be called subtriangular, moderately produced below, the inner lip nearly vertical, broadly reflexed. Surface markings consisting of unequal sublamellose lines of growth, sweeping backward very strongly to the peripheral band.

This elegant species is undoubtedly closely allied to *L. oweni*, but the persistence and sharpness of its upper and lower keels serve readily in distinguishing it. The lower extremity of the mouth also is more rounded, while the umbilicus is a trifle larger and the umbilical fold, which is a well-marked feature in that species, is much less developed or quite unrecognizable. *L. pulchella*, which also we regard as closely related, is a very much smaller shell. In *L. ampla* the apical angle is wider, the upper carina scarcely as sharp, the lower carina quite obsolete, and the inner lip peculiarly twisted.

*Formation and locality.*—Upper Trenton, near Nashville, Tennessee, where the seven silicified shells upon which the species is founded were collected by Prof. J. M. Safford. This gentleman is not only an illustrious geologist, but the kindest and most generous that it has been our good fortune to meet. We consider it, therefore, peculiarly appropriate that this shell, perhaps the handsomest ot the fossil gastropods occurring in the state which he has so long and honorably served as state geologist, should be connected with his name.

### Lophospira spironema, *n. sp.*

PLATE LXXII, FIGS. 44—47.

Hight 10 to 15 mm.; apical angle 58° to 62°. Volutions five or six, angular; periphery trilineate, very prominent, the surface on each side decidedly concave; lower carina sharp and strong; upper carina thin but distinct, close to the suture. Lines of growth very fine, not sharp, strongest near the suture, curving strongly backward from both sides to the peripheral angle; entire surface with very delicate revolving lines.

This shell, in its general expression, is exceedingly like *L. pulchella*, and we doubt very much that abraded examples of the two could be separated. The carinæ may be somewhat sharper and the apical angle greater, but the only reliable and important difference lies in the surface markings, that species having no spiral lines, while its striæ of growth are stronger. The next species, *L. tenuistriata*, approaches closely but has sublamellose lines of growth, finer spiral lines, less prominent carinæ and different peripheral band.

*Formation and locality.*—Ctenodonta bed of the Black River group, Chatfield and near Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich. (5 specimens.)

### Lophospira tenuistriata, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIGS. 48—50.

Hight 10 to 16 mm.; greatest width about 69-100ths of the hight; apical angle about 57°. Volutions six or seven, angular, with only moderately developed upper and lower carinæ; central carina very prominent, thick, rounded, bordered on each side by a delicate raised line; basal part of shell somewhat ventricose, gently concave above the lower carina; upper slope moderately concave in the outer part; umbilicus very small, sometimes apparently covered by the reflected inner lip. Surface with transverse and revolving lines, the former curving strongly backward toward the peripheral band and consisting of two sets, one lamellar with distant raised edges, the others exceedingly fine, parallel with the other set, and five or six times as numerous. The whole surface, including the peripheral band, is covered with the revolving lines which are inclined to be irregular and more delicate even than the transverse set, requiring a good light and a magnifying power of no less than four diameters to be clearly visible. On the peripheral band the lunulæ are distant and strongly curved backward.

Differs from the earlier *L. spironema* in having the basal part of the last turn slightly more ventricose, the carinæ less strong, the peripheral band rounded instead of sharp, and the surface markings more delicate excepting the sublamellose growth lines which are wanting in that shell. *L. pulchella* also resembles it greatly but has a smaller apical angle and so far as observed its surface is entirely without revolving lines.

The extreme delicacy of the surface markings renders them unusually liable to removal through maceration and weathering. The best examples were obtained by picking away the thin parasitic bryozoan, *Leptotrypa clavis* Ulrich, which frequently covers this and other fossils of the Utica group. Without the characteristic surface ornamentation *L. tenuistriata* might be confounded with the young shells of the Utica form of *L. oweni.* In such cases, however, the presence of a lower carina in the *tenuistriata* and its absence in the *oweni* will usually suffice in distinguishing them.

We have before us two imperfect specimens, collected by one of the authors in the Stones River group at High Bridge, Kentucky, of another species of *Lophospira* with spiral lines. It is larger than either of the two of this type described in this work, and differs from them besides in having the revolving lines coarser and in wanting the lower carina. The general shape and character of the shell seems to have been very similar to our L. *medialis.*

*Formation and locality.*—Shales of the Utica group, Cincinnati, Ohio, and Newport and Covington, Kentucky.

*Collection.*—E. O. Ulrich.

### LOPHOSPIRA PERFORATA, *n. sp.*

PLATE LXXIII, FIGS. 32–35.

*Murchisonia bicincta?* MEEK and WORTHEN, 1868, Geol. Sur. Ill., vol. iii, p. 317, pl. III, fig. 4. (Not *M. bicincta* HALL, 1847.)

Hight 33 mm.; greatest width 26 mm.; apical angle about 50°. Volutions six or seven, relatively depressed, with the hight and width, as shown in a transverse section, nearly equal. In internal casts of old shells the peripheral or central angle is sharp and prominent on the lower turns only, while it is nearly obsolete on the upper ones; last whorl exhibiting a well-marked lower angle between which and the peripheral carina there is a broad concave band, while the under side, between the lower angle and the relatively large and abrupt umbilicus, is only slightly convex; in the middle of the basal space the cast exhibits an obscurely defined line; upper slope gently concave or flat, except near the suture where the internal cast is slightly convex. The matrix shows that there was a thin upper carina on the shell. Surface markings but faintly indicated by the specimens at hand, but it is certain that they curved backward strongly as in *L. perangulata*, while it is probable that they agreed in other respects also with those marking that species.

The umbilicus is larger in this species than in any of genus previously described. In other respects it resembles *L. pulchella* very closely, though a much larger shell. *L. fillmorensis*, though considerably smaller and without an umbilicus, will strike the ordinary observer as even more like it. But if good specimens can be compared it will be noticed that the lines of growth on the concave band beneath the peripheral angle of *L. fillmorensis* are but little oblique and nearly straight instead of strongly curved backward—in short that that shell belongs near *L. bicincta*, while *L. perforata* is one of the group of which *L. perangulata* is typical.

We have before us the original type used by Meek and Worthen. After clearing it of the matrix we found that it has at least one more whorl than stated by them, and that the apical angle instead of being 55° is not more than 50°. The last whorl of the specimen is crushed in such a manner that the angle has been increased at least 5° beyond the normal. An examination of the matrix proved further that the shell really has an upper carina. Finally, it is clear that the umbilicus was not filled, as they supposed, by the columella. That it was not is conclusively shown by the core of limestone occupying all the cavity save a narrow space between it and the cast of the interior of the whorls which represents the space originally occupied by the walls of the shell.

*Formation and locality.*—Trenton group, Jo Daviess and Carroll counties, Illinois. We refer here two small casts from the Fusispira bed near Fountain, Minnesota.

*Collections.*—Illinois State Museum; E. O. Ulrich.

### LOPHOSPIRA PERLAMELLOSA, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIGS. 55 and 56.

Hight 13 mm.; greatest width about 10 mm.; apical angle 65°. Spire subconical, volutions about five, angular; upper side first gently convex and then slightly concave to the prominent peripheral band; base at first a little concave because of a low ridge a short distance beneath the band, then following the course of the striæ, with a concave outline to the acute basal extremity; umbilicus very small; inner lip nearly vertical, twisted, and greatly produced below. Surface markings very faint upon the upper side of the volutions; on the base they consist of rather regular, strong, overlapping lamellæ, curving strongly forward from the peripheral band and, finally, running in a nearly vertical direction, and almost parallel with the inner lip, to the narrow basal extremity of the aperture.

There is no described species (of this family) known to us having the aperture produced below as much or in the same manner as in this shell. A similar condition is exhibited by two specimens from the Lorraine group, one from Cincinnati, the other from central Kentucky, but as the apical angle is somewhat less in these (56° and 57°) and the lower side of the volutions more ventricose, we hesitate to say that they belong to the same species. The surface being abraded on them we cannot say how the markings compare with those observed on the type described and figured.

*Formation and locality.*—Richmond group of the Cincinnati period, Hanover, Butler county, Ohio.
*Collection.*—E. O. Ulrich.

## LOPHOSPIRA BOWDENI *Safford.*

PLATE LXXII, FIGS. 40–43.

*Murchisonia bowdeni* SAFFORD, 1869, Geol. of Tenn., pl. G, figs. 2*a*–2*c*. (Not described.)

Hight 40 to 70 mm., usually 45 to 50 mm.; apical angle of Tennessee types of species averaging about 27° but varying between the extremes of 26° and 30°; of the Lorraine group variety 30° to 34°; of the Richmond group form 25° to 28° for specimens from Trimble county, Kentucky, and 27° to 33° for those from Boyle county in the same state; volutions eight to ten, moderately angular, the peripheral band thick, convex, varying as to prominence, situated beneath the center of the whorls; upper slope convex, sometimes obscurely carinated, in the upper half, more or less concave in the lower half; lower carina obscure, never sharp, often indistinguishable, the space above it to the peripheral carina generally a little concave; a minute umbilicus usually present, though in narrow specimens it is commonly covered by the reflexed inner lip; aperture subtriangular or irregularly quadrate, the outline depending upon the angle at which it is viewed; inner lip nearly vertical, generally exhibiting a small channel in its lower part. Surface with obscure undulations or unequal lines of growth. Th ͤse are very strongly recurved toward the peripheral band, indicating a large and deep >shaped notch in the outer lip· The band is distinctly convex, occasionally subangular in the middle, has obscure lunulæ, and is bordered on both sides by a delicate raised line.

The prominence of the peripheral band varies considerably. As a rule it is the most pronounced in specimens from the Richmond group and least in those obtained from the "Upper Nashville" of Tennessee and the Lorraine of Kentucky and Ohio. The apical angle also is variable though fairly constant in specimens from a given locality and horizon. The Lorraine variety is the widest, the Trimble county Kentucky, and Tennessee specimens the narrowest. The latter look like our fig. 42 only not so angular. Fig. 40 is perhaps a fair average for the species.

Cincinnati collectors formerly confounded casts of this species with *Hormotoma bellicincta* Hall sp., but we now know it as a totally distinct shell. *Hormotoma* has a concave band and, as may be seen from our figures, differs in many other respects, while *L. bowdeni* has the band of a *Lophospira* and in reality differs from such a typical species of the genus as *L. oweni* chiefly in the hight of the spire.

*Formation and locality.*—"Upper Nashville" near Hartsville and at other localities in Tennessee; Lorraine group at numerous localities in Ohio, Indiana and Kentucky; Richmond group at many localities in the same states, especially in the upper fifty feet in Kentucky.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

## Lophospira augustina *Billings.*

PLATE LXXI, FIGS. 1 and 2.

*Murchisonia augustina* Billings, 1865, Pal. Foss., vol. i, p. 234.

Hight 80 to 120 mm., apical angle 33° to 40°; whorls eight or nine, perhaps ten, yet casts of the interior, in which condition only the species has been observed in Minnesota, rarely preserve more than the last four or five. Whorls (of casts) strongly convex, obtusely angulated just below the middle, angular above, forming a narrow horizontal space at the broad open suture. Aperture about as wide as high, slightly drawn out and channelled at the lower angle. The lip is free all around, on the upper side in contact with the penultimate whorl, on the inner side with a broad fold which never quite closes the umbilical perforation. The latter is represented in casts by a flattened spirally twisted core. Casts of the interior preserve not even a trace of the surface markings, nor are they clearly indicated in the molds of the exterior seen by us. As near as can be determined from the material at hand, they consist, as described by Billings, of obscure undulations curving strongly backwards to the rounded peripheral band. The shell itself was strong and thick, especially in its sutural parts.

This is one of the forms usually identified with Hall's *Murchisonia major*, but if our views of that shell are correct, then this is most certainly distinct, while it seems to be equally certain that it is the same as the Newfoundland species which Billings has called *Murchisonia augustina.* Billings, it is true, considered the *augustina* as a variety of *Murchisonia*, or, as it should now be called, *Hormotoma bellicincta*, but relying on the accurracy of his description and figure, this cannot be so, since the angular whorls and convex band remove his *augustina* far from *Hormotoma* in which the band is concave or flat and the whorls nearly always rounded. In our opinion the species is related to *Lophospira bowdeni* Safford sp., differing therefrom chiefly in the lesser angularity of its whorls. Of course it is not likely to be confused with that species, being a much larger and relatively wider shell.

*Formation and locality.*—Maclurea bed of the Trenton group, Stewartville and other localities in southern Minnesota. Billings' types are said to be from divisions H, I, K, L, M, N, of the Quebec group, at Pistolet bay, Burnt cape, Table head, and Point rich, Newfoundland.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, Nos. 7345, 7478.

### Lophospira augustina, var. minnesotensis, *n. var.*

PLATE LXXI, FIGS. 3 and 4.

Hight 80 to 120 mm., apical angle 36° to 45°.

Of this supposed variety we have only three casts of the interior which one of the authors found in the same block of limestone from which he extracted a number of good casts of *L. augustina*, and three fragments belonging to the Survey collection.* The obtuse angulation of the whorls, which marks the position of the band, is lower than in the typical form of the species and the whorls are on the whole less convex, the result being a more conical form, probably not greatly unlike, externally, *L. conoidea* (Pl. LXXIII, Fig. 22). Continuing our comparisons with *L. augustina* we find that the under side of the whorls is also less ventricose and the total hight of each somewhat less.

In the absence of any knowledge of the external markings, we prefer to rank this form as a variety though strongly inclined to believe that it will prove specifically distinct.

*Formation and locality.*—Maclurea bed of the Trenton group, Stewartville, Minnesota; Ottawa, Canada.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, Nos. 7389, 8726.

### Lophospira (? Seelya) lirata, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIGS. 56–59.

Hight 15 to 24 mm.; apical angle 65° to 70°, the angle of the first three whorls usually a little wider. Volutions about five and a half, ventricose, the carinæ not greatly interfering with the general roundness of their outlines. Peripheral band median, appearing lower on the whorls of the spire, very slightly prominent, trilineate, the lines of equal strength and elevation or the median one is a little

* Since the above was written, I have received a specimen of this variety from Mr. W. R. Billings, who found it in the Trenton limestone at Ottawa, Canada. E. O. Ulrich.

weaker and not as sharply defined as the margined ones. About midway between the band and the suture lines a small ridge or carina divides the upper slope into two flat or slightly concave spaces. Nearly the same distance beneath the lower margin of the band in the typical form of the species we meet with the first and strongest of about eight revolving ribs. These ribs, excepting occasionally the first, are wanting in a variety which, if it is desirable to name it, might be called var. *obsoleta.* Umbilicus exceedingly small, sometimes closed by a slight overlap of the inner lip. Aperture subovate, rounded below, and rather straight at the inner side. Lines of growth sharp, thread-like, regular, either fine and equal on all parts of a whorl or they may be farther apart with interpolations on the upper slope as shown in figs. 58 and 59. The lunulæ of the band are fine and regularly curved.

This species is not closely related to any American fossil known to us. It resembles *Plethospira semele* Hall sp. in its general form and size and casts of the interior are not easily distinguished. They are, however, widely distinct genetically and as long as good exteriors are available there is little danger of confusion between them. In the *Plethospira* the band is simple and concave (not bi-concave) while the very delicate line near the suture and the other on the lower half of the whorl compare very ill with the revolving ridges and ribs of *Lophospira lirata.* A true relative is described by Lindström from the Upper Silurian of Gothland as *Pleurotomaria robusta.* That it was derived from the same stock as our species seems very obvious, for, aside from several minor differences, the same characters occur in both. *L. lirata* has a relatively higher spire while the central line of the band is not as prominent as in *L. robusta.*

Our main reason for referring these two species to *Lophospira* instead of *Seelya* is that the band is of the convex instead of the concave type. With *L. humilis* Ulrich as an intermediate form it is not difficult to reconcile the other characters with the more common types of *Lophospira.*

*Formation and locality.*—Not uncommon, chiefly as casts of the interior, in the Utica group at Cincinnati, Ohio.

*Collection.*—E. O. Ulrich.

## Lophospira (?) knoxvillensis, *n. sp.* (*Ulrich.*)

PLATE LXV, FIGS. 38—40.

Hight 30 to 40 mm., width about the same; apical angle about 105°; whorls three and a half or four. The shell is about the size and looks much like *Trochonema beloitensis* and *T. eccentrica*, the whorls having a broad vertical peripheral space bordered above by the slit-band and below by a simple angle, and the aperture being oblique and subquadrate or, if the small lower-outer side be considered, subpentagonal in outline, with the lower half of the entire peristome thick and reflexed. The upper side of the whorls is distinctly concave to the narrowly yet deeply impressed suture. The channel-like character of the suture is discernible only in a view of the upper side. The basal slope to the edge of the moderate umbilicus is more or less flattened. The slit-band, which occupies the upper of the two peripheral angles, consists of a sharp ridge-like center with a delicate raised line on each side of its base. The surface markings consist of lines of growth only. These curve very strongly backward and are comparatively weak on the concave upper slope. Beneath the slit-band they increase in strength downward, while their direction is first, with a moderate curve forward, down to the lower angle of the vertical periphery of the volution. Here they turn backward and proceed across the base to the umbilicus in a direction conforming with the broadly sinuate under lip. The depth of the sinus, however, seems to have increased with age.

Though there may be some doubt as to the strict propriety of referring this and the two following species to *Lophospira*, we believe that a careful consideration of the whole of their characters will show that of all the established genera the claims of the one in which we have placed them are supported by the strongest evidence. We take it for granted that, despite their remarkable resemblance to the most typical species of *Trochonema* and the remote genetic relations so strongly indicated therein, all will agree that the possession of an unequivocal slit-band renders an alliance with *Trochonema* out of the question. We say this too without losing sight of the fact that we describe species of that genus (e. g. *T. retrorsa* and *T. bellula*) having a notch in the aperture of very nearly the same character and at the same point at which it occurs in the trochonemoid species of *Lophospira* under consideration. There is one feature about these notched *Trochonemas* that must always distinguish them, the upper peripheral angle toward which the lines of growth are recurved is comparatively thin and sharp with the lines continuing without interruption over the summit. (See pl. LXXVII, fig. 38.) In the Trochonemoides section of *Lophospira* on the other hand, the angle at the end of which we find the notch, is thick and carries a true pleurotomarian band of which it is probably unnecessary to say that it interrupts the continuity of the lines of growth.

*Phanerotrema*, proposed by Fischer for species of the type of *Pleurotomaria labrosa* Hall, also reminds one in a general way very strongly of these shells. That the latter have a large umbilicus and *P. labrosa* none, is probably not of much consequence, but there are other differences that doubtless are of greater importance. Of these we will point out only one, namely, the long apertural slit which occurs in *Phanerotrema* and is wanting in *Lophospira*, and which of itself is considered sufficient to warrant a generic separation.

*Formation and locality.*—Lower part of Trenton period (?Chazy) near Knoxville, Tennessee. We owe the opportunity of describing this as well as the following two equally interesting species to their discoverer, Prof. J. M. Safford.

## LOPHOSPIRA (?) TROCHONEMOIDES, *n. sp.* (*Ulrich.*)

PLATE LXV, FIGS. 41–44.

Hight 22 mm.; width 23 or 24 mm.; apical angle 100°; volutions four and a half; general appearance of shell decidedly like *Trochonema bellula* Ulrich. Upper peripheral carina thick, rounded, lower carina moderately distinct and sharp except on the latter half of the last whorl on which it grows gradually weaker until at the aperture it is quite obsolete; outer two-thirds of upper slope distinctly concave; remaining third flat to the suture; umbilicus large, only moderately steep, at first sharply outlined by a ridge which gradually becomes indistinct and at the same time moves outward causing the slope to the bottom of the umbilicus to become proportionally more gentle. Surface markings and aperture about as in *L. knoxvillensis*, from which the present species is distinguished by its smaller size, more slowly enlarging volutions, relatively larger umbilicus and by the upper carina which is wanting in that species.

As *L. trochonemoides* occurs at the same locality and geological horizon as *Trochonema bellula*, and as the two might very easily be confounded by persons not thoroughly accustomed to separating fossil *Gastropoda* it may be well to point out some of the differences. First, both the lower peripheral and umbilical carinæ are stronger and more persistent in the *Trochonema;* then the space between the upper carina and the suture line is concave instead of flat; finally, the upper of the peripheral carinæ is not so thick and sharper than it is in the *Lophospira*, while the lines of growth, since there is no slit-band, pass over its summit without interruption.

*Formation and locality.*—"Central limestone" of the Stones River group, Murfreesboro, Tennessee.

## LOPHOSPIRA (?) NOTABILIS, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIGS. 33–35.

Hight and width nearly equal, a full grown specimen measuring about 27 mm., a small one 19 mm.; apical angle about 87°; volutions five. Shell like that of a *Trochonema*, with a moderate umbilicus, oblique aperture, and strongly carinated whorls, the last partly free in old specimens. Upper carina very strong and prominent, situated midway between the suture and slit-band; lower peripheral carina also unusually strong and prominent; midway between these carinæ, and separated from them by concave spaces but little wider than itself, is the broad and salient slit-band, composed of comparatively distant, convex imbricating lamellæ, averaging on the last whorl about seven in 10 mm. The top of the whorls (*i. e.* the space between the suture and the upper carina) is flat and the base moderately ventricose with an obscure carination around the umbilical depression. The aperture is oblique, more rounded than angular, and abruptly notched at the extremity of the slit-band; the peristome is entire, the lower portion thick. The surface markings consist of rather coarse and irregular lines of growth. These, in crossing the whorls from above downwards, are not much recurved until just before they reach the slit-band. On the concave peripheral space they are approximately vertical, on the base broadly recurved about as in *L. knoxvillensis* and *L. trochonemoides.*

The most striking feature of this remarkable shell, and one that will distinguish it at once from every one of the host of Lower Silurian *Pleurotomariidæ* known to us, is the coarsely marked slit-band. This, as well as the form of the aperture and, in fact, the general aspect of the whole shell, is so different from the usual types of *Lophospira* that, if we had not at the same time seen *L. knoxvillensis* and *L. trochonemoides* which, while having the usual *Lophospira* band, yet agree very closely with it in all other respects, we would have considered ourselves justified in proposing a new genus for its especial benefit. As it is, we are not at all satisfied that it would not be better to set these three species apart as a distinct genus, thereby facilitating reference to a genetic relationship that before the discovery of these shells was not even suspected. That a relation of this kind does exist between *Trochonema* and the *Pleurotomariidæ* is now scarcely to be denied, for it seems almost inconceivable that such intimate agreement in structure could occur except in near branches of the same stock. For further remarks on this group of species see under *L. knoxvillensis.*

*Formation and locality.*—Black River group (Carter's Creek limestone) Maury county, Tennessee, and Mercer county, Kentucky.

## Genus SCHIZOLOPHA, Ulrich.

For generic characters see page 952.

Of all the known Lower Silurian *Pleurotomariidæ*, the two species of this genus alone possess a true apertural slit. In both the length and actual presence of the slit were established by the fact that a parasitic crust, in one case of a coral, in the other a bryozoan, which covered the shells evidently during life, grew up to but not over the slit and thus left a narrow space uncovered corresponding in width and length with the slit in the shell. In *S. moorei* the slit extends backward for a distance equaling about one-fifth of the circumference of the last whorl, in *S. textilis* about two-ninths. The general expression of the two shells reminds one strongly of *Lophospira*, and when we add that the slit-band is of the convex type, we believe we are fairly justified in assuming that they were derived from some member of that genus.

*Schizolopha* may be compared with *Phanerotrema*, Fischer, an Upper Silurian and Devonian genus, also provided with a long slit but differing in having a concave slit-band. *Phanerotrema* reminds one in some respects very strongly of the Trochonemoides section of *Lophospira*, but it recalls in other features the Calciferous *Lophospira cassina* Whitfield quite as much. The last species is represented in the collections before us, and we can say most positively that it is not a *Lophospira*. Having a concave band, situated somewhat obliquely upon the periphery, it had perhaps best be placed under *Eotomaria*, though scarcely as a good species of that genus. Having a concave band and agreeing also in all other respects, save in wanting a slit and revolving surface markings, we believe we have in *Lophospira* or *Eotomaria cassina* a reasonably plausible progenitor for *Phanerotrema*—certainly a more likely one than any of the forms that we refer to *Lophospira*. If this is correct, then *Schizolopha* and *Phanerotrema* must be maintained as representing two distinct though almost parallel lines of development.

### Schizolopha textilis, *n. sp.*, (*Ulrich.*)

PLATE LXV, FIG. 30.

Hight 30 mm., width 27 mm.; apical angle about 80°. Shell turbiniform, volutions about five, ventricose below, with a subcentral and only moderately prominent peripheral angle; above this a slightly concave space to the summit of a ridge which lies somewhat less than midway to the suture, then a wider and more deeply concave space to a scarcely perceptible shoulder at the suture; immediately above the last lies the slit-band of the preceding whorl; umbilicus very small; aperture subovate, higher than wide, the inner lip not very thick and curving outward in the lower half; slit about 0.6 mm. in width and 15.0 in length. Entire surface very delicately cancellated, the revolving lines much the finer of the two sets, the lines of growth rather regular, raised, just about visible to the unassisted eye, moderately recurved to the slit-band.

*Formation and locality.*—Upper part of Trenton group, Nashville, Tennessee.

*Collection.*—E. O. Ulrich.

### Schizolopha moorei, *n. sp.* (*Ulrich.*)

PLATE LXV, FIGS. 31—37.

Hight of Richmond group form 28 to 38 mm., width 27 to 41 mm.; apical angle of same 75° to 82°; hight of Lorraine group form 20 to 29 mm., width variable, usually about the same as the hight; apical angle 65° in one instance, 83° in another, usually about 75°. Of whorls there are at least six in the shell, but casts of the interior, in which form the species occurs almost invariably, rarely if ever preserve more than three or four, the first two or three having been filled with shelly matter. In casts it is only the last whorl that is strongly carinate on the periphery, the upper ones being more or less rounded. The umbilicus is variable, being as a rule relatively larger and less steep in the Richmond group form, which we regard as the typical one for the species, than it is in the Lorraine group variety. On the shell of the latter the edge of the narrow umbilicus is angular. That a similar angle surrounds the umbilicus in the typical form is doubtful, though we have seen no specimens showing this part of the shell. Very few casts give any idea whatever of the surface markings. As seen on gutta percha impressions of natural molds of the exterior, they appear as rather coarsely lamellose and strongly recurved lines of growth. The convexity of the slit-band seems to grow less with age, the elevated line on each side of it stronger.

*Formation and locality.*—Lorraine group at numerous localities in the vicinity of Cincinnati, Ohio; reappears in the upper part of the Richmond group, of which it is one of the most characteristic fossils, at many localities in Indiana and Ohio, being perhaps the most abundant at Richmond in the former state and Oxford in the latter.

*Collection.*—E. O. Ulrich.

## Genus LIOSPIRA, n. gen.

In part *Pleurotomaria* and *Raphistoma* of many authors.

For generic characters see page 953.

We doubt that any one can, after a thorough investigation, deny that this is not only a very convenient but also a most natural division of the *Pleurotomariidæ.* The lenticular form of shell which pertains to the majority of the species is of course shared by other types, notably *Raphistomina* and *Trepospira*, and in a lesser degree by *Eotomaria;* but who will say that the differences which exist between these various types of shells, and which have in part been pointed out on preceding pages, are not amply sufficient for their separation and recognition? *Raphistomina*, as we have shown on pages 931–939, and 941, and as may be seen from the figures on plate LXVIII, has a very different aperture, being entirely without the peripheral notch and band. These differences are so important that the two genera cannot possibly belong even to the same family. As to our *Trepospira*, it resembles *Liospira* greatly, and may really be, though we are much inclined to doubt it, a lineal descendant of the Lower Silurian type. However that may prove to be, a generic separation must always be maintained because of the changing characters of the whorls of the spire and the short apertural slit which together characterize *Trepospira* and not *Liospira*. We refer the reader to page 957 for more detailed observations on these points.

When it comes to *Eotomaria*, we are willing to admit something more than mere resemblance. The form in that genus is more conical than lenticular, the suture better defined, the lines of growth generally stronger, and the peripheral band situated entirely upon the upper side of the edge, while the inner lip, so far as known, is never reflected over the umbilicus as is so commonly the case in *Liospira*. In the latter the sutures are nearly always enamelled and so that part of the band is covered. In *Eotomaria*, on the other hand, all of the band is visible and the outer edge of the inner whorls projects slightly above and over the inner edge of the next. These differences, we believe, are quite sufficient to separate the two types of shells as distinct genera, especially as they hold their own without any appreciable tendency to run into each other. Still, we believe that one was derived from the other.

Of the two genera *Liospira* probably was the older. We come to this conclusion because its band is of the convex type, which, it seems to us, is necessarily a more primitive structure than the concave band. The convex form of band we believe always points to an alliance with the *Euomphalidæ* which, theoretically at least, are older than the *Pleurotomariidæ*. *Liospira* undoubtedly began earlier than the Calciferous, in which it was represented by at least one good species. What it was derived from we cannot say at present, yet we feel convinced that *Lophospira* originated in the same stock. As to the origin of *Eotomaria* we are not so confident, still we are strongly inclined to regard it as evolved from *Liospira*. There is nothing unreasonable about this belief, for that the necessary changes in the position and character of the band may have occurred is indicated by *L. decipiens*, in which the periphery is sharp and that portion of the band which lies on its upper side is not only decidedly concave but much the greater part of the whole.

We describe, and in most cases illustrate, a total of fourteen species of this genus. Besides these we regard *Raphistoma prævium* Whitfield (Calciferous), *Pleuro-*

*tomaria numeria* Billings (Quebec group), *Pl. eugenia* Billings, *Helicotoma larvata* Salter (Black River group), *Pl. subtilistriata* Hall (Trenton group), and *Pl. helena* Billings (Hudson River group) as belonging here. Then there is a considerable number of other Lower Silurian lenticular shells which cannot be placed satisfactorily because the most essential characters are neither mentioned in the descriptions nor shown in the figures so far published. There may be some of *Liospira* among them, but there is just as much reason for referring them to *Raphistoma, Raphistomina* or *Eotomaria.* Finally, there is a group of species of which *Pleurotomaria docens* Billings is a good representative. This species was recently referred to *Raphistoma* and it cannot be denied that in the general form of the shell it agrees very well with the most typical species of that genus. Still, *P. docens* has a band and that alone positively forbids its being referred to *Raphistoma.* Now, as to the band, is it entirely on the upper side of the peripheral angle, or does it turn over the edge and thus lie upon both sides of it? Judging from a Tennessee specimen which Billings himself identified with his species, we should say that the latter is the case and, therefore, that the species is to be viewed as a flat-topped *Liospira.*

As at present constituted *Liospira* includes five species (*L. larvata* Salter sp., *L. numeria* Billings sp., and our *L. rugata, L. mundula* and *L. angulata*) that remind one very strongly of the euomphaloid genus *Helicotoma.* But they all have an unquestionable slit-band and one that, so far as we have been able to learn, is in every respect like that of the most typical forms of *Liospira. Helicotoma,* however, has no true slit-band. Instead we find merely a thin sharp ridge—with occasionally a line on only one side of its base—placed entirely upon the upper side of the whorls. That these species belong to *Liospira* is, we believe, shown conclusively by such obviously intermediate forms as *L. subconcava, L. persimilis, L. helena* and *L. eugenia.* It seems to be merely another case showing how some of the subdivisions of ordinarily widely different branches of the same radical may come to agree in structure through, in this case we presume, a kind of atavism.

### Liospira micula *Hall.*

PLATE LXVIII, FIGS. 24–29.

*Pleurotomaria micula* Hall, 1862, Geol. Rep. Wis., p. 55. (Figured but not described.)

A small discoidal shell having the umbilicus filled by a reflexed callosity of the inner lip. This filling is concave externally, perfectly smooth, and generally rather distinctly outlined and distinguished from the finely striated under side of the volutions. There are about four volutions, and within these a minute nucleus, the sutures are very shallow, the spire, excepting an occasional slight convexity of the upper whorls, forming an almost continuous even slope from the apex to the slightly obtuse periphery. The surface markings consist usually of fine lines of growth only, but nearly all of the best specimens show traces of an exceedingly fine set of revolving lines. On the under surface of the whorls the lines of growth make a broad curve, the inner half being the most curved. The band occupies the periphery though somewhat obliquely, nearly twice as much of it being visible in a view of the upper side than is seen in a basal view. It is to be distinguished only on the best specimens, but we have at least fifty before us showing it very clearly. The inner lip is almost vertical in the Trenton variety of the species and always more nearly so than in the Utica form.

This species rarely, if ever, exceeds 16 mm. in diameter, the average for most localities being 11 or 12 mm. The Maquoketa shales types are commonly less than 10 mm. in diameter. Aside from the fact that it is considerably smaller there is little to distinguish *L. micula* from *L. progne* Billings sp. They are doubtless closely related species.

*Formation and locality.*—Trenton group, Burgin, Danville and Frankfort, Kentucky; Utica group (Maquoketa shales) at various localities in Minnesota, Wisconsin, Illinois and Iowa, associated with *Ctenodonta fecunda;* also in Ohio and Kentucky, where there is reason to believe that it ascends into the Lorraine group.

*Collection.*—E. O. Ulrich.

## Liospira abrupta, *n. sp.*

PLATE LXXXII, FIGS. 36–38.

A small species like the preceding but with the spire relatively less elevated and not entirely smooth at the sutures, the outer edges of the inner whorls projecting just enough to be noticed readily by the naked eye. The band is also more distinct, especially upon the upper side where it reminds one considerably of the concave band of an *Eotomaria;* then it is also sharper on the edge, while the lower half of the band is usually much more distinct. The umbilicus is not filled but extends up to the apical whorl, showing all the whorls within; its edge is sharply angular, the sides nearly vertical, while its width equals something like a fourth of the greatest diameter of the shell. The base is a trifle higher than the spire, the basal slope, from the periphery to the edge of the umbilicus, gently convex; the aperture is triangular, its width slightly exceeding the hight. Aside from the peripheral band, the surface appears to have been without markings of any kind. There are four whorls without counting the minute nucleus.

The largest of four specimens from Minnesota, belonging to this or a closely related species, has a width of 8.5 mm. The width in about one hundred specimens from Tennessee varies from 7 to 10 mm., and in nine-tenths of these from 8 to 9 mm. The Minnesota specimens doubtfully referred here differ from the Tennnesee and Kentucky types of the species in the more rapid expansion of the whorls, three sufficing where it requires four in the latter, and in having a relatively higher spire. In both of these points they agree with *L. micula* Hall sp., and we would refer them to that species were it not that they have an open umbilicus.

*Formation and locality.*—Stones River group, Murfreesboro, Tennessee; High Bridge, Kentucky. Two of the Minnesota specimens referred to are from the limestone at Minneapolis, the others from the Black River shales at Chatfield.

*Collection.*—E. O. Ulrich.

## Liospira vitruvia *Billings.*

PLATE LXIX, FIGS. 3–8.

*Pleurotomaria vitruvia* Billings, 1865, Pal. Foss., vol. 1, p. 171.
*Pleurotomaria* (or *Raphistoma*) *lenticularis* (part.) of numerous American authors.

Specimens of this well marked species are not known to exceed 30 mm. in diameter, a good average being about 25 mm. The hight is about half of the width. The upper side of the last whorl is frequently a little concave because of a slight elevation of the peripheral band. The umbilicus is open but varies somewhat in size, its width being often not more than a fourth, at other times quite a third of the greatest diameter of the shell. The principal peculiarities of the species occur on the under side. Here we have first the open umbilicus with its angular margin and flattened sides; and then the unusual prominence and the sharpness of the curve of the central portion of the outline of the lower lip. The angularity of the margin of the umbilicus is of course much less marked in casts of the interior than on the shell itself. Still it is always indicated with sufficient clearness to be unmistakable to the trained observer. For comparisons see following species.

*Formation and locality.*—Ranges from the base of the Stones River group to the Richmond group. The geographical distribution also is very extended, it having been found in Canada, New York, Tennessee, Kentucky, Ohio, Indiana, Illinois, Iowa, Wisconsin, and Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, Nos. 6765, 7287, 7380.

## Liospira americana *Billings.*

(Not Figured.)

*Pleurotomaria americana* Billings, 1860, Can. Nat. and Geol., vol. 5, p. 164.
*Pleurotomaria* (or *Raphistoma*) *lenticularis* (part.) of American authors. (Not Sowerby's species.)

Diameter 30 to 40 mm., hight one-half the diameter or less; apical angle about 130°.

This species grew to somewhat larger size than *L. vitruvia*, with which it is generally confounded and excusably so, considering the imperfect condition of the great majority of specimens. We have found it much less abundant than that species, while its vertical range also is less extensive, being restricted apparently to the Trenton period. When good specimens are compared it may be distinguished at once from *L. vitruvia* by the different shape of the under lip and a corresponding difference in the course of the lines of growth. In *L. vitruvia*, namely, (see pl. LXIX, fig. 4) the central portion of the lower lip projects greatly forward, the anterior outline being sharply rounded in consequence. In *L. americana*, on the other hand, the projection is much less and the curve of the outline, therefore, broader, the conditions being about as in *L. micula* and *L. progne*. (See pl. LXVIII, figs. 24 and 38.) When the aperture is imperfect and the lines of growth are not preserved, we must depend upon the characters of the umbilicus, which is a little wider and less abrupt in casts of *L. americana*, while the shell itself presents no sign of the angulation which encloses the umbilicus in *L. vitruvia*. Where casts of the interior only were available we found it sometimes impossible to distinguish them from *L. progne*, but fortunately it is very rare to find casts of *L. americana* in which the umbilical cavity is freed entirely of the matrix. This fact affords an almost infallible clue, for, if the cavity contains any of the stony matrix in which the fossil was imbeded, the observer may rest assured that the specimen is not one of *L. progne*. In the latter species the relatively large umbilical space is completely occupied by shell-matter, so that the cavity remaining after the dissolution of the shell could not, under ordinary circumstances, be filled with matter of the same kind as that which fills the interior of the whorls.

*Formation and locality.*—Stones River group, Lebanon, Tennessee; Black River group, Maury county, Tennessee; Trenton group (Fusispira bed), Fillmore county, Minnesota; also several localities in Manitoba.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, Nos. 7348, ?7395.

## Liospira progne *Billings.*

PLATE LXVIII, FIGS. 38—44.

*Pleurotomaria progne* Billings, 1860, Can. Nat. and Geol., vol. 5, p. 163.

Width 25 to 35 mm.; hight about half the width; volutions four to four and a half; apical angle about 120°.

This is another of the forms that, especially where it occurs as casts of the interior, is generally referred to as *Raphistoma lenticulare* =*Liospira americana* Billings sp. Although casts of the interior resemble that species very closely (for comparisons see preceding page) the affinities of *L. progne* are really much nearer *L. micula* Hall sp. Indeed, the last is probably nothing more than a dwarfed variety of *L. progne*, and if it were not for the fact that it held its own with remarkable constancy through a long period and is perhaps the most common type of the genus, we would be inclined to place its name on the list of synonyms. The closed umbilicus distinguishes both very easily from *L. americana*, *L. vitruvia*, and other species of the genus having an open umbilicus, while the extreme faintness of their suture lines and the flatness or slight convexity of the upper surface of their volutions separates them at once from such close allies of *L. helena* Billings sp. and *L. persimilis* Ulrich.

*Formation and locality.*—Stones River group, Murfreesboro and Lebanon, Tennessee; Black River and Trenton groups, Mercer county, Kentucky, and near Ottawa, Canada; Trenton group, Clitambonites and Fusispira beds, Goodhue and Fillmore counties, Minnesota.

*Collection.*—E. O. Ulrich.

## Liospira angustata, *n. sp.*

PLATE LXVIII, FIGS. 35–37; PLATE LXIX, FIGS. 1–2.

Stones River group variety: Width about 17 or 18 mm., hight about 9 mm.; apical angle 125°. Trenton group variety: Width 29 to 45 mm., hight 15 to 22 mm.; apical angle about 130°. Number of volutions four to five.

This species, casts of which are exceedingly like those of *L. americana* and *L. progne*, is distinguished from the former by the great and gradually increasing deposit of shell-matter on the umbilical side of the whorls, and from the latter by the fact that this deposit does not, as is the case in that species, fill the umbilical cavity entirely, but leaves a narrow subcentral perforation. As shown in figure 37 on plate LXVIII, the umbilical perforation is relatively much larger in the younger stages of the shell than it is in fully grown examples, showing that the deposit, which we take to be a callous reflection of the inner lip, was proportionally much greater in later stages of growth. The callosity did not spread itself over the bottom of the umbilicus but was confined to its sides, and herein lies the principal difference between *L. angustata* and *L. progne.* Another difference is that the anterior outline of the lower lip is more broadly and less uniformly convex.

*Formation and locality.*—Of the small Stones River group variety we have four specimens which one of us collected in the Vanuxemia bed at Minneapolis. Of the larger variety, which occurs in the Fusispira bed of the Trenton group at several localities in Fillmore county, we have five specimens.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

***Museum Register***, No. 7494.

## Liospira obtusa, *n. sp.*

PLATE LXVIII, FIGS. 30–34.

Hight of a large specimen 25 mm., width of same 44 mm.; hight of a small example 17 mm., width of same 32 mm. Volutions four to five, with the periphery rounded and the upper side very slightly convex. Umbilical cavity rather large in casts but in the shell itself it is filled, excepting a minute central perforation, by a distinctly outlined, thick external deposit on the inner side of the whorls. This deposit is as heavy relatively on the inner whorls as on the last. The last feature, together with the obtuse character of the periphery, distinguishes this species from *L. angustata.*

Among a lot of Lower Silurian *Gastropoda* kindly sent us by Prof. J. M. Safford, we find two specimens which he collected from the "Ridley limestone" in Rutherford county, Tennessee, which agree in all respects with this species save that the umbilicus is not constricted by a deposit of shell such as we find in this and the preceding species. The umbilicus is about as large as in *L. vitruvia* but the margin of it, though rather abruptly rounded, is not angular as in that species. We believe these specimens represent another undescribed species of this important genus and one that, if time and space had permitted, we would have illustrated because we expect it will prove a necessary link in showing the evolution of the family. Since it is easily recognized, and as it would facilitate reference to it, we propose to call it *Liospira convexa.*

*Formation and locality.*—Vanuxemia bed of the Stones River group, Minneapolis, Minnesota, Dixon, Illinois, and Beloit, Wisconsin.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 687.

## Liospira decipiens, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 39–41.

Width 18 to 23 mm ; hight 8 to 11 mm.; apical angle about 135°; angle formed by slope of spire and outer half of basal slope about 60°. Volutions five, flat above from the suture to the sharp, thread-like inner or upper margin of the peripheral band. At least two-thirds of the latter lies upon the upper side of the acute edge of the shell. This portion of the band is distinctly concave and presents exactly the appearance of the entire band of an *Eotomaria*. When, however, the edge is in good condition, it will be seen that the remaining third of the band turns over the edge and lies, as it should in *Liospira*, on the under side of the periphery. Excepting the slight elevation of the band, the upper side of the shell forms a smooth even slope, with the lines of growth very obscure. On the under side the umbilicus is covered about as in *L. subconcava* and *L. progne*, the forward curve of the lines of growth is only moderate, the mouth transverse, acuminate-ovate.

The unusual sharpness of the peripheral edge and the distinctly concave character of the upper part of the band are the principal peculiarities of this species. These features will distinguish the species at once from all others now referred to *Liospira*. At the same time, when the upper side only is visible, one is very liable to mistake the generic position of the shell.

*Formation and locality.*—Safford's "Central limestone" of the Stones River group, Murfreesboro, Tennessee.

*Collection.*—E. O. Ulrich.

## Liospira persimilis, *n. sp.* (*Ulrich.*)

PLATE LXVIII, FIGS. 45–47.

In size and general expression, especially in a view on the upper side, this fine shell resembles *L. helena* Billings sp. very greatly, but when we turn them over and compare the basal portions, at least one decided difference is quickly observed. Namely, in *L. helena* (we have an authentic specimen of this species before us) while the umbilicus is in most cases entirely closed, there is, nevertheless, a small depression, the umbilical region, with the callous reflection of the pillar lip, appearing about as the same part in *L. micula* and *L. progne.* In *L. persimilis*, on the other hand, this region is scarcely, or at any rate less, depressed, while the smooth callosity extends as a thin sheet for a considerable distance beyond what may be properly included in the umbilical region. Among other differences we may mention that the proportional hight of the Canadian shell is as a rule greater, being from two-thirds to three-fourths of the greatest width, while in *L. persimilis* it varies between one-half and two-thirds. The upper side of the whorls also is generally more strongly concave than in our species. Compared with other species *L. persimilis* is distinguished from all others of the family known to us by the great extent of its umbilical callosity. The next species is closely related. The largest specimen seen is 30 mm. in diameter, the smallest 18 mm. 25 or 26 mm. appears to be a fair average.

*Formation and locality.*—Trenton group, Hartsville, Tennessee, where the seven specimens used in the above description were collected by Prof. J. M. Safford.

## Liospira subconcava, *n. sp.* (*Ulrich.*)

PLATE LXIX, FIGS. 30—32.

Average diameter about 20 mm., but varying in thirteen specimens between the extremes of 15 and 25 mm. The hight, which is about equally divided between the spire and base, compares with the greatest width about as six to eleven. On the upper side of the shell the surface of the whorls is concave, but this concavity is produced chiefly by the elevation of the two edges, the peripheral one being thick and the sutural one thin and sharp. The umbilicus is filled, the surface of the filling but slightly concave and its outer margin, which includes a space with a diameter equalling somewhat less than a third of the greatest width of the shell, more or less sharply defined. The anterior outline of the lower lip bows rather strongly forward in the outer two-thirds, and always more so than it does in *L. persimilis.* If we add to this that the umbilical cavity is much less depressed, and its filling not nearly so extensive as in that species, we have at least three good characters by which ordinarily good specimens of the two species may be distinguished.

Compared with other species we find that both *L. helena* and *L. eugenia* of Billings are closely related. In the first the hight is relatively greater, the inner lip higher and more nearly vertical and the umbilical depression narrower, more abrupt, and much deeper. In the second the outer part of the basal half of the shell is more nearly vertical, the form of the aperture more nearly quadrate, and the whorls "gently convex above near the suture."

*Formation and locality.*—Lowest division of the Stones River group, near Murfreesboro, Tennessee.

*Collection.*—E. O. Ulrich.

## Liospira rugata, *n. sp.* (*Ulrich.*)

PLATE LXIX, FIGS. 33—36.

In ten representative specimens the width varies from 14 to 20 mm. The hight equals about two-thirds of the width. Volutions four or five, with a thick ridge above along the suture, deeply concave between this and the elevated band which is set obliquely upon the upper angle of the periphery. The latter is vertical, rather wide and unusually well defined below where it passes into the moderately convex base. Lower and outer portions of peristome bowed strongly forward, and prominent at the obscure angle of the periphery, above which the outline curves strongly backward toward the band. Inner lip thick, turned outward, excavated in front, reflected and completely covering the umbilicus. Mouth rounded-pentagonal; shell rather thick. The surface markings are not well preserved. As far as known they consist of strong, almost wrinkle-like, lines of growth. As this is an unusual feature among species of this genus, we have chosen a specific name that will call attention to it.

Of previously described species, only *L. eugenia* Billings, need be compared. That species agrees closely in most respects, but evidently has finer surface markings, while it differs decidely in the more uniform convexity of the under side of the whorls. *L. helena* Billings is farther removed. Two other Canadian species, *L. numeria* Billings sp., and *Helicotoma larvata* Salter, resemble our species, yet may be distinguished at once by the umbilicus which is open in them and closed in *L. rugata.* The next species, *L. mundula*, is as closely related as any.

*Formation and locality.*—Richmond group, Lincoln county, Kentucky.

*Collection.*—E. O. Ulrich.

## Liospira (?) mundula, *n. sp.* (*Ulrich.*

PLATE LXIX, FIGS. 37—41.

The average width of this shell, according to twenty specimens, is about 12 mm., the hight about 7 mm. The largest seen has a width of 15 mm. The species is closely related to *L. rugata* but does not attain the size of that shell, has finer lines of growth, a more uniformly rounded base, and relatively smaller and deeper umbilical depression. From *Helicotoma larvata* Salter, with which it is associated in the Black River group of Canada, it is distinguished by having a more obtuse periphery and the umbilicus not only a trifle smaller but also covered entirely by the reflection of the inner lip. In *H. larvata*, which may belong to *Liospira*, the umbilicus is open, angularly outlined, and exposes all the whorls.

*Formation and locality.*—Black River group, Pauquettes Rapids, Ottawa River, Canada; lower part of Trenton group, Mercer county, Kentucky; upper beds of same near Danville, Kentucky.

*Collection.*—E. O. Ulrich.

## LIOSPIRA ANGULATA, *n. sp.*, (*Ulrich.*)

PLATE LXIX, FIGS. 42—46.

Hight and width respectively as five is to eight or nine. Average width about 15 mm. Width of the largest of thirty specimens 17 mm. Whorls slender, about five in number on the upper side, with a slightly elevated peripheral edge, concave within this and convex in the inner third. This convexity and the raised edge of the whorl next within produces a deeper suture line than in any other species of the genus known. Periphery obtuse, nearly vertical beneath the slit-band; base convex to the angular edge of the umbilicus. The latter slopes rapidly without being vertical, exhibits all the whorls within, and as a rule makes up about one-third of the width of the shell. Aperture subpentagonal; anterior outline of lower half of peristome not very strongly bowed forward, the inner extremity of the upper lip extending slightly beyond it.

This species seemed at first to be the same as *L. numeria*, described by Billings as a *Pleurotomaria* from division G of the Quebec group of Newfoundland. A second and more careful comparison, however, brought out at least one difference upon which to base a separation. Namely, the upper side of the whorls is said to be "nearly flat or gently concave" in *L. numeria*, and Billings' figure (Pal. Foss., vol. I, p. 229, fig. 213*a*) shows that this concavity extends inward quite to the suture. His description, which would almost certainly do so if anything of the kind occurred in the Newfoundland shell, makes no mention of a ridge-like convexity in the inner third like that which occurs here in *L. angulata* not only on the exterior but on casts of the interior as well.

*Formation and locality.*—In cherty layers of the Black River group, Mercer county, Kentucky.

*Collection.*—E. O. Ulrich.

## Genus EOTOMARIA, n. gen.

In part *Pleurotomaria* and *Raphistoma* of American authors.

For generic characters see page 954.

Restricting *Pleurotomaria* to species agreeing closely with the original type of the genus, *P. anglica*, we find that it is characterized (1) by a long slit, (2) the supra-peripheral position of the band, (3) the posterior direction of the outer lip beneath the band, and (4) the coarsely nodose and longitudinally striated surface of the whorls. In *Eotomaria* there is a notch in the outer lip merely and no slit, one edge of the band, the lower, forms the periphery of the whorls, the lines of growth curve more or less forward beneath the band and the surface is marked by simple lines of growth only. *Raphistoma*, as we have shown on preceding pages, is a totally different type of shell, being without not only slit but a band as well, while the lines of growth, which of course indicate the outlines of the lip, follow a simple or double sigmoid curve in crossing the flat upper side of the whorls.

The true relations of *Eotomaria* seem to be with *Liospira, Euconia, Bembexia* and *Clathrospira.* In *Liospira* the surface is smoother, the sutures generally much less distinct, and the band less sharply defined, convex instead of concave, and turned partly over the peripheral edge instead of being placed entirely upon the upper side. *Bembexia,* which is mostly a Devonian genus, and of which we consider *Pl. sulcomarginata* Conrad (see accompanying figures) a characteristic species, is

FIG. 6.—Views of the upper and lower sides of a perfect shell of *Bembexia sulcomarginata* Conrad sp., natural size, showing long apertural slit and other features distinguishing *Bembexia* from *Eotomaria.* The specimen is from the Hamilton group of New York, and now in the collection of E. O. Ulrich. For description and remarks on *Bembexia* see pages 954 and 955.

probably a direct descendant of *Eotomaria* and chiefly distinguished by its long apertural slit. *Clathrospira* has the band directly upon the periphery and a cancellated surface. *Euconia,* whose relations to *Eotomaria* perhaps are more apparent than real, has a more strictly conical form, more numerous whorls and a flattened base, while the anterior outline of the under lip is straight excepting in its extreme outer part where it turns slightly backward before it reaches the lower edge of the band.

We believe *Eotomaria* was derived from *Liospira.* Although the actual connecting links are unknown, we can, after a comparison of known species, readily imagine the modifications required to produce the main distinguishing feature of *Eotomaria,* viz.: a *concave* band lying entirely upon the sloping upper side of the volutions instead of a *convex* band lying upon the peripheral edge, and partly visible in a view of the base. In the most typical species of *Liospira* no part of the band can be described as concave and both margins are very distinctly defined. In *L. abrupta* Ulrich, however, the upper border of the band is better defined and an appreciable concavity lies between it and the extreme periphery of the whorl. In *L. decipiens* Ulrich, which might easily be mistaken for an *Eotomaria,* the band is sharply marked and its upper part decidedly concave, while only a small portion of the band turns over the peripheral edge. After reaching this stage but a small step remains to bring us quite within the limits of *Eotomaria.* Nothing more was required than to continue the upward movement of the band until its lower boundary coincided with the peripheral edge of the whorls.

To give a just idea of this new generic group we have illustrated all of the six species which we are reasonably satisfied belong here. All belong to the age of the Trenton period, and three occur in Minnesota, while the others are so far known only from localities in Tennessee.* These species exhibit considerable variety in the form of the lower lip. In *E. vicina* U. and S., and *E. dryope* Billings sp., the outline of this portion of the apertural margin is comparatively straight, the outer half being less curved and produced than in *E. canalifera* Ulrich, and very much less than in *E. supracingulata* Billings sp. The last species reminds one very strongly of the *L. mundula* section of *Liospira.* At first we believed that the several species which group themselves about *L. mundula,* together with *E. supracingulata,* should be viewed as a distinct genus. A reconsideration, however, seemed to show that such a course would scarcely be justifiable at present, first, because the *mundula* group is closely connected with the more typical species of *Liospira* by *L. progne* Billings and *L. subconcava* Ulrich, and second, because the species *supracingulata* differs decidedly from the others in having a concave band. The latter reason decided the question, since, with our present knowledge, we cannot admit that concave-banded species are congeneric with convex-banded forms. For further remarks on the *L. mundula* group of species see page 994.

### EOTOMARIA CANALIFERA, *n. sp.* (*Ulrich.*)

PLATE LXIX, FIGS. 9-14.

Width 15 to 30 mm.; hight about two-thirds of the width, in young examples relatively greater than in old; apical angle 80° to 85° for the first three or four whorls, the following whorls spreading more rapidly and in some cases bringing the angle of the entire shell to 100°; volutions five to six and a half in number.

Shell subconical, moderately convex below, with a very small umbilicus and distinct yet not deep sutures. Band concave, sharply defined, channel-like, its outer border slightly overhanging the suture and forming the sharply angular periphery of the whorls, the inner border strongly defined, elevated, its prominence increasing with the growth of the shell. The contour of the upper surface of the whorls changes considerably with growth. The apical whorl has not been observed, but the second and third are nearly flat and the fourth very gently convex, while in the fifth and succeeding turns a furrow just within the band gradually widens and deepens until at least two-thirds of the space between the band and suture is distinctly concave. (The specimens illustrated on plate LXIX are not sufficiently developed to show the last of these changes satisfactorily). Aperture subrhomboidal, a little wider than high; inner lip oblique, not very thick. Lines of growth rather unequal, never strong, very fine on the upper turns. On the upper surface they are strongly recurved, indicating a deep notch in the aperture. Beneath the periphery they first curve forward but soon, and rather abruptly, turn backward and finally forward again as they descend into the umbilicus. Lunulæ of band very delicate, rarely preserved.

*Formation and locality.*—Stones River group ("Central limestone") near Murfreesboro, Tennessee.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

* We suspect that two or three other species described by Billings and Hall will prove to belong to *Eotomaria*, but as our efforts to see the original types have failed, and as the published descriptions and illustrations are too indefinite to admit of certainty, we have thought it best to postpone their consideration.

## Eotomaria labiosa, *n. sp.* (*Ulrich.*)

PLATE LXIX, FIGS. 15-17.

Width about 24 mm., hight about 20 mm.; apical angle 90°; volutions four and a half or five.

This species is associated with, and in most respects greatly resembles, *E. canalifera.* Carefully compared, however, several minor differences, as well as one that must be regarded as important, will soon convince the observer that the two forms are less closely related than the first superficial glance may lead one to suppose. The principal difference lies in the relative development of the inner lip. This is somewhat excavated and much stronger in *E. labiosa*, while the lower border also is expanded in a way that has not been observed in *E. canalifera.* Among other differences we may mention that the upper sloping surface of the whorls is on the whole flatter, the band less sharply defined, the surface markings more obscure, the base more ventricose, and the umbilical perforation even smaller than in that species.

*Formation and locality.*—Lower division of the Stones River group, Murfreesboro, Tennessee.

*Collection.*—E. O. Ulrich.

## Eotomaria vicina, *n. sp.*

PLATE LXIX, FIGS. 18-20.

Shell rather small, 14 to 20 mm. wide, 10 to 14 mm. high, depressed conical above the angular periphery, moderately ventricose beneath; apical angle 97° in one specimen, 107° in another. Volutions four, the upper sloping surface nearly flat, the last a little convex above near the slightly impressed suture line. Band only moderately distinct, apparently more nearly vertical than usual for the genus. Umbilicus equalling nearly a fourth of the width of the shell, the convex base turning rather abruptly into it.* Lines of growth showing obscurely on casts of the interior, rather strongly defined exteriorly, particularly upon the under side. On the upper slope they curve strongly backward from the suture to the band, on the lower surface very slightly forward.

The umbilicus is larger and the anterior outline of the lower lip less curved than in either of the preceding species. In both of these features it agrees with *E. dryope* Billings sp., with which it is also found associated in Minnesota, but the relative flatness of the upper slope of the whorls distinguishes it readily from that species.

*Formation and locality.*—Stones River group, Minneapolis, Minnesota, and Mineral Point, Wisconsin.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 5106.

## Eotomaria dryope *Billings.*

PLATE LXIX, FIGS. 21-25.

*Pleurotomaria dryope* Billings, 1865, Pal. Foss., vol. 1, p. 170.

This well-marked species differs from *E. vicina* in the contour of the upper side of the whorls, the outer two-thirds or three-fourths of the slope being decidedly concave, the remaining fourth next the suture convex. In other respects the two species agree very closely.

Although the surface markings in our specimens are not as regular as in Billings' figures, the resemblances in all other particulars are so exact that we cannot doubt for a moment that they are specifically identical with the Canadian types. We notice a slight difference between the specimens obtained from the Stones River group and those from the Black River limestone. In the latter the apical angle is not so wide, being about 100°, while the whorl next to the last is, as described by Billings, "slightly

*In the reproduction of figure 20 on plate LXIX some of the shading failed to "come up," causing the umbilicus to appear narrower than it is in the specimen.

turretted." In the Stones River specimens the last feature is not apparent and the spire is more depressed, giving an apical angle of about 110°.

*Formation and locality.*—Stones River group, Vanuxemia bed, Minneapolis and Cannon Falls, Minnesota. Black River group, Maury county, Tennessee.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

## EOTOMARIA SUPRACINGULATA *Billings.*

PLATE LXIX, FIGS. 26-29.

*Pleurotomaria supracingulata* BILLINGS, 1857, Rep. of Progr., Geol. Sur. Can., p. 302; 1863, Geology of Canada, p. 181, fig. 175.
*Pleurotomaria nasoni* HALL, 1861, Geol. Rep. Wis., p. 34; WHITFIELD, 1895, Mem. Amer. Mus. Nat. Hist., vol. i, pt. 2, p. 61, pl. VIII, figs. 4-7.
*Raphistoma nasoni* WHITFIELD, 1883, Geol. of Wis., vol. iv, p. 215, pl. VI, figs. 2-3.
*Raphistoma nasoni* WALCOTT, 1884, Pal. Eureka District, p. 78, pl. XI, figs. 21, 21*a*.

*Original description.*—"Obtusely conical or lenticular, apical angle 105°; hight about two-thirds the width; whorls four, angulated and keeled on their upper outer margin, their sides vertical, their upper surfaces gently convex from the distinct suture half-way to the margin, and then scarcely concave to the spiral band; lower side of body-whorl convex; the spiral band narrow, and lying wholly on the upper side of the whorl, where it forms a border along the margin following all the whorls to the apex; umbilicus large; width one inch and a quarter; hight ten lines; width of umbilicus at center of body-whorl three lines and a half; width of band on last whorl about half a line."

To the above we may add that the lines of growth are generally not strongly marked, and when they are distinct it is only on the lower side of the last whorl of old shells. On the best specimens they consist of obscure undulations, from 1 to 2 mm. apart, with four or five very fine lines between any two undulations, all curving backward on the upper side in the usual manner and degree. Beneath the band, however, the lines make a sharper and longer sweep forward than in any pleurotomaroid shell known to us. Just before reaching a point midway between the band and the obtuse edge of the umbilicus they begin an almost equally strong backward curve, which in turn is overcome as they enter the umbilical depression on the sides of which they bend once more, this time gently forward. In accordance with the lines of growth, the aperture is very deeply notched and the outer lip greatly produced, the most prominent point on its narrowly rounded anterior outline extending slightly beyond the sutural extremity of the upper lip, while the lower lip is broadly and rather deeply sinuate. These features of the aperture are shown in our figures 27 and 29 on plate LXIX. The band is sharply defined and concave on the exterior of the shell, rounded or obscurely flattened on casts of the interior. The outer side of the whorls is never quite vertical, nor is the band horizontal. The latter slopes with the spire. The largest specimen seen is 43 mm. wide and about 27 mm. high.

That *Pleurotomaria nasoni* Hall is a synonym for *Pl. supracingulata* Billings is so obvious that we cannot understand why the fact was not discovered years ago. Perhaps it is because one was described from a testiferous specimen, while the other was founded on casts of the interior. Another thing that we cannot understand is how Prof. Whitfield can say that "this shell appears to possess all the features requisite for a true *Raphistoma.*" So far as we can see it has not one of the essential characters of that genus. There is some reason for calling the species a *Pleurotomaria*, but none that we can discover for placing it with *Raphistoma*. Excepting the unusual prolongation of the outer lip, and this is not an insuperable objection, every feature conforms strictly with our genus *Eotomaria*.

*Formation and locality.*—Stones River group, Dixon, Illinois; Mineral Point and Beloit, Wisconsin. Black River group (Upper Buff limestone), Beloit and Janesville, Wisconsin; Rockton and Dixon, Illinois; St. Joseph island, lake Huron. According to F. W. Sardeson this species occurs in the Vanuxemia bed at Minneapolis.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7296.

EOTOMARIA ELEVATA, *n. sp.* (*Ulrich.*)

PLATE LXX, FIGS. 68-69.

Shell resembling *Lophospira;* width 15 mm.; hight about 20 mm.; hight of aperture about 12 mm. apical angle 74°; volutions four or five, the last comprising much the greater part of the shell, slightly; turretted, the upper slope nearly flat; band slightly concave, the outer border forming the angular periphery of the whorls, the inner border consisting of a sharply elevated thin line; band very wide, occupying nearly two-fifths of the sloping space between the periphery and suture; base large, its surface moderately convex, with a slightly concave band a short distance beneath the periphery; aperture obliquely subquadrate or subtriangular, narrow below, the hight greater by a fifth or a sixth than the width; columellar lip thick, reflexed, almost entirely covering the minute umbilicus; surface marked distinctly though rather irregularly with lines of growth, strongly recurved above, more gently below; lunulæ of band uniformly curved, unequal, occasionally strong.

The fact that the band is placed wholly above instead of *on* the periphery of the whorls, distinguishes this peculiar shell at once from *Lophospira*, several species of which it resembles in form. The great width of the band may suggest relations to *Omospira*, but the uniform curvature of the lunulæ proves that the species belongs to the *Pleurotomariidæ* and not to the *Raphistomidæ:* In placing the species under *Eotomaria* we have been guided principally by the position of the band.

*Formation and locality.*—Upper part of the Trenton group, Hartsville, Tennessee.

*Collection.*—E. O. Ulrich.

## Genus CLATHROSPIRA, n. gen.

*Pleurotomaria* (part.) of numerous American and European authors.

For generic characters see page 954.

In this genus we propose to include subconical or turbinate shells differing from *Eotomaria* in having a delicate cancellated surface sculpture and the band, which is of the concave type, placed vertically and directly upon the periphery of the whorls The outer lip is merely notched, not slit as in *Pleurotomaria* and similar genera The group is represented by at least three species, two of them new, in Lower Silurian strata of America, and by four—possibly six—European species that Lindström has described from the Upper Silurian rocks of the island of Gotland, under the following names: *Pleurotomaria claustrata, P. glandiformis, P. hindei, P. latezonata, P. gradata* and *P. scutulata.* The last two of these six species, though agreeing in most respects very well with *Pl. subconica* Hall, the type of the proposed genus, are peculiar in having a pair of thin elevated lines just above the center of the slit-band. The significance of these lines is not clear at present, but we suspect that they represent homologically the median line of the band of *Lophospira bicincta,* and if that is a fact, then the species in question cannot belong to *Clathrospira,* for this genus and *Lophospira* are widely distinct genetically.

As near as we could learn, all of these Gotland species agree with the American species in having no slit. All differ, however, in having the anteriorly curved portion of the lines of growth just beneath the band much shorter and the anterior outline of the lower lip, as seen in a view of the base, much straighter. But this modification is in accordance with a tendency that has been followed almost generally in the development of the whole family. As a rule it appears to have preceded the development of the apertural slit.

At present we regard *Clathrospira* as the stock from which the Devonian group of species that includes *Pleurotomaria lucina, P. hebe, P. itys, P. filitexta* and *P. ella* (all described by Hall) was derived. The aperture in all of these species, so far as known, is without a slit, and the surface cancellated. Taken as a group, their whorls are more rounded than in their supposed Lower Silurian ancestors, but this difference, provided that our information concerning the remaining characters is reliable, would be no serious objection to classing them as congeneric with *Clathrospira subconica.* Still, we cannot be too cautious in matters of this kind, and we wish to be understood as merely suggesting and not as proposing the transference of these Devonian species to *Clathrospira.* If the old genus *Pleurotomaria* is to be successfully broken up according to the principles of ontogenetic classification, we must be reasonably sure of our ground before making sweeping changes in nomenclature. For other remarks on these Devonian shells see page 956.

### Clathrospira subconica *Hall.*

PLATE LXIX, FIGS. 47–50; PLATE LXX, FIGS. 5–6

*Pleurotomaria subconica* Hall, 1847, Pal. New York, vol, i, pp. 174 and 304; Whitfield, 1883, Geol. of Wis., vol. iv, p. 216.

Shell with a short conical spire, consisting, when fully grown, of six and a half or seven volutions, of which the two at the apex are usually broken away; greatest width and hight nearly equal, varying generally between 25 and 30 mm., but attaining occasionally a width of over 40 mm.; apical angle 70° to 80°, but in four specimens out of every five the variation is only about one degree either way from 74°. Volutions flattened above in the direction of the slope of the spire, the inner half of the slope gently convex, the outer half correspondingly, or more strongly concave; convex portion of slope just touching or failing to reach a line drawn from periphery to periphery of succeeding whorls; under side of whorls rounded, occasionally very slightly concave near the periphery, this condition appearing, however, only in specimens in which the band is unusually prominent, umbilical depression small, terminating generally in a minute axial perforation. Band prominent, sharply defined, rather wide, concave, nearly vertical, situated on the periphery of the last volution, and lying immediately above the suture line on the upper whorls. Aperture subquadrate, outer lip broadly notched; columellar lip not very strong, thin, folding about the small umbilical perforation. Surface sculpture beautifully cancellated, consisting of two sets of fine, subequal, thread-like lines, one revolving, the other running parallel with the margin of the aperture. The transverse lines, of which three to five occur in the space of 1 mm., are recurved as usual on the upper side and quite as much on the lower side. At intervals, sometimes quite regular, many specimens exhibit more or less distinct undulations of growth, in some examples little more than a millimeter apart, in others two, three, or four millimeters. Considerable variety as regards strength and arrangement of the lines forming the surface sculpture may be observed in specimens from different localities. As a rule the revolving lines are strongest on the basal portions of the shell, and in some of the specimens from the "Glade limestone" of Tennessee they appear to be wanting entirely on the upper side. In the latter cases the transverse lines are stronger than usual In all the specimens from the Stones River group of Illinois, Wisconsin and Minnesota that retain the markings, the two sets of lines are almost equally developed, and on the whole finer than on the Tennessee shells. The lunulæ of the band are distinct, strongly curved, and crossed by a varying number of delicate revolving lines. Suture linear and inconspicuous except between the last two whorls of old shells. The last volution usually descends more rapidly than the preceding whorls.

In casts of the interior, the condition in which this fossil usually occurs, the suture, for obvious reasons, is deeper than in the shell itself, the periphery of the whorls oftener rounded than flat or concave, and the surface markings restricted to more or less obscure impressions of the varices of growth. Even the molds of the exterior in the dolomitic limestone in which the species occurs so abundantly in Wisconsin and Minnesota, only in rare instances preserve any recognizable traces of the delicately cancellated surface sculpture. But we have never failed to detect it whenever the grain of the matrix was fine enough. That the surface in these specimens was originally cancellated, as shown in figure 5 on plate LXX, is further established by two specimens collected by one of the authors in the fine-grained upper member of the Stones River group at Dixon, Illinois. These specimens preserve not only portions of the outer layer of the shell with its beautiful markings, but here and there retain irridescent patches of the nacrous inner layer which, since it has been observed in so many different forms, probably pertained to all of the *Pleurotomariidæ*.

We are in doubt as to the occurrence of this species in the Black River shales of Minnesota. The small casts usually referred here by collectors belong chiefly to our *C. conica*. Some of the others may represent *C. subconica*, but we have not seen any of which we would like to say positively that it does. Nor have we seen a specimen in either the Clitambonites, Fusispira or Maclurea bed of the Trenton group. If it occurs at any of these horizons in Minnesota, it must be very rare. Casts of a species of *Clathrospira* occur in the Lorraine and Richmond groups of the Cincinnati region. They have always been regarded as belonging to *C. subconica*, but every testiferous specimen of *Clathrospira* that we have seen from that region has proved to belong to our *C. conica*. Though it must be admitted that the occurrence of *C. subconica* in the Cincinnati rocks requires verification, we are fully prepared to believe that many of the interior casts found there are really of that species, and until we know better they should be so regarded.

*Formation and locality.*—Stones River group, Minneapolis, St. Paul, Cannon Falls, and other localities in Minnesota; Beloit, Janesville, and other localities in Wisconsin; Dixon, Rockton, and Jo Daviess and Calhoun counties in Illinois; High Bridge, Kentucky; Lebanon and other points in Tennessee. Also in the Black River group at several of the foregoing localities. In Canada and New York it occurs in the Black River and Trenton groups, and probably also in the Hudson River group. In Ohio, Indiana and Kentucky, casts supposed to belong to this species occur at many localities in both the Lorraine and Richmond groups.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, No. 5037.

## Clathrospira convexa, *n. sp.*

PLATE LXIX, FIG. 51.

Casts of the interior, the only condition in which we have observed this rare species, agree very closely with *C. subconica* in all respects save in the contour of the upper side of the volutions. This, instead of being nearly flat (*i. e.* gently convex above and slightly concave below) in the space between the suture and the upper margin of the peripheral band, is rather strongly convex. The elevation of the band produces a narrow concavity immediately above it, but this does not greatly effect the general roundness of the whorls. They are more rounded than angular; in *C. subconica* the opposite is the case. The specimen figured on plate LXIX has all the appearances of being fully grown. If this is true, then *C. convexa* is a smaller shell than *C. subconica*. The same specimen preserves traces of the surface sculpture. This is of a coarser pattern than that of *C. subconica*, there being only four or five of the transverse lines in 2 mm. instead of seven to ten.

*Formation and locality.*—Stones River group, Calhoun county, Illinois.

*Collection.*—E. O. Ulrich.

## CLATHROSPIRA CONICA, *n. sp.*

PLATE LXX, FIGS. 1–4.

This species has been, we believe, often confused with young specimens of *C. subconica* Hall sp. Though greatly resembling that species, especially in the condition of casts, and perhaps derived from it, it is nevertheless a well-marked form and worthy of a distinct name. It is always smaller, the largest of over fifty specimens being only 25 mm. wide, while in at least four-fifths of the specimens found in the Black River and Trenton groups the width is less than 18 mm. The average width of the Cincinnati form is somewhat greater, being something like 23 or 24 mm. Aside from the matter of size, the species differ constantly from *C. subconica* in at least two particulars. First, the upper slope of the whorls is nowhere convex but is either gently concave throughout or flat from the linear suture to the rising base of the upper boundary of the peripheral band. The second difference lies in a more or less well-marked concave space which occupies the outer third of the base of the whorls. The inner border of this space is often very sharply defined on testiferous examples and readily traced on most casts of the interior. Among less obvious and perhaps less constant differences we may mention that the periphery is more angular, the whole base less convex, and the surface markings altogether less beautiful, less distinct and less regular. In *C. subconica* the lines of the surface sculpture are sharply raised and look like woven threads; in *C. conica* they are neither sharp nor thread-like and generally require a good glass to bring them out at all.

*Formation and locality.*—Not uncommon in the shales of the Black River group (Ctenodonta bed chiefly) at Minneapolis, St. Paul, Cannon Falls, Chatfield, and other localities in Minnesota. Also, but not so frequently, in the Clitambonites and Fusispira beds of the Trenton group at localities in Goodhue and Fillmore counties. In central Kentucky it occurs in the Trenton group; at Cincinnati, Ohio, in the Lorraine group.

*Collections.*—E. O. Ulrich; W. H. Scofield.

## Genus PLETHOSPIRA, n. gen. (Ulrich.)

In part *Pleurotomaria* and *Holopea*, the first of HALL, the second of WHITFIELD.

For generic diagonosis see page 958.

This genus is proposed for more or less turbinate *Holopea*-like shells, consisting of not more than five rapidly expanding ventricose whorls, with a broad, flat or concave, band situated near the middle of the whorls. There is no slit and the surface markings consist simply of lines of growth. None of the preceding genera are very closely related. *Lophospira* has angular whorls and a convex band, and represents quite a different line of development. *Eotomaria* may be nearer, yet is quite as easily distinguished. Both *Phanerotrema* Fischer, and *Bembexia* Œhlert, possess a long apertural slit besides peculiarities of their own. The true position of *Plethospira* appears to be in the immediate vicinity of *Hormotoma*, Salter, and *Seelya*, Ulrich. From the former it differs in having fewer and more rapidly enlarging volutions, and a shallower apertural notch, the forward curve of the lines of growth beneath the band, corresponding with the lower half of the outer lip, being much shorter than in Salter's genus. The lower extremity of the aperture also is much less produced and wider than is usual in that genus. *Seelya* includes very similar forms but they are easily distinguished by their different surface sculpture.

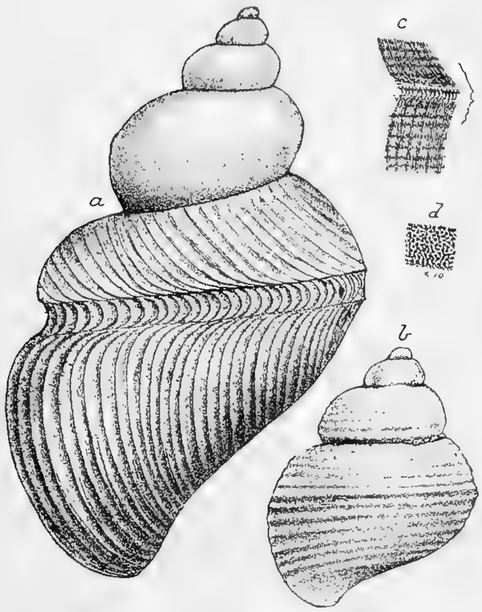


FIG. 7.—*a*, *Plethospira cassina* Whitfield sp , Calciferous formation, Fort Cassin, Vermont. Somewhat restored view of a good specimen belonging to the U. S. National Museum. The last whorl retains much of the shell, and shows the characters of the band and surface markings. *b*, *c*, *d*, *Seelya ventricosa* Ulrich, n. sp., Calciferous formation, Fort Cassin, Vermont. *b*, Cast of the interior of a rather small specimen, collected by Prof. H. M. Seely and presented to one of the authors. The ridge which forms the lower margin of the band is not prominent enough in the figure. *c*, Surface of the shell of a species of *Seelya* from Fort Cassin, x2, taken from an incomplete specimen belonging to the U. S. National Museum, showing the band and surface markings. *d*, small portion of the same, x10, showing the grano-punctate character of the outer surface. This specimen probably belongs to *Seelya difficilis* Whitfield sp. Another specimen of *S. ventricosa* in the National Museum is much larger than *b*, being 57 mm. high and 40 mm. wide. The last whorl descends very much as in *a*, and is marked by five ridges above and five below the band.

*Plethospira* probably will not prove to be a large genus, yet, as it represents an easily recognized type of shells that moreover continued through a long period of time, it deserves and probably will receive recognition from systematists. *P. cassina* Whitfield sp. is a fine species from the Calciferous rocks of the Lake Champlain region. A second species from that region was somewhat doubtfully identified by Whitfield with Billings' *Murchisonia arenaria.* For some unaccountable reason Whitfield places both of these Calciferous species under *Holopea.* A third species, evidently very closely related to the preceding, was called *Murchisonia hyale* by Billings, who gives it as from "the Chazy or perhaps the Black River limestone" of Canada East. The same author has described other Lower Silurian shells that may belong here, but, as we have not yet seen his original types, we prefer to postpone their removal from the genera to which he assigned them. Lindström's *Pleurotomaria valida*, an Upper Silurian species, has a very thick shell and rather too high a spire, but otherwise seems to agree very well with *Plethospira.* Regarding the following two species, perhaps they are not very good examples of *Plethospira*, still, it would be difficult to pick out any important differences; at any rate, we cannot suggest a more fitting disposal of them at present.

## PLETHOSPIRA SEMELE *Hall.*

PLATE LXX, FIGS. 8-10.

*Pleurotomaria semele* HALL, 1861, Geol. Rep. Wis., p. 36; WHITFIELD, 1895, Memoirs of the Amer. Mus. Nat. Hist., vol. i, pt. 2, p. 61, pl. VIII, figs. 8-10.

*Original description.*—"Shell subconical; spire ascending; hight and breadth nearly equal, consisting of four or five rounded or subangular volutions, the last one ventricose, subangular on the periphery, regularly rounded below into the small umbilicus. Aperture round. Surface marked by a subangular carina a little below the suture, and on the periphery by a moderately broad revolving band, sharply elevated at the margins and concave in the middle. Entire surface marked by sharp, elevated, closely arranged, concentric striæ, which are curved abruptly backwards from the suture to the revolving band, on which they make a shallow retral curve, and below the band have a gentle forward curvature in passing downward to the umbilicus. Hight a little more than one inch; width three-fourths of an inch."

We have two specimens of this species besides an interior cast that may belong to some other species. One of these (the specimen represented by figures 8 and 9 on plate LXX) retains considerable of the shell with its markings, and permits us to add several particulars to the above description. First, there is a slight angle or ridge, about midway between the peripheral band and the margin of the umbilicus, that shows only on the last whorl, being just covered in the preceding whorls. The space above it is flat or a trifle concave. Next, the umbilical perforation is very small and partly covered by the reflexed columellar lip. Finally, the lines of growth are quite regular, with between two and three in the space of one millimeter. The apical angle is about 65°.

We cannot understand how Prof. Whitfield's figure 10 (*loc. cit.*) can possibly be a true portrayal of the surface markings of the original type of the species. Certain it is that it does not give them as they are in the specimens which we have identified with *P. semele*. Nor does it agree with Hall's description, while our specimens do. Hall says that the lines of growth below the band "have a gentle forward curvature in passing downward to the umbilicus." In Whitfield's figure, however, they are represented as curving very *strongly* forward. The latter shows also an angular bend in the striæ at the upper carina which is not mentioned by Hall, and which is, to say the least, a very rare condition among shells of this family. Now, either Whitfield's illustration is wrong or Hall's description, and as our specimens agree with the latter, we are obliged to believe that the fault lies with the figure. The course, as well as the character of the striæ is, we believe, accurately represented in our figures 8 and 9.

Whitfield's remark that "there is no doubt that this shell is a true *Murchisonia*, unless it prove to be a *Lophospira*," strikes us as a very peculiar statement. He proposed *Lophospira* and should therefore know when he has a species of his own genus before him and when one of *Murchisonia*. However that may be, *P. semele* most certainly belongs to neither of those genera. As we have said on a previous page, the occurrence of a true *Murchisonia* in American strata is yet to be established. As to *Lophospira*, it has a convex band, and includes only shells having strongly angular whorls, while *P. semele* has rather rounded whorls and is a species of the concave-banded types.

Concerning the original of our figure 10, we wish to say that if it really is an interior cast of a shell of this species, and a small patch of shell on the under surface, as well as a flattening of the peripheral band near the mouth indicates that it is, then casts are sometimes dangerously like casts of *Lophospira bicincta.*

*Formation and locality.*—Utica group (Maquoketa shales), Maquoketa creek and Graf, Iowa.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7334.

## Plethospira striata, *n. sp.* (*Ulrich.*)

PLATE LXX, FIG. 7.

Shell turbinate, apical angle at least 85°, hight nearly 22 mm., width about 19 mm.; volutions at least four, probably five, convex below, nearly vertical in the middle third, concave above the band, horizontal between the upper carina and the suture; band supra-median on the last, infra-median on the whorls of the spire, decidedly concave, with thick and prominent margins; lines of growth rather regular, strong and heavy, rounded, wave-like, five or six on the last whorl in 4 mm.; on the upper side they curve strongly backward, beneath the band they are almost vertical saving a very short retral curve above; lunulæ obscure; aperture rounded-pentagonal, outer lip with a broad but very shallow notch, columellar lip straight, obtusely angular below, reflexed, completely covering the minute umbilicus.

This well-marked species cannot be confounded with any other shell known to us. The surface markings are highly characteristic.

*Formation and locality.*—Richmond group, Hanover, Butler county, Ohio.

*Collection.*—E. O. Ulrich.

## Genus SEELYA, n. gen. (Ulrich.)*

*Pleurotomaria*, in part, of Meek and Worthen, and Whitfield.

For generic diagnosis see page 958. For figures of typical species see page 1009.

The species which we propose to arrange under this generic title agree closely with *Plethospira* in all respects excepting that they have a narrower band and a spirally furrowed surface sculpture. As the group is easily recognized, a natural one, and ranges from the Calciferous to the top of the Niagara, we think that it should be distinguished by a name of its own. Whether the group is to be viewed as a genus or as a subgenus is of little consequence now. Our knowledge of Paleozoic Gastropoda is yet far from that point when we may decide such questions with anything like confidence in the stability of the result.

In the Calciferous of the Champlain valley we have two species of this genus, the type, *S. ventricosa* Ulrich, and *Pleurotomaria difficilis* Whitfield. These possibly are not distinct, but if Whitfield's figures of his species are correct, and we have no reason to doubt it, then it is clearly another form, having a lower spire, more numerous revolving furrows, and a shoulder-like angulation near the suture that is wanting in *S. ventricosa*. An imperfect specimen in the U. S. National Museum, which seems to belong to Whitfield's species, differs further in having a larger umbilical perforation.

Judging solely by the illustration given by Billings in Paleozoic Fossils, vol. i, p. 187, fig. 171, of his *Murchisonia cassandra*, we would say that the species was

* The genus is named in honor of Prof. H. M. Seely, of Middlebury College, who, because of his valuable work on the Calciferous-Chazy fauna and rocks of the Champlain valley, in connection with Prof. Brainerd, has fully earned the compliment. One of the authors is also indebted personally to Prof. Seely for numerous specimens, among them the type of the present genus, from Fort Cassin and other localities in the Champlain valley. These have been of much assistance in our work. Some paleontologists probably will contend that the name should have been written *Seelyia*, but the shorter form *Seelya* seemed so preferable that we concluded to risk their criticism.

founded on an interior cast of a rather slender shell of this genus. It is from the Point Lévis limestone of the Quebec group. We know of no species in the Trenton, and the Cincinnati species about to be described is a very modest representative. There are at least two Upper Silurian species. One of these occurs in the Niagara limestone at Chicago, and was described by Meek and Worthen as *Pleurotomaria cyclonemoides.* The other is the well known *Pleurotomaria lloydii* of Sowerby, occurring in England and Gotland. Several good varieties or closely related species are included in the European species, and one, as figured by Lindström, greatly resembles our *S. ventricosa.*

### SEELYA MUNDULA, *n. sp.* (*Ulrich.*)

PLATE LXX, FIGS. 11-12.

Hight and width nearly equal, 10 to 13 mm.; apical angle 70° to 75°; volutions four, subangular; band prominent, narrow, concave; upper side of whorls with a strong angulation or carina midway between the band and the suture, and sometimes with a small ridge close to the suture, the intermediate spaces more or less concave; lower side convex except immediately beneath the salient band, with two or three (perhaps more) small revolving ridges; umbilical perforation very minute; aperture rounded, lines of growth obscure.

Remembering that the band is concave, we know of no shell in the Trenton and Cincinnati or Hudson River periods that might be confounded with this species.

*Formation and locality.*—Lower part of Lorraine group, Cincinnati, Ohio, and Newport, Kentucky. Good specimens appear to be very rare.

*Collection.*—E. O. Ulrich.

## Genus HORMOTOMA, Salter.

*Murchisonia* (part.) of authors.

*Hormotoma*, SALTER (as subgenus of *Murchisonia*, D'Arch. and Vern.), 1859, Can. Org. Remains, Decade 1, p. 18; ŒHLERT, 1887, Extr. Bull. Soc, d'Etud. Sci. d'Angers, p. 18.

*Goniostropha* (part.), ŒHLERT, *op. cit.*, p. 13.

For generic characters see page 959.

This division of the *Pleurotomariidæ* seems to us as in every way fully deserving the rank of a distinct genus. In the first place, the species of *Hormotoma* have no discoverable relation to the original types of *Murchisonia*, the genus with which they have been heretofore almost universally associated. Next, the generic type maintained its peculiarities through a long period of time, beginning no later than the Calciferous and extending upward through the intervening beds to the top of the Upper Silurian. Beyond this horizon we meet with slightly modified but undeniable descendants in the lower and middle divisions of the Devonian system. The latter, because they have developed a short apertural slit, should perhaps be separated, in which case the somewhat inappropriate term *Goniostropha* might be utilized.* The third qualification lies in the comparatively obvious fact that the rather numerous species comprised in the genus constitute an evolutional series. That this is so can scarcely escape anyone who will take the trouble to compare critically the various forms which we refer here. A fourth and very important quality of the genus is its convenience in classification. The use of the term *Hormotoma* tells us at once that we are dealing with practically imperforate shells forming a high spire composed of numerous rounded or subangular whorls having simple surface sculpture and a subcentral flat or concave band terminating in a deep >shaped notch. These features furthermore are all readily apparent on all reasonably well preserved specimens.

The most natural position and true relations of *Hormotoma* appear to be with *Plethospira,* Ulrich, on the one side, and *Turritospira,* Ulrich, on the other. From the former it is distinguished by its higher spire, more numerous and slowly enlarging volutions and deeper apertural notch; from the latter chiefly by the central position of the band which, in that genus, lies considerably beneath the middle of the whorls. *Turritospira* may not be as closely related as the great similarity of its shells leads one to suppose. Considering the position and relative prominence of the band and the external contour of the whorls in that genus, we see much to remind us of those low-spired and equally ancient genera *Euconia* and *Eotomaria.* Accordingly we are prepared to see it proved that *Turritospira* is nothing more nor less than a high-spired type of one or the other of those genera.

In some of its forms *Lophospira* slightly resembles *Hormotoma,* but the more angular whorls and, especially, the convexity of the band in that genus renders confusion in this direction highly improbable. And yet, there is a possibility that some kind of relation exists between the two genera. Evidence of such a condition is furnished by two species, one, a Calciferous form described by Billings as *Murchisonia artemesia,* the other, an Upper Silurian shell described by Lindström as *M. attenuata* Hisinger sp., which have all the characters of *Hormotoma* except the band which is convex as in *Lophospira.* We are in doubt as to what should be done with these geologically widely separated two species, but would advise that they be referred provisionally to *Hormotoma* and leave it to the future to determine whether

* *Goniostropha* might be retained as a subgenus under *Hormotoma,* Salter, or possibly as a distinct generic designation for the Devonian group of species which we would otherwise refer to *Hormotoma* as the *Desiderata* section; providing that the slit-band in Œhlert's type, *M.* (*Goniostropha*) *bachelieri* Ronault sp., terminates in a short slit. That such a slit is present in the *bachelieri* we believe highly probable, and our investigations so far lead us to expect its presence in the majority, if not in all, of the Devonian shells agreeing otherwise strictly with *Hormotoma.* Still, in the absence of positive knowledge on the point, we do not consider ourselves justified in accepting *Goniostropha* for the group of shells in question. However the investigation of the species *bachelieri* may turn out, we are convinced that less than half of the twenty species referred to his subgenus by Œhlert really belong there. With some of the species we are not sufficiently acquainted to pass judgment upon them. Of the others we would say that *M. cingulata* Hisinger, and *M. moniliformis* and *M. obtusangula* of Lindström, are not at present distinguishable from *Hormotoma;* that *M. cochleata* Lindström, *M. extenuata* Conrad, *M. angulata* d'Arch. and Vern., and *M.* (*G.*) *chalmasi* Œhlert, belong to various sections of *Lophospira;* and that *M. micula* Hall, and *M. larcomi* McCoy, belong to an easily recognized and long-lived type which we propose to name *Solenospira.*

they have or have not been derived from elongated species of *Lophospira* like *L. bowdeni* Safford.

Besides the five Trenton and Cincinnati species about to be described, we refer here *Murchisonia anna*, *M. simulatrix* and *M. vesta*, three species described by Billings as occurring in the Calciferous in Canada; *M. gracilens* Whitfield from the same horizon in Vermont; *M. procris* Billings, from the Black River group of Canada; *M. moniliformis*, *M. obtusangula* and *M. subplicata*, Gothland species described by Lindström; and *M. hebe* Billings, Gaspé of Canada. *M. cingulata* Hisinger (as figured by Lindström) and *M. egregia* Billings, have the band too low to be counted as typical members of the genus, yet, it is probably best to place them here. We have already mentioned *M. attenuata* Hisinger, and *M. artemesia* Billings. *M. agilis* Billings, Quebec group, Canada, as is the case with other species described as *Murchisonia*, may belong here but is not sufficiently known to permit us to say that it does. *M. teretiformis*, of the same author, provided the Manitoba specimens identified by Whiteaves with this species are really the same as Billings' original types, has all the characters of *Hormotoma*, despite the great size which this shell attains.* Œhlert describes two species from the Devonian of France as *M.* (*Hormotoma*) *lebescontei* and *M.* (*H.*) *clavicula*. The same author proposes *Goniostropha* as a section of *Murchisonia* and includes in it several of the species that we refer to *Hormotoma*. If *Goniostropha* is to be recognized it must be for the reason given on page 1012. If these are not sufficient then the American species *M. desiderata*, *M. maia* and *M. leda* of Hall, together with some of the European shells which Œhlert places in his proposed section, must be regarded as congeneric with the Silurian species of *Hormotoma*. As defined by Œhlert, *Goniostropha* is clearly an incongruous assemblage.

### HORMOTOMA GRACILIS *Hall, and varieties.*

PLATE LXX, FIGS. 18–36 and ?42–43.

*Murchisonia gracilis* HALL, 1847, Pal. New York, vol. i, p. 181 (not SALTER, 1859, Can. Org. Rem., Dec 1, p. 22.)
*Murchisonia angustata* HALL, 1847, Pal. New York, vol. i, p. 41.*
Comp. *Murchisonia gracilens* WHITFIELD, 1889, Bull. Amer. Mus. Nat. Hist., vol. ii, p. 53, pl. VIII, fig. 14.

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* We are strongly inclined to doubt that the Manitoba specimens, which are from the Trenton limestone (Fusispira or Maclurea bed), are specifically the same as the Hudson River group, Anticosti, originals of *M. teretiformis*. The apical angle in the former is 35° or more, while Billings gives the angle for the Anticosti types at 27°. Since the foregoing was placed in the printer's hands, Mr. J. F. Whiteaves has kindly sent us the two best specimens of these Manitoba and Anticosti forms in the museum of the Canadian survey. As a result of our comparison, we are now firmly convinced that the two forms are specifically distinct, differing from each other in the same manner as *H. bellicincta* and *H. trentonensis*. The Manitoba species resembles the former, having more whorls, especially in the upper half of the spire, than the true *H. teretiformis*.

† As will be noticed, the description of *M. angustata* occurs on an earlier page in the work cited than that of *M. gracilis*, and if we followed the usual custom in such cases the first name would have been adopted for the species instead of the second. But as the date and authority for the two names is the same, and as the name *angustata* has been scarcely recog. nized while *M. gracilis* has been described and quoted perhaps hundreds of times since 1847, it is evident that the latter has the better right to be retained for the species.

## *Typical form.*

PLATE LXX, FIGS. 18-21; ?22.

Hight 20 to 33 mm., apical angle very constantly about 18°. Shell small, slender; volutions about fourteen in a length of 30 mm.; rounded, generally with a slight angulation, on which lies the band, a little beneath the middle; band seldom preserved, when perfect, rather narrow, smooth, flat or faintly concave and margined on each side by a delicate raised line; suture simple, deep; lines of growth fine, bending strongly backward from the suture to the band, and beneath this curving very strongly forward again, the whole indicating a deeply notched mouth; aperture a little higher than wide, rounded except below where it is somewhat produced; inner lip reflected, forming a slightly twisted and thickened columella.

The original of fig. 22, which was found with many specimens like figs. 20 and 21, in the Richmond group near Spring Valley, has the whorls too angular. Perhaps it would be better to place it with the var. *goodhuensis.*

### Variety ANGUSTATA *Hall.*

PLATE LXX, FIGS. 30-36.

Has more uniformly rounded whorls and slightly wider band than the typical form. So far as observed, this variety never reaches a length of 25 mm., the majority of specimens varying between 17 and 20 mm.

### Variety SUBLAXA, *n. var.*

PLATE LXX, FIGS. 23-25.

This form is distinguished by its rather loosely coiled volutions, deep oblique suture, and wide band.

### Variety MULTIVOLVIS, *n zar.*

PLATE LXX, FIGS. 26-29.

Distinguished from the foregoing varieties by its closely wound, vertically depressed volutions.

### ? Variety GOODHUENSIS, *n. var.*

PLATE LXX, FIGS. 42–43.

In this form the whorls are unusually high and angular, almost rivalling, in the latter feature, the next species, with which, moreover, it was found. But the apical angle is only about 18 degrees, and this agrees with *H. gracilis*, while it is too narrow for *H. subangulata.* We have only two specimens and therefore do not like to say anything positive about the form. A larger supply of specimens may show it to be more distinct than it now appears. At any rate, it seems worthy of recognition as a variety. On plate LXX, fig. 22 gives a view of a similar specimen which occurred with *H. gracilis* and the var. *multivolvis* in the Richmond group at Spring Valley. Possibly this represents a later appearance of var. *goodhuensis.*

One or the other variety of *H. gracilis* occurs in greater or lesser abundance at most localities in the the eastern half of the United States and Canada exposing the rocks of the Trenton and Hudson River periods. Really satisfactory specimens, however, are rare, especially such as preserve the shell and surface markings. The var. *angustata* is scarcely distinguishable in the condition of casts of the interior, in which it is usually found, from the typical form of the species, but it is probably safe to say that all the specimens of the species found in the Stones River group belong to this variety, since none of the other varieties have so far been identified in rocks beneath the Black River group. The variety *angustata* seems to occur as far down as the Calciferous sandstone, since we can see no difference whatever between the Stones River form and *Murchisonia gracilens* of Whitfield. The other varieties are sometimes associated with the typical form of the species, but they are readily enough distinguished, either as casts or shells, by the peculiarities above mentioned.

*Formation and locality.*—Var. *angustata* occurs rather rarely in the Vanuxemia bed of the Stones River group at Cannon Falls, Minnesota, and in equivalent strata in Wisconsin, Illinois, Kentucky, Tennessee, New Yo k and Canada; also in the shales of the Black River group at Minneapolis and near Cannon Falls, and in the Utica group at Cincinnati, Ohio. The typical form is found from the Black River group on up to the top of the Richmond group at many localities. Good specimens occur in the Maquoketa or Utica shales at Graf, Iowa. Var. *sublaxa* is so far known only from the Trenton group at Auburn, Missouri, var. *multivolvis* in the Richmond group near Spring Valley, Minnesota, and var. *goodhuensis* in the Phylloporina bed of the Black River group in Goodhue county, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, No. 7337.

## HORMOTOMA SUBANGULATA, *n. sp.*

PLATE LXX, FIGS. 37—41.

Length 20 to 30 mm., apical angle about 25°, band flat, median in position on the angular whorls.

The apical angle is wider and the volutions much more angular than in any of the varieties of *H. gracilis*. The upper slope of the whorls is generally flat or very slightly convex, but occasionally it may be a trifle concave. In none of nine specimens is the apical angle less than 24°, and in one it is 26°. The two specimens represented on the same plate by figures 42 and 43 resemble this species in the angularity of their whorls, but as the apical angle is only about 18° in these specimens it is perhaps advisable to refer them provisionally to *H. gracilis*. (See preceding page.)

*Formation and locality.*—Ctenodonta bed of the Black River group, Chatfield and near Cannon Falls, Minnesota. At the latter locality a cast of the interior apparently of this species was found in the Clitambonites bed of the Trenton group.

*Collection.*—E. O. Ulrich.

## HORMOTOMA SALTERI, *n. sp.* (*Ulrich.*)

PLATE LXX, FIGS. 44—51.

*Murchisonia* (*Hormotoma*) *gracilis* SALTER, 1859, Can. Org. Rem., Dec. 1, p. 22. (Not HALL'S species.)

Hight 25 to 40 mm.; apical angle 20° to 24° in typical form (figs. 44-48), about 25° in var. *canadensis* and 20° in var. *tennesseensis* (figs. 49-51); volutions nine or ten, rounded, more or less distinctly thickened above at the suture and flat or concave just beneath; band rather wide, flat or slightly concave, median in the var. *canadensis*, a trifle beneath the center in the typical form and a little above the center in the var. *tennesseensis;* lines of growth unequal, rather fine, never sharp.

This is a larger shell and has a wider apical angle than *H. gracilis*. In the typical form the thickening of the upper edge of the whorls is usually a well-marked feature, but it is less constant in both of the Black River group varieties, and often wanting or quite inconspicuous in the Canadian form. Evidently, the peculiarity increased with the evolution of the species.

Another variety may be distinguished as var. *nitida*. This occurs rarely near the top of the Trenton group in association with the typical form, from which, however, it is readily separated by its larger size, relatively plump form and much wider apical angle. The latter is about 30°, while the hight of a large specimen was nearly 50 mm. The concavity beneath the suture is not very distinct on the lower two or three whorls, but in all other respects their markings are precisely as in the typical form of the species.

*Formation and locality*—Var. *canadensis* occurs abundantly in the Black River rocks at Pauquettes rapids on the Ottawa river, and, more rarely, together with the var. *tennesseensis*, in equivalent or somewhat younger strata between Nashville and Lebanon, Tennessee. The typical form was found in abundance, var. *nitida* rarely, in the upper part of the Trenton group between Burgin and Danville, Kentucky.

*Collection.*—E. O. Ulrich.

## Hormotoma bellicincta *Hall*.

PLATE LXX, FIGS. 15–17.

*Murchisonia bellicincta* Hall, 1847, Pal. New York, vol. i, p. 179, pl. xxxix, figs. 1*a* and 1*b*, ? 1c and 1*d*, not 1*e*.

Hight 20 to 45 mm., apical angle 42° to 50°, generally about 44°; volutions neatly rounded, sometimes appearing a little flattened in the upper half, rather closely wound, depressed so that the hight and width is respectively as one is to two, about six or seven in number, casts, however, rarely preserving more than four; band wide, flat, clearly defined on shells, just above or exactly in the middle of the whorls of the spire; lines of growth strongly recurved to the band, regular, comparatively strong and distant, rarely visible on casts of the interior; a small, sometimes sharply defined umbilicus; aperture rounded, except at the lower angle, which is somewhat extended.

At least two species were united under the name *Murchisonia bellicincta* by Hall and most subsequent authors who have had occasion to write about the species, while collectors have used the name in a very loose and shifty manner. That Hall's original figures (*loc. cit.*) embrace at least two species must be evident to all who will take the trouble to compare his 1*a* and 1*e*. How could the former, representing a small testiferous specimen, possibly be the apical portion of an example of the same species as the original of the latter, which is said to be an incomplete "cast of a large specimen"? In the first place, the apical angle of 1*a* is about 50°, while that of 1*e* is only about 32°. So great a difference, especially in a genus of shells in which the apical angle is unusually constant, almost certainly indicates specific variation. When we add that in corresponding parts of the two figures the one has four whorls where the other has but three, we may well wonder how the fact has so long escaped observation. Both forms occur in Minnesota, and our only difficulty has been to decide as to which is the better entitled to retain the name *bellicincta*.

So far as known, neither occurs in any disvision of the Cincinnati period, and both appear to be confined strictly to the Trenton proper. The larger form, however, seems to be the more common of the two and therefore probably the form that has been the more frequently referred to by authors. On the other hand, the smaller species precedes the larger on the plate, and, as the specimens figured of it are in a better state of preservation than the other, it is reasonable to assume that they furnished the greater part of the characters brought out in Hall's description. We have therefore concluded to restrict the application of the name *bellicincta* to forms of the type of Hall's figs. 1*a* and 1*b*, and propose a new designation for the species represented by his fig. 1*e*.

*Formation and locality.*—Not uncommon in the Trenton limestone in New York and Canada. In Minnesota we have collected a total of eleven specimens, all from the lower part of the Fusispira bed at various points in Goodhue county.

*Collections.*—E. O. Ulrich; W. H. Scofield.

## Hormotoma trentonensis, *n. sp.*

PLATE LXX, FIGS. 13 and 14.

*Murchisonia bellicincta* (part.) Hall, 1847, Pal. N. Y., vol. 1, pl. xxxix, fig. 1*e* (not 1*a*-1*d*); Owen, 1852, Geol. Rep. Wis., Iowa and Minn., pl. ii, fig. 8.
*Murchisonia major* Whitfield, 1882, Geol. Wis., vol. iv, p. 244, pl. ix, fig. 4 (not *M. major* Hall).

Hight 30 to 100 mm., apical angle 32° to 37°, generally about 35°; volutions seven or eight, almost uniformly convex from suture to suture, not very closely wound, with the hight and width respectively as 2 is to 3 or 3 to 5; band median, wide, flat, the lunulæ very moderately curved; lines of growth regular, fine, somewhat thread-like, averaging about eight in 5 mm., with the usual backward curve; notch deep and wide; mouth greatly produced and turned backward below; inner lip thin, reflected, above partly covering a small umbilical perforation.

This beautiful shell has been for many years confused with *H. bellicincta* Hall sp. On the preceding page we give our reasons for restricting *Murchisonia bellicincta* to the smaller of the two species figured by

Hall under that name. The course adopted having necessitated a new name for the larger form, we propose to call it *trentonensis*, since the species is one of the most characteristic fossils of the Trenton group. The respective peculiarities of the two species are perhaps sufficiently brought out by our carefully drawn illustrations on plate LXX. The principal differences are that the apical angle is considerably wider and the whorls relatively much more depressed in *H. bellicincta* than in *H. trentonensis*. These differences, considering that they are repeated with an unusual degree of constancy in specimen after specimen, and maintained from Vermont and Canada to Minnesota, surely deserve specific recognition. We have not seen the aperture of *H. bellicincta* entire, but in our judgment it is not so much produced below as in *H. trentonensis*.

Several large species occur in the Trenton that are often extremely difficult to distinguish when, as almost invariably happens, nothing but casts of the interior are available; and when these are not good the task is in many cases hopeless. However, when some of the outer surface of the shell is preserved the difficulties vanish generally at once. Thus we have a form which we have identified with Hall's *Murchisonia major*. The shell of this species is readily distinguished by the character of its suture, the upper part of the whorls, instead of sinking in gradually as in *H. trentonensis*, being flattened and prolonged upward at the edge over the preceding whorl so as to form a kind of "enamelled" suture. In Manitoba there is another species (Whiteaves has identified it with *M. teretiformis* Billings) that, excepting that it grew to a much greater size (we have before us a specimen fully 8 inches in length), can scarcely be distinguished without the shell and surface markings. These show that the broad band lies lower on the whorls (its upper margin lies a trifle beneath the center), while the lines of growth are coarser and, especially those coming from below, more decidedly inclined backward in their course to the band. *Lophospira augustina* Billings sp. is another fossil that is likely to be confounded with these species of *Hormotoma* by careless collectors, but the obtuse angulation of the whorls cannot escape the practised eye.

*Formation and locality.*—While testiferous specimens of *H. trentonensis* are everywhere extremely rare, casts are common enough in the Trenton limestone of Canada and New York. Specimens of any sort are rare in Kentucky and Tennessee. In Minnesota the species occurs rather frequently in the Fusispira bed and occasionally in the Maclurea bed. When the strata are shaly the specimens are beneath the average in size.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, No. 305.

## HORMOTOMA (?) MAJOR *Hall.*

PLATE LXXI, FIGS. 5-7.

*Murchisonia major* HALL, 1851, Geol. Lake Superior Land District, vol. ii, p. 209.

Not *M. major* WHITFIELD, 1882, Geol. Wis., vol. iv, p. 244, pl. IX, fig. 4. (=*Hormotoma trentonensis* of this work.)

Shell large, 80 to 150 mm. in hight, rather slender, composed of about nine whorls; apical angle of first four or five turns, which are usually broken or dissolved away, about 37°, of the following four or five only 25° to 27°. In a specimen having a maximum width of 65 mm., the last three whorls reach a hight of fully 110 mm., while the hight of the aperture, measuring from its lower extremity to the anterior end of the suture line, does not exceed 44 mm. In casts of the interior there is a rather large umbilical perforation, the whorls are distinctly separated by an intervening space, the upper edge of the whorls more or less sharply angular, and their sides strongly convex in the lower and almost flat in the upper half. In the shell itself the umbilicus is very small, the suture shallow and indistinct, the whorls of the spire but slightly convex in the lower and middle thirds and gently concave in the upper, the thin upper edge of each being turned upward so as to lap over a part of the convex base of the preceding whorl. Aperture angular above, only very moderately produced below, on the whole somewhat rhomboidal in outline. Notch deep and wide, the deepest part lying about midway between the extremities of the outer lip or a little beneath the center. Neither the surface markings nor the band have been observed, but the latter, judging from the apertural notch, must lie but a short distance above the suture line.

Concerning the identity of the species just described and Hall's *Murchisonia major*, we can only say that after as careful an investigation as was possible without having an opportunity of studying the original types, we are fairly well satisfied that our shells are really the same as the one figured by Hall. Very likely his original lot of specimens included other forms of these large shells, but if the present species is, as we believe, among them, then it would be well to retain the name *major* for it and throw out the others. This course is to be commended if only for the reason that it will greatly simplify matters in the way of synonomy.

It is often asserted that *H. major* is but a large form of *H. bellicincta*, while Whiteaves would make it the same as Billings' *M. teretiformis*. However, and providing that we have correctly identified these species, the totally different suture of *H. major* shows conclusively that it is not even closely related to either of the two other species mentioned.

The unusual character of the sutural region, which is well shown in our fig. 7, is of itself sufficient to distinguish this shell from all associated gastropods. Casts are separated from those of *H. trentonensis* by their narrower apical angle (taking the whole shell into consideration), by the less uniform convexity of the whorls, and the rectangular instead of rounded junction of the upper and outer sides of the whorls. The last difference is very striking when transverse sections of the whorls are compared. The lower extremity of the mouth also is much less produced and therefore blunter. Casts of *Lophospira augustina* Billings sp., are sometimes found in the same layers with *H. major*, but the wider apical angle and obtusely angulated whorls of the former renders confusion in this case highly improbable. If perfect shells of these various species could be compared, we are convinced that the merest tyro in the science would separate them at once.

*Formation and locality.*—Though widely distributed, this species appears not to be abundant at any locality. It is restricted to the Trenton group, and in Minnesota occurs in both the Fusispira and Maclurea beds at Lime City, Stewartsville, Mantorville, Hader, and other localities. The original types were obtained in Wisconsin, and the species is said to occur at many points in that state. Good casts have been found in Pike county, Missouri.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, Nos. 7345, 7485, 7842.

## Genus CŒLOCAULUS, Œhlert.

*Murchisonia* (part.) of LINDSTRÖM, BILLINGS, and other authors.
*Cœlocaulus* ŒHLERT (as subgenus of *Murchisonia*), 1888, Extr. Bull. Soc. d'Etud. Scientif. d'Angers, p. 20.

For generic characters see page 959. The date of this genus should be 1888 instead of 1887.

This type of shells is not as closely related to *Hormotoma* as may appear on a hasty comparison. To the practised eye there is something peculiar about their general aspect that at once causes them to be set aside as a group by themselves. With few exceptions they are all very slender many-whorled shells, with a continuous narrow umbilical perforation, the inner lip straight and the lower angle of the aperture comparatively very little produced. The whorls are depressed, in two instances our (*C. neglectus* and *C. barroisi* Œhlert) probably not more than twelve in number, generally exceeding fifteen, and in some cases as many as thirty. The band in all observed cases is wide and flat and lies beneath the middle of the whorls of the spire. In at least some of the species a considerable number of the apical whorls are filled with an organic deposit.

Species whose known characters are in accord with this diagnosis of *Cœlocaulus* occur in most of the principal formations from the Calciferous on to well up into the Devonian system. Of these *Murchisonia linearis* Billings, is the oldest. Then followed our *C. œhlerti* and *C. neglectus*, both Trenton forms, *M. compressa* Lindström, from Upper Silurian strata in Gothland, *M. bivittata, M. longispira, M. logani* and *M. turritiformis*, four Guelph species described by Hall, and *C. davidsoni, C. barroisi* and *C. procerus*, three species described from the Devonian of France by Œhlert. And there are others which probably belong here, but they are as yet too little known to justify their removal to *Cœlocaulus.* However, without them, the ten species mentioned make a sufficiently respectable showing to establish the genus in the classification of the Paleozoic Gastropoda.

## Cœlocaulus œhlerti, *n. sp.*

PLATE LXX, FIGS. 61—63.

This species is known only from fragmentary casts of the interior, but as it is an interesting and striking form we deem it well worth a description. The apical angle is about 12°, and, if the taper of the spire is uniform an entire specimen must consist of at least thirty whorls, and have a length of about 60 mm. The largest specimen, having a maximum diameter of 12 mm., has eight whorls in a length of 30 mm.; another, 9 mm. in diameter, has twelve whorls in the same distance. The hight of the whorls is to their width as 2 is to 5 or 3 to 8. The whorls are very little separated and decidedly convex in casts but in the shell itself, which evidently was very thin except at the sutures, the convexity must be considerably less. Transverse section of whorls rounded quadranglar. Band and surface markings not observed, probably obscure, since no trace of them is visible on a mould of the exterior.

We know of no other shell in the Lower Silurian deposits of the Mississippi valley that could for a moment be confounded with *C. œhlerti.* The next species is smaller and has a much wider apical angle, with fewer whorls.

*Formation and locality.*—A rare fossil of the Trenton group (Galena limestone), and so far known only from Jo Daviess county, Illinois.

*Collection.*—E. O. Ulrich.

## Cœlocaulus neglectus, *n. sp.*

PLATE LXXXII, FIGS. 29—31.

Hight about 18 mm., apical angle about 25°. The only specimen seen is a slightly distorted cast of the interior, consisting of only four whorls, the uppermost of which has an obtusely rounded termination, indicating that the apical whorls were filled with an organic deposit. These four whorls have a hight of about 12 mm., the last a diameter of 7 mm., the first of about 3 mm. The whorls are rounded in transverse section, the sutures deep, the umbilical perforation small, yet very obvious.

This small species might be confused with *Hormotoma subangulata* or with certain varieties of *H. gracilis*, but if the observer will bear in mind that the umbilicus is very small and quite inconspicuous in casts even of those shells, that their whorls are not so much depressed nor subcircular in section, and that the upper turns are never lacking except through accident, he should not have much trouble in disting uishing the *Cœlocaulus.*

*Formation and locality.*—Clitambonites bed of the Trenton group, near Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich.

## Genus SOLENOSPIRA, n. gen.

*Eunema* (part.) of SALTER and BILLINGS.
*Murchisonia* (part.) of WHITFIELD and other authors.

For generic characters see page 959.

This is a long-lived group of species that can always be recognized by the broad saliently margined concave band which occupies the greater part of the middle third of the whorls. In their general appearance they remind one of *Turritellidæ* rather than pleurotomaroids, and so far as we can see there is no serious objection to considering them as the ancestors of that graceful family of shells.

So far as known the notch or sinus in the outer lip was never prolonged into a slit. This of itself is a suspicious circumstance when we consider the usual progress of development pertaining to nearly all of the various types of the *Pleurotomariidæ.* The proportionally great width of the band, together with the fact that its transverse markings are of the same character as the fine recurved lines of growth—indeed they are mere connecting continuations of them—strengthens this suspicion almost to conviction that *Solenospira* represents the root of a line of development that later on (in Carboniferous and subsequent times) diverged widely from ordinary pleurotomarians. And what family is a more likely continuation of the line than the *Turritellidæ*?

We place the genus with the *Pleurotomariidæ,* in the immediate vicinity of *Hormotoma,* chiefly because we know of no other stock from which it might have been derived. The depth of the apertural sinus and the fact that its deepest part is marked off in such a manner that with continued growth of the shell it formed a sharply margined spiral band, are both highly characteristic conditions of the *Pleurotomariidæ,* while the features mentioned in the preceding paragraph are such only as might very well have occurred in the separation of a line culminating in *Turritella.*

The oldest of the species which we place here is the *Eunema prisca* Billings of the Calciferous formation of Canada. An apparently undistinguishable form, occurring in the Stones River group in Minnesota, Wisconsin, Illinois and Tennessee, is described and figured in this work. The Quebec group furnishes two other species, *Murchisonia adelina* and *M. missisquoi* of Billings. The latter of these two species possibly may, when better known, prove to have other affinities. In the Black River group we have the type of the genus, *Eunema ? pagoda* Salter. We know of no other good representatives of the genus, in American deposits, at any rate, until we reach the Hamilton group, from which Hall has described one as *Murchisonia turricula,* or as it is now known, *M. micula,* the specific name having been changed because the first had been used previously under *Murchisonia.* The next American species occur in the St. Louis group of the Subcarboniferous system, from which Hall has described three species, *M. attenuata*, *M. turritella* and *M. vermicula*, every known character of which allies them with *Solenospira*. Of European species probably belonging here, we may mention the Devonian *M. tricincta* d'Arch. and Vern., and the Carboniferous *M. quadricarinata* McCoy, *M. larcomi* McCoy, *M. gracilis* Goldf., and *M. nana* and *M. tenuis* of DeKoninck. There are some new species also, and no doubt others have been described, but it is difficult to decide from illustrations alone whether they belong here or not. Some of the latter having more than four revolving carinæ may belong to *Aclisina.*

## SOLENOSPIRA PRISCA *Billings.*

PLATE LXX. FIGS. 52–55.

*Eunema prisca* BILLINGS, 1859, Can. Nat. and Geol., vol. iv, p. 360.
*Murchisonia* (*Eunema?*) *pagoda* WHITFIELD, 1883, Geol. of Wis., vol. iv, p. 218. (Not *Eunema? pagoda* SALTER.)

We have eight more or less imperfect specimens, three of them casts, the rest testiferous, one from Minneapolis, two from Wisconsin, three from Dixon, Illinois, and two from Murfreesboro, Tennessee, of a species of this genus, that after repeated efforts we have failed to distinguish from the Calciferous shell which Billings called *Eunema prisca.* In all these specimens, the largest indicating a total length of between 40 and 50 mm., the apical angle is constantly about 14°. Our figures 53 and 55 (Plate LXX) are so clear and satisfactory that a detailed description is unnecessary. Besides these we have another lot of seven specimens that is not exactly like the first lot. The specimens of the second lot, namely, while agreeing precisely with the northwestern form as far down the spire as the eighth or tenth whorl, from here on reduce the apical angle to only about 10°. At the same time the relative hight of the whorls is increased. These peculiarities are shown very well in figures 52 and 54. If a subordinate name is desired for this peculiar Tennessee form, it may be called var. *extenuata.*

Compared with *S. pagoda* Salter sp., the only difference of any consequence is that while each whorl in that shell has four carinæ—two in the middle, one below and one above, the latter two being almost in contact at the suture—*S. prisca* has but three, the upper one being absent, while the lower one is visible on the base of the last whorl only.

*Formation and locality.*—Billings' types came from the "Calciferous sandrock, Mingan Islands." The specimens used by us are all from the Stones River group at the localities mentioned above.

*Collection.*—E. O. Ulrich.

## SOLENOSPIRA PAGODA *Salter.*

PLATE LXX. FIGS. 56–60.

*Eunema? pagoda* SALTER, 1859, Canadian Organic Remains, Dec. 1. p. 30, pl. VII, fig. 5.
Not *Murchisonia* (*Eunema?*) *pagoda* WHITFIELD, 1883, Geology of Wisconsin, vol. iv, p. 218. (=*Solenospira prisca* BILLINGS sp.)

Hight generally 25 to 30 mm., probably not exceeding 40 mm.; apical angle 14° or 15°; volutions ten to fifteen, furnished each with two prominent keels which divide the surface into three approximately equal concave spaces or furrows; a third but smaller carina above at the sutural edge, while a fourth is visible generally only on the base of the body whorl; surface markings, aside from the strong revolving keels, consisting of extremely fine lines of growth which are directed rather strongly backward from both above and below to the median keels, passing apparently over these and then across the concave central space with a slight backward curvature (see fig. 56, pl. LXX); aperture subquadrate, very slightly produced below; umbilical perforation extremely minute or wanting.

The small carina just beneath the suture line distinguishes this species from *S. prisca*.

If Salter's figure (*loc. cit.*) is correct, then the Canadian types of the species must have a wider apical angle than the Minnesota and Wisconsin specimens above described. The angle of the illustration in question is about 22°, while it is not over 15° in our examples. We are, however, inclined to doubt the accuracy of the Canadian illustration, especially since Billings, after giving the apical angle of his *Eunema prisca* at "about 12°," says that his species is distinguished from *E. pagoda only* by the absence of the upper carina.

*Formation and locality.*—Black River group, Pauquettes rapids, Ottawa river, Canada; Phylloporina bed, near Cannon Falls, Minnesota; "Upper Buff limestone," near Beloit, Wisconsin.

*Collections.*—University of Wisconsin; E. O. Ulrich.

## Family EUOMPHALIDÆ.

This important family, according to our opinion, is to be viewed as an off-shoot from the same early type in which both the *Raphistomidæ* and *Pleurotomariidæ* also originated. It is to be expected, therefore, that, although some of the earliest forms of the family underwent very rapid and strongly marked changes, the majority are decidedly like their contemporaneous cousins. For the same reason it is evident that for some of the "majority" it is difficult to decide whether they had best be regarded as *Euomphalidæ* or as members of one of the other families. With our present limited knowledge of their progenitors, it is perhaps impossible to arrive at positive conclusions.

Already in the Calciferous and Quebec groups, which contain the earliest fully known representatives of the present subclass, we find unequivocal members of the family. Of them we may mention *Eccyliomphalus intortus, distans* and *canadensis* of Billings, *E.* (*Caularops*) *lituiformis* Whitfield, *Straparollus quebecensis* Billings, and *Euomphalus calciferus* Whitfield. The Eccyliomphali are clearly of the line of development which found its continuance in *E. angelini* Lindström, of the Swedish Lower Silurian, *E. undulatus* Hall, of the Stones River group, and our Trenton species, *E. subrotundus;* and possibly its culmination in the Upper Silurian shells from the island of Gothland, described by Lindström as *Euomphalus triquetrus* and *E. gotlandicus.** Concerning this line of development, we are fully convinced that it stands in only very remote genetic relationship to the large group of Upper Silurian Carboniferous species which is typified by *Euomphalus pentangulatus,* the derivation of the latter group from the equally ancient types of *Ophileta*, being, as we shall show presently, very easily demonstrated.

The immediate progenitor of the Calciferous Eccyliomphali, we conceive to have been a form like our *Ec. contiguus* with contiguous, though perhaps narrower,

* Walcott's *Eccyliomphalus devonicus* (Monog. U. S. Geol. Sur., vol. viii, p. 187; 1885) may represent a continuation of this type, but his specimen is so imperfect that it is impossible to arrive at satisfactory conclusions respecting it.

whorls, rounded or obtusely angular upon the upper side, the angle marking the bottom of a broad sinus in the lip; the first departure from this type consisted in the loosening and straightening of the last whorl (*Eccyliomphalus*, or as Whitfield would have it, *Caularops canadensis* Bill. sp.); next all the volutions became disjoined as in *Ec. intortus* and the later *Ec. undulatus*. We have no evidence to show that one or the other of these stages was not strictly maintained as a specific peculiarity by each of the early forms—it certainly was so with the Trenton species—but, according to Lindström, the whorls in his *E. gotlandicus* vary from closely coiled to perfectly evolute. All these species have a broad sinus in the upper lip and, so far as traced, we have found no evidence to show that the later (Devonian and Carboniferous) shells commonly referred to *Straparollus* (*i. e.* euomphaloid shells having rounded whorls and nearly or quite straight transverse lines of growth) were developed from them. On the contrary *Straparollus* or *Straparollus*-like shells seem to us to have been evolved probably at several successive times from true Euomphali. Still, we are not prepared to say that some of them may not have been derived from the Lower Silurian species which Billings called *Straparollina*. However, though with nothing but Billings' figures to base our judgment upon, we are strongly inclined to regard *Straparollina* as closely related to *Holopea* and consequently as widely distinct from the *Euomphalidæ*.

In our opinion, therefore, *Eccyliomphalus*, as this genus is defined and used by most American authors, deserves recognition as a well-marked and limited generic group, principally because it represents a distinct line of development. *Phanerotinus* Sowerby, which is similar in habit and sometimes considered as synonymous, is founded upon evolute Straparollus-Euomphali of the Devonian and Carboniferous rocks. As now used the genus is not a natural group, but it may well be retained, provisionally at least, as a designation of convenience for those Euomphali having rounded and more or less widely disjoined volutions and no apertural sinus. In America only three species fulfill these requirements, viz.: *P. parodoxus* Winchell (Burlington group), and *P. eboracensis* (Hamilton group), and *P. laxus* (Corniferous group) of Hall. The second is peculiar because its shell attaches to itself foreign objects. *Eccyliomphalus undulatus* Hall had a similar habit, and its frequent occurrence in several European Devonian *Euomphalidæ* has been observed by Deslongchamps, Koken and others, and quite recently has led Kayser to propose the new generic term *Philoxene* (Zeitschr. d. deutsch. geol. Gesellsch., Jahrg. 1889.) This peculiar feature reminds one of the recent genus *Phorus*, but we agree fully with Hall and Koken in attaching very little significance to its presence in these otherwise clearly Euomphaloid shells.

As far as we can go back in geological history, the developmental line of

*Euomphalus* began in *Ophileta.* Typically, this genus is probably restricted to rocks of the age of the Calciferous, and consists of discoidal shells, with the spire concave and the base nearly flat. The whorls are narrow, in contact, all exposed, and flattened or gently convex beneath, angular at the lower part of the slightly convex or flattened periphery and more sharply angular on the upper side. The anterior extremity of the upper keel marks the bottom of a deep >-shaped apertural sinus or notch. The keel itself is homologous with the slit-band of the *Pleurotomariidæ* though of more simple structure. The outer lip extends forward a trifle farther or about as far as the innermost part of the upper, while the lower on the whole is nearly direct though slightly insinuated in the outer half.

From the typical forms of the genus like *O. complanata* we pass by rather easy gradations through forms like *O. ? bella* Billings and *Euomphalus uniangulatus* Hall, to *Helicotoma,* Salter, the change consisting in the raising of the spire till it projected slightly above the level of the last volution, in the deepening of the umbilicus and in the rounding of the outer and lower sides of the whorls. The course of the lines of growth and the >-shaped notch at the end of the upper carina remain about the same. But it is not from fully developed *Helicotoma,* which continued as an independent genus to the close of the Lower Silurian, that the later Euomphali were evolved. In our opinion they were derived from a second branch of the Calciferous *uniangulatus* section of *Ophileta,* the first resulting in *Helicotoma,* the farther development of which tended toward the early pleurotomarian rather than the euomphaloid type of structure. In *Helicotoma,* namely, the upper carina becomes very much like a slit-band, and that is precisely the opposite of what was necessary to produce an *Euomphalus,* in which the apertural notch is reduced to the minimum.

Now, if the student will compare species like *O. bella* Billings, *O.* (*Eu.*) *uniangulatus* Hall, *Eu. obtusangulus* Lindström, *E. præcursor* Lindström and *E. walmstedi* Lindström, the last two Upper Silurian species, we think he will be prepared to admit the correctness of our views, since with our present knowledge it is quite out of the question to arrange the last of the species mentioned in any other position than in the immediate vicinity of the original Carboniferous types of *Euomphalus.*

During Devonian times a side branch from *Euomphalus,* for the best species of which Hall proposed the generic name *Pleuronotus,* became very abundant in individuals if not in species also. It is interesting to note that *Pleuronotus* represents a very striking return to characters pertaining to *Ophileta,* there being the same flat base, carinate upper side, and deep apertural notch which previously had been the main characteristics of that primitive genus. It might be contended that *Ophileta* enjoyed a continuous existence from the Calciferous to the Devonian and that

*Pleuronotus* therefore is really nothing more than a continuation of the original type. Such a view, however, is rendered untenable, so far as negative evidence can do so, by the fact that we have no knowledge whatever of the presence of the *Ophileta* type in the rocks lying between the base of the Trenton and the top of the Upper Silurian. *Pleuronotus* appears to have diverged rather suddenly during early Devonian times from the true *Euomphalus* line, but we do not now feel justified in designating the particular species which gave it origin. As to the length of time that it existed, we are inclined to believe that it became extinct before the close of the Devonian.

Following the development of *Euomphalus* into the Carboniferous rocks we find three types of shells: one, including *E. subrugosus* M. and W., *E. subquadratus* M. and W., and others, in which the spire is concave, the volutions quadrangular in section, and the upper and lower boundaries of the broad, nearly vertical and flat or gently convex periphery are marked by more or less sharp angles over which the lines of growth pass without being much recurved. On the peripheral side these lines are straighter than usual, and sometimes even curved very slightly backward. This group reminds one greatly of the Jurassic *Discohelix*, and probably is to be viewed as the stock from which that genus sprang. The second group includes the original types of the genus, *E. pentangulatus* and *E. catillus* of Sowerby, and a number of other European species whose volutions have an upper and usually also a lower keel or angulation, with the periphery, on which the growth lines are more or less bowed forward, strongly convex, and the spire flat or concave. A slight sinus in the upper lip is common. In its typical expression this group is unknown to us in American deposits save through a single small species from the Upper Carboniferous of Missouri, which seems to be new. The third group on the other hand is well represented here, we being acquainted with, besides several undescribed forms, the following five species: *E. latus* Hall, Burlington gr., *E. similis* Meek and Worthen, St. Louis gr., *E. planidorsatus* M. and W., and *E. subumbilicatus* Worthen, Chester gr., and *E. umbilicatus* M. and W., Coal Meas. In all these shells the spire rises above the plane of the last volution, and in some of them to an unusual extent. The whorls are rounded on the outer and sometimes also on the lower side, but generally the boundary of the umbilicus is angular. The upper keel is always present and situated much nearer the periphery than the suture; between the latter and the keel the surface is flat or gently concave. The general aspect of the shells is greatly like that of the prevailing forms of the Lower Silurian genus *Helicotoma*. In some this resemblance extends even to the possession of a number of obscure revolving lines on the peripheral region like those seen in *H. planulata*. There is, however, a very decided difference in the course of the lines of growth marking the surface of the outer layer. Thus, while the upper keel terminates anteriorly in a deep notch and the growth lines curve backward strongly both from above and below in approaching the keel in *Helicotoma,* they pass almost directly across the whorls in these Euomphali. In passing over the keel they are but little, if at all, deflected, but a broad backward sweep on the lower side of the whorls produces a slight obliquity of the aperture.

In stating the differences in the direction of the lines of growth of the Carboniferous and Lower Silurian shells just compared, we were careful to say, "the surface of the outer layer," because we have reason to believe that the markings of the inner layer are not the same as those of the outer. We have before us a remarkable specimen of an undescribed *Euomphalus* from the oolitic limestone of the Upper Coal Measures at Kansas City, Missouri. The species is closely related to and perhaps not specifically distinguishable from the Chester group shell to which Meek and Worthen have given the name *E. planidorsatus.* There is no doubt then about its genetic relations. The specimen in question has the external layer of the shell peeled off in patches so as to expose the inner layer. Both layers show lines of growth very distinctly, and it was in comparing their respective directions in the region of the upper keel that we met with a surprise. On the outer layer, namely, the striæ pass almost straight from the suture to the keel, beyond which they turn first very gently forward and then more strongly backward into the broad basal sinus. The inner layer seems to be composed of short overlapping laminæ, the edges of which impressed themselves upon the internal cast as closely arranged parallel grooves. The latter, instead of being direct like the lines of the outer layer, curve backward strongly in passing over the region of the keel, thus indicating a very decided >-shaped notch in the lip, which must, however, have been confined to the inner layer of the shell. Immediately beneath the keel the test is thick enough to produce a faintly concave instead of convex band on the interior cast.

After seeing this specimen, the important question arises, do not the same conditions pertain to all the similarly carinate Euomphali? Unfortunately we have no positive data bearing upon the question, although we have seen specimens of other species in a similar state of preservation; but the specimen described is the only one showing any sign of transverse markings on the inner surface of the shell, the casts in every other instance being quite smooth. Still, the Kansas City specimen proves that a notched aperture may really exist in species of *Euomphalus* exhibiting no external sign of its presence, and this fact is, to say the least, worthy of being remembered.

In addition to the euomphaloid types discussed on the foregoing pages, we distinguish three others, two of them under new names, the third described and named *Eccyliopterus* by Remele.

*Ophiletina* is a new generic or subgeneric name proposed by us for the reception of two or three peculiar yet obviously euomphaloid shells occurring in the Stones River, Black River and Trenton groups in Minnesota and elsewhere. Compared with other types of the family, we find that they resemble certain Carboniferous species of *Euomphalus* (the *E. subquadratus* section) more closely than any others found in Paleozoic rocks. Nearer even than these is a Triassic species which Koken figures and describes as *E. cassianus*, (*op. cit.*, p. 416). Now, we consider it quite out of the question that either the Carboniferous or the Triassic species are descended from the Lower Silurian shells under consideration. What we do believe is that *Ophiletina* is a rapidly evolved side branch from *Ophileta* that became extinct before or with the close of the Lower Silurian age. The principal reason for this opinion lies in the fact that no shell of this type is known from the Upper Silurian, nor from the Devonian, unless *Pleuronotus* be so considered. The latter, however, is more like *Ophileta* than *Ophiletina*.

*Hisingeria* is proposed for the reception of *Inachus planorbis* His., a well known fossil of the Upper Silurian strata of the island of Gotland, that, since 1828, when Hisinger first identified it with Wahlenberg's *Turbinites centrifugus*, has been referred to under no less than seven different generic names. Until the appearance of Lindström's grand work on the "Gastropoda of Gotland," in which it is referred to *Pleurotomaria*, most authors called it an *Euomphalus*. In 1837 Hisinger proposed the generic name *Inachus* for it, but as this had been used many years before by Fabricius, it could not be retained.* Believing that Hisinger was fully justified in separating his species *planorbis* (or *sulcatus*, as he often called it) from previously established genera, it seems to us only a just recognition of his acumen to substitute *Hisingeria* for his *Inachus*. We may add that Koken (*op. cit.*, p. 419) also regards the species *planorbis* as "the representative of an independent genus."

*Hisingeria planorbis* is most certainly not a true *Pleurotomaria*, nor is it, if our views are correct, even a member of that family. Lindström admits that there are "some features which remind of *Euomphalus*." We should say *many* instead of *some*, and add that we have not found a single character that may be justly set against them. That *Hisingeria* has a deeply notched aperture and a kind of slit-band is no more indicative of pleurotomarian than euomphaloid affinities, and when we consider that the detail of the band, together with every other feature of the shell, is more in accordance with the latter than the former, a little surprise at Dr. Lindström's positive reference of *H. planorbis* to *Pleurotomaria* may be pardoned. The form of the shell is decidedly euomphaloid, as is also the position of the band on

* It seems that DeKoninck (Faune Carbonif., 1881.) intended to replace *Inachus*, Hisinger, with *Polytropis*, but as he mentions *Euomphalus discors* Sowerby, as the typical species, which is at least generically distinct from *Inachus sulcatus* (*planorbis*), it is evident that *Hisingeria* does not conflict with *Polytropis*.

the upper side of the whorls, the band, in low-spired pleurotomarians, being almost invariably situated on the periphery. Again, the rounded character of the whorls of the interior casts, which necessitated a strong deposit of shell beneath the external keels, the lower especially, recalls a common condition among species of *Ophileta*, *Euomphalus* and *Pleuronotus*, but not of any of the *Pleurotomariidæ*.

According to our view, *Hisingeria* is a strongly marked descendant of the *Helicotoma* or *Ophileta* type. Though the general aspect is widely different, the real differences are not so great as they appear on first sight, and, what is more important, they are rather easily accounted for. In *Hisingeria* the slit-band or keel has been reduced in prominence and moved inward from the outer edge of the upper side of the whorl to near the suture line, while the revolving striæ, which as a rule are but ill developed in *Helicotoma*, have been strengthened and the outer basal angle somewhat extravagantly thickened. The last feature is perhaps the most striking peculiarity when compared with, for instance, *Helicotoma planulata* Salter, but in our *H. subquadrata* the outer basal angle is somewhat prominent, while in our *H. marginata*, a new species from the extreme top of the Lower Silurian, a similar feature is even more abruptly developed. Still, we doubt very much that the latter is in any wise an ancestor of *Hisingeria planorbis*, the real line of descent from *Ophileta* being, in our opinion, as yet undiscovered or unrecognized as such.

*Eccyliopterus*, Remele, which we place in this family, has already been discussed in connection with *Raphistoma* on pages 935 to 938. The genus is a good one and includes shells with contiguous whorls similar in most respects to those of *Helicotoma*, and others in which they are more or less completely disconnected. The latter have usually been confounded with *Eccyliomphalus*, but as we have endeavored to show, the true position of the genus is nearer *Ophileta* and *Helicotoma* than *Eccyliomphalus*. The distinguishing character of *Eccyliopterus* lies in the remarkable development of the upper keel which projects beyond the surface of the whorls like a high collar.

### Genus OPHILETINA, n. gen.

For remarks on this genus see page 1028.

Only two or possibly three small species of this interesting genus are known. In these the whorls are rather slender, contiguous or partly free, coiled almost in the same plane, and either hexagonal or subquadrate in section. On the upper side and forming the outer edge there is a sharply elevated convex—or flat-topped—ridge which looks very much like a true slit-band, being covered with strongly recurved lines (lunulæ) and terminating anteriorly in a well-marked notch. On the vertical outer side the lines of growth are bowed forward in the middle, on the lower side broadly backward. Of the following two species, *O. sublaxa* may be regarded as the type.

The principal, or perhaps we should say only feature relied on in distinguishing this new generic group from *Ophileta* on the one side and *Euomphalus* on the other, is the slit-band. Both of those genera may often have an apertural notch at the terminus of the ridge corresponding to the "band," but there is never anything like a definite band, the lines of growth passing over the ridge without interruption further than is occasioned by changing their direction from obliquely backward to obliquely forward. In *Ophiletina,* however, as is shown in figures 41 and 47 on plate LXXIV, the ridge is as much of a "slit-band" as in the majority of the Lower Silurian *Pleurotomariidæ.* In *Helicotoma,* certain species of which are considerably like our *Ophiletina angularis,* the summit of the corresponding ridge, though never flat nor bearing lunulæ, is occasionally margined on each side by a delicate raised line, the result being a "band" that is not greatly different from the kind pertaining to species of *Lophospira* like *L. acuminata* (compare fig. 8, plate LXXIII, and fig. 24, plate LXXIV). Another constant and easily recognized difference between *Ophiletina* and *Helicotoma* is furnished by the course of the lines of growth across the vertical outer surface of the shell. In the former the lines curve forward in the upper half and just as much backward in the lower, the direction on the whole, therefore, being essentially vertical. In the latter the forward direction continues to the basal angle (compare plate LXXIV, fig. 46 with 15, 16, 22, 33 and 37).

## OPHILETINA SUBLAXA, *n. sp.*, and varieties.

PLATE LXXIV. FIGS. 40–42 and 47.

Shell small, 13 to 16 mm. in diameter, coiled approximately in one plane, the upper side flat, the lower gently concave; volutions slender, three in number, without the more or less prominent nucleus, hexagonal in transverse section, a little wider than high, the greater part of the last free. Of the six angles the strongest bears the band and lies at the outer edge of the upper side. Within this the space to the suture line is divided into halves, the outer concave, the inner a flat slope, by a second carina. The third is prominent and thin and lies considerably beneath the middle of the outer surface of which the fourth carina forms the base. The fifth and sixth angles are more obtuse, and lie one about the middle of the inner side, the other at the junction of the inner and lower sides. Lines of growth strong, equal, somewhat imbricating, averaging about seven in 2 mm., making a slight retral bend (it is often stronger than in our engraving) in crossing the central angle of the upper face, a very strong and sharp retral bend or loop on the sides and summit of the band-ridge, a slight forward curve on the outer and a retral curve on the lower surface. The band itself is convex and sharply defined, the lunulæ strong.

The above description is strictly of the northwestern form of the species. Of this we have three specimens, one from each of the three states of Minnesota, Wisconsin and Illinois. We have a fourth specimen (original of fig. 42), found by one of the authors in the lower part of the Stones River group in Tennessee, which differs slightly in several particulars. In the first place the whorls are more slender when viewed from above; next the hight and width of the volutions are more equal; then the inner face of the whorls is steeper and rounded rather than angular; finally, the upper side of the shell is concave and the lower flat instead of the reverse. Possibly this Tennessee specimen, which, although a silicified shell, retains no trace of surface markings, represents a distinct species, but the material at hand is scarcely sufficient to justify specific separation. A subordinate designation, however, may be allowable and we therefore suggest that it be known provisionally as var. *depressa*.

Another variety or closely related species occurs in the Fusispira bed of the Trenton group. We have seen but a single example, a cast of the interior attached to a piece of stone so that only the upper side is visible. As far as can be seen it agrees with *O. sublaxa* in all respects except that the last whorl is scarcely separated from the inner turns. Considering that the Lower Silurian euomphaloids are all very restricted in their vertical ranges, it is highly improbable that perfect shells of the later form would agree in all respects with the Stones River group types of the species. We venture therefore to separate the Fusispira bed form as var. *sequens*.

*Formation and locality.*—The typical form occurs in the limestones of the Stones River group at Minneapolis, Minnesota, Mineral Point, Wisconsin, and Dixon, Illinois; var. *depressa* in the lower division ("Central limestone") of the same group at Murfreesboro, Tennessee; var. *sequens* in the Fusispira bed of the Trenton group at Wykoff, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota (two specimens of typical form); E. O. Ulrich (one specimen of typical form and both varieties).

*Museum Register*, Nos. 6869, 7302.

### OPHILETINA ANGULARIS, *n. sp.*

PLATE LXXIV, FIGS. 43–46.

Shell small, 8 mm. wide; 2.3 mm. high; planorbiform; spire flat, under side concave from the peripheral edge on; whorls in contact, quadrangular or subpentagonal in section; outer side vertical, nearly flat, with a small carina near its middle; upper side concave between the elevated band, which is flat and lies at the outer edge, and a low ridge two-thirds across the whorl, beyond which the surface descends rapidly into the sutural channel. The lines of growth, except that they are somewhat finer, are very much as in *O. sublaxa*. Four or five lines occur in 1 mm. With the aid of a glass of low power the direction of the lines can be made out very clearly on our engravings, special care having been given to this feature.

We know of no shell found in the Lower Silurian rocks of America that is at all likely to be confused with either this or the preceding species. In the Coal Measures and in the Triassic of Europe there are several small forms of *Euomphalus* that, aside from the fact that they have no defined band, greatly resemble *O. angularis*.

*Formation and locality.*—Phylloporina bed, Black River group, near Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich.

## Genus ECCYLIOPTERUS, Remele.

In part *Eccyliomphalus*, *Euomphalus*, *Ophileta*, *Maclurea* and *Raphistoma* of authors.
*Eccyliopterus*, REMELE, 1888, Zeitschr. d. deutsch. geol. Ges., Band xl.

For generic characters and general remarks see pages 935 to 938, and page 1029.

To give a better idea of this genus than is furnished by the two Trenton species next described, and particularly to show the evolute character pertaining to some of the species, we have added figures, on plate LXXIV, of two Calciferous forms which have been erroneously referred to *Eccyliomphalus* by Whitfield. Otherwise *E. owenanus* presents an excellent general idea of the present genus. The "collar" is always a notable feature and especially high in the species mentioned. We have a species from the Shakopee formation of Minnesota agreeing very closely in all respects with *E. triangulus,* excepting that its whorls are all contiguous save a part of the last.

### ECCYLIOPTERUS BELOITENSIS, *n. sp.*

PLATE LXII, FIG. 70; PLATE LXXIV, FIGS. 1–4.

Width 30 to 45 mm., greatest hight nearly half the width; whorls enlarging rather rapidly, three or three and one-half in number, coiled very nearly in the same plane; upper side of shell broadly concave; umbilicus large, half the diameter of the shell; under side of whorls strongly convex, outer side vertical, upper side concave in the outer half, convex in the inner; suture deep, collar only moderately high, well indicated, however, even on casts of the interior; mouth somewhat acuminate-ovate, very oblique. Lines of growth obscure, directed backward, on the upper side with a slightly sigmoid curve.

*Formation and locality.*—Stones River group, Beloit, Wisconsin; High Bridge, Kentucky.

### ECCYLIOPTERUS OWENANUS *Meek* and *Worthen.*

PLATE LXXIV, FIGS. 10–14.

*Ophileta owenana* MEEK and WORTHEN, 1868, Geol. Sur. Ill., vol. iii, p. 313.

This is a smaller shell than *E. beloitensis,* the width of the largest seen being only about 26 mm., while the average for fourteen specimens is about 22 mm. The whorls are more slender, being four in number, and the collar, which is scarcely indicated on casts, is relatively much higher and thinner than in the larger species. Indeed, the collar is nearly as high as the cavity of the whorl. While the upper sides of casts are nearly as much depressed, the whorls themselves are much less concave in the outer half, this part being almost flat. The inner half generally slopes rather rapidly inward and downward, in some cases forming an obtuse median angulation. The collar of the inner turns may stand up free or be joined in part to the inner slope of the next whorl.

The *E. ottawaensis* Billings sp., from the Trenton limestone of Canada, seems to have even more slender whorls and a flatter spire. The whole shell also appears to be more depressed.

*Formation and locality.*—Fusispira bed of the Trenton group, Wykoff, and various localities in Goodhue county, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register,* No. 7376.

## Genus HELICOTOMA, Salter.

*Helicotoma,* SALTER, 1859, Can. Org. Rem., Decade 1, p. 13.

If in separating the *Euomphalidæ* and *Pleruotomariidæ* we placed all our dependence on the presence or absence of a slit-band as distinguished from a simple retral curve of the lines of growth, *Helicotoma,* as well as *Ophiletina,* also *Pleuronotus,* would be arranged with the latter instead of the former family. But we cannot assume one character as absolute in assigning position. No, every feature and circumstance must be compared and weighed if we would arive at anything approaching a natural classification. Particularly important matters to be determined fall under the term of chronogenesis. In the discussion of the family beginning on page 1023, we follow up the development of *Helicotoma* and conclude that it was derived from *Ophileta*—further, that the *Helicotoma* line terminated with itself and that *Euomphalus*, which it resembles in many respects, was not derived from it but directly from *Ophileta*. The connection with *Ophileta* must determine the position of *Helicotoma* since that genus is most certainly not a member of the *Pleurotomariidæ*, while we are fully satisfied of its affinities with typical *Euomphalidæ*.

The Calciferous formation furnishes at least one unquestionable species of *Helicotoma*, viz.: *H. perstriata* Billings. There is a small species (less than one-half an inch in diameter) in the Shakopee of Minnesota, that seems to differ very little except in size from our *H. umbilicata* of the Stones River group. Other species of the Stones River group are *H. tennesseensis* Safford, *H. declivis* Safford, *H. planulata* var. *robusta* U. and S., *H. planulatoides* Ulr., *H. verticalis* Ulr., and *H. granosa* Ulr. The Black River group has *H. planulata* Salter, the type of the genus, and *H. muricata*, *H. spinosa* and *H. larvata* of the same author. From the Quebec group of Canada Billings described five species (*eucharis*, *gorgonia*, *misera*, *proserpina* and *tritonia*) with characters apparently in strict accordance with *Helicotoma*. Only *H. marginata* Ulr. is known to us from strata of the Cincinnati period. H. *naresi* Etheridge, an Upper Silurian shell, and the Devonian *H. serotina* of Nicholson, probably belong to some other genus.

### HELICOTOMA PLANULATA *Salter*, and var. ROBUSTA, *n. var.*

PLATE LXXIV, FIGS. 15—17.

*Helicotoma planulata* SALTER, 1859, Can. Org. Rem., Decade I, p. 14.

*H. planulata* is distinguished from nearly all other species of the genus by having from three to six strong, simple or double, revolving lines on the outer side of the whorls. Beneath the marginal notch-ridge the outer side is more or less distinctly concave. The summit of the ridge may be on the same plane in all the whorls, but, as a rule, on each it is a little lower than on the preceding turn. Within the ridge, which is sharply elevated and marked on its outer side by an impressed line, the depressed upper side of the whorls is quite flat. The under side of the whorls may be regularly convex or an obscure angle may form the boundary of the umbilicus. A full grown individual has five whorls. On plate LXXIV, figs. 16 and 17, are two views of what we consider as a typical example of the species.

### Var. ROBUSTA, *n. var.*

PLATE LXXIV, FIG. 15.

This variety is founded on a single imperfect specimen. It has revolving lines like *H. planulata*, but differs in certain respects too obviously to be referred to that species without question. In the first place its whorls enlarge more rapidly both in hight and width. The inner whorls are missing, but we are well satisfied that the specimen consisted originally of no more than four whorls. Next the concavity of the upper part of the outer side of the whorls is scarcely noticeable. Finally the lines of growth cross this side more obliquely.

*Formation and locality.*—The typical form of this species, excepting a single example from an undetermined Trenton horizon in Lincoln county, Missouri, is only known from the Black River limestone at Pauquettes rapids of the Ottawa river, in Canada. The type of our var. *robusta* is from the Stones River group in Jo Daviess county, Illinois.

*Collection.*—E. O. Ulrich.

## HELICOTOMA PLANULATOIDES, *n. sp.* (*Ulrich.*)

PLATE LXXIV, FIGS. 28—30.

Specimens of this species range in width generally between 15 and 25 mm. The form is closely related to *H. planulata* Salter, but there are only about four whorls instead of five, and each descends slightly beneath the level of the preceding. Compared further with the Canadian species, we find that the umbilicus is somewhat narrower. A more striking difference, however, is the total absence of revolving lines. See *H. tennesseensis* for comparisons with that species.

*Formation and locality.*—Ten specimens were obtained in the vicinity of High Bridge, Kentucky, where they occurred at the top of the Stones River group or base of the Black River limestone. Two others, from the Black River group of middle Tennessee, occurred in a lot of fossils received from Prof. Jas. M. Safford.

*Collection.*—E. O. Ulrich.

## HELICOTOMA TENNESSEENSIS *Safford.*

PLATE LXXIV, FIGS. 20—24.

*Helicotoma tennesseensis* SAFFORD, 1869, Geol. of Tenn., p. 288. (Neither defined nor illustrated.)

This abundant shell holds about the same size and is closely allied to *H. planulata* and *H. planulatoides.* A constant peculiarity is a narrow downward slope along the suture line. Aside from this and the absence of revolving lines, we fail to see any difference between the Tennessee and Canadian species. The Kentucky species, however, attains a larger size with the same number of whorls.

*Formation and locality.*—Very abundant in the lower division ("Central limestone") of the Stones River group at Murfreesboro, Tennessee.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

## HELICOTOMA SUBQUADRATA, *n. sp.* (*Ulrich.*)

PLATE LXXIV, FIGS. 31—33.

Although closely related to all three of the preceding species, the present form is readily distinguished by the subquadrate section of its whorls, the junction of the outer and lower sides of the whorls, which are both flattened, being rather strongly angulated. The notch-carina is not much elevated, and the surface of the whorl within it is perfectly flat to the suture line.

*Formation and locality.*—Same as the preceding. Only two specimens have been observed, and these were both received from Prof. Jas. M. Safford.

## HELICOTOMA UMBILICATA, *n. sp.*

PLATE LXII, FIG. 68; PLATE LXXIV, FIGS. 25—27.

This species has been quite generally confused with *H. planulata,* but after seeing a number of specimens of both forms we are prepared to assert, with much confidence, that they are not the same. It is true *H. umbilicata* has, like the Canadian form, revolving lines on the outer side of the whorls, but these are never very strong and in most cases so weak that they cannot be distinguished on even good moulds of the exterior. Comparing other features, it will be found that the shell of *H. umbilicata* is more depressed, the width of the whorls being constantly somewhat greater than the hight, while in *H. planulata* the two dimensions are equal. But the differences principally relied upon in distinguishing the two forms are (1) that the apertural notch is much deeper and, consequently, the lines of growth more strongly recurved, and (2) the umbilicus is wider and shallower in our species than in the Canadian shell. In nine specimens of the latter before us the umbilicus in no case exposes quite half of the width of each of the nine whorls. On the other hand, in eleven specimens of *H. umbilicata* the amount exposed varies from fully two-thirds to nine-tenths of the width, and in most cases exceeds three-fourths. *H. tennesseensis* Safford is probably nearer than any of the other species, but has constantly a higher spire and narrower umbilicus. On the exterior of the shell, the lower part of the outer side of the whorls is sometimes quite prominent.

*Formation and locality.*—Stones River group, Minneapolis and St. Paul, Minnesota; Beloit, Janesville and Mineral Point, Wisconsin, and Dixon, Dunleith, La Salle and Rockton, Illinois. Though widely distributed it seems not to be common at any point.

*Collections.*—University of Wisconsin; E. O. Ulrich.

## HELICOTOMA VERTICALIS, *n. sp.* (*Ulrich.*)

PLATE LXII, FIG. 69; PLATE LXXIV, FIGS. 18 and 19.

This species is known from casts of the interior only, but they are readily distinguished from all of the preceding forms by the rectangular form of the outer and upper surfaces of the whorls. The latter are not more than four in number, enlarge rapidly, are strongly convex below and leave a deep and relatively narrow umbilicus. On the under side the cast resembles the shell of *H. planulatoides* very closely, but in other respects is quite different, the outer side of the whorls in that species being concave and inclined inwards above instead of convex or flat and vertical. The upper surface of the whorls, in accordance with the differences just mentioned, is considerably wider in *H. verticalis.*

Koken figures a Russian shell which he calls *Raphistoma damesi* (N. Jahrbuch f. Mineralogie, etc., 1889, Beilageband vi, pl. XI, figs. 4, 4*a*) that reminds one greatly of *H. verticalis.* If he is right in calling his species a *Raphistoma*, then it is evident that it cannot be very closely related to our shell. If, on the other hand, it is, like ours, a *Helicotoma*, then it might be difficult to distinguish it from the American form. Still, the outer side of the whorls in Koken's species is not quite vertical, but begins to slope inward at the upper angle.

*Formation and locality.*—Upper part of Stones River group, High Bridge, Kentucky, where it occurs associated with *H. planulatoides* and *H. granosa.*

*Collection.*—E. O. Ulrich.

## HELICOTOMA GRANOSA, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 32—44.

Shell small, generally 7 to 9 mm. in diameter, probably not exceeding 12 mm; hight equaling about a third of the width; notch-carina prominent, thin, its summit carrying a row of small nodes; whorls three and a half or four, the inner ones raised, the outer two coiled nearly in the same plane; upper surface of whorls depressed, nearly flat and sloping slightly downward toward the suture; umbilicus large, exposing about three-fourths of each of the inner turns; outer side of whorls strongly convex in the lower half and distinctly concave in the upper; entire outer side of whorls, when perfect, covered with irregularly distributed or retrally curved rows of granules or small nodes; a series of similar nodes along the center of the upper side of the first two and a half volutions.

When the sculpture bearing layer is removed, the shell is smooth, and in this condition it is most difficult to distinguish from the young of *H. umbilicata.* Perfect specimens, however, with their peculiar granulose markings, could not possibly be confused with any other species known.

*Formation and locality.*—Upper part of Stones River group, High Bridge, Kentucky.

*Collection.*—E. O. Ulrich.

### HELICOTOMA DECLIVIS *Safford.*

PLATE LXXIV, FIGS. 34—38.

*Helicotoma declivis* SAFFORD, 1869, Geol. of Tenn., p. 288. (Neither defined nor illustrated.)

This species is remarkable especially for two reasons: first, the umbilical cavity, which is rather wide, has even slopes on which the inner whorls are more or less obscurely or quite indistinctly defined; second, the upper surface of the whorls is raised so as to form a broad, obtuse, median angulation or ridge. The inner whorls of the spire are depressed slightly beneath the level of the outer one while the notch-carina is so small that it fails to rise to the level of the median ridge.

*Formation and locality.*—Associated with *H. tennesseensis* in the lower part of the Stones River group at Murfreesboro, Tennessee.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

### HELICOTOMA MARGINATA, *n. sp.* (*Ulrich.*)

PLATE LXXIV, FIG. 39.

Of this species we have seen but the unique example of which a view of the upper side is given on plate LXXIV. It is remarkable chiefly because the lower part of the outer side of its whorls is so prominently developed that it projects like a broad flange.

*Formation and locality.*—Found at the extreme top of the Richmond group, Elkhorn falls, near Richmond, Indiana.

*Collection.*—E. O. Ulrich.

## Genus ECCYLIOMPHALUS, Portlock.

*Eccyliomphalus*, PORTLOCK, 1843, Geol. Rep. Lond., p. 411.

For remarks on this genus see pages 1024 and 1029.

### ECCYLIOMPHALUS UNDULATUS *Hall.*

PLATE LXXV, FIGS. 19—23.

*Ecculiomphalus undulatus* HALL, 1861, Geol. Rep. Wis., p. 37; WHITFIED, 1895, Mem. Am. Mus. Nat. Hist., vol. i, pt. 2, p. 63, plate VIII, figs. 1—3.

*Original description.*—"Shell consisting of one or two volutions, spirally coiled, but distantly separated from each other, rapidly increasing in size from the apex, and of a subtriangular or ovate-triangular form, the upper side being convex and curving to the ventral margin; the dorsum is somewhat flattened, and the lower side sloping with a gentle curve from the lower lateral angle to the ventral side, which is narrow and sharply rounded. Along the ventral side and a little below the center there is a narrow, abruptly depressed groove, which extends the entire length of the shell.

"Surface of the shell marked by obscure undulations, which are most distinct on the lower lateral angle, also on the lower side by two or three revolving ridges.* Fine transverse lines of growth parallel to the margin of the aperture are visible over the greater part of the surface of the specimen, which is essentially a cast of the interior."

To the above description we may add that there is a broad sinus in the upper part of the mouth, and that the depressions on the outer side of the shell are due to agglutinated foreign objects like fragments

* We do not understand what is meant by the "two or three revolving ridges" on the lower side, since we have not observed anything of the kind on our specimens. That the latter are specifically identical with Hall's species we are confident after seeing Whitfield's figures of the original type (*loc. cit.*).

of *Orthis.* Also that the inner whorl is cut off from the remainder of the spiral tube by imperforate concave partitions.

*Formation and locality.*—Stones River group, Minneapolis, Minnesota; Beloit, Wisconsin; La Salle, Illinois; and Lebanon, Tennessee.

*Collection.*—E. O. Ulrich.

### Eccyliomphalus subrotundus, *n. sp.*

PLATE LXXV, FIGS. 17 and 18.

This shell differs from *E. undulatus* in that it forms little more than a single volution, that the shell expands more slowly, that it is almost circular in cross-section, that it is coiled in the same plane, and has the ridge on the inner side placed lower. The ridge is also more sharply defined and thinner. *E. intortus* Billings, of the Point Lévis limestone in Canada, is in many respects a similar shell, yet is more closely involute, expands more rapidly, and is without the ridge on the inner side.

*Formation and locality.*—Fusispira bed of the Trenton group, Wykoff, Minnesota.

*Collection.*—E. O. Ulrich.

### Eccyliomphalus contiguus, *n. sp.* (*Ulrich.*)

PLATE LXXV, FIGS. 48–52.

Shell 12 to 30 mm. in diameter; 7 to 16 mm. in hight, consisting of three or four rapidly enlarging contiguous whorls, coiled so as to leave a deep umbilicus in which from a third to a half of each of the inner whorls is visible; whorls subovate in section, higher than wide, somewhat narrowly rounded in the outer half of the upper surface. On the upper side the inner whorls may be sunken slightly beneath or raised above the level of the last; innermost whorl with a free termination. Mouth obliquely subovate, the margin rather deeply notched above, broadly curved forward on the outer side and gently sinuate below. Surface markings somewhat irregular and coarse, parallel with the edge of the mouth

That the whorls in this shell are contiguous, we cannot consider as a serious objection to classifying it with *Eccyliomphalus.* A sufficient justification of our arrangement is found in Lindström's *Euomphalus gotlandicus* which clearly belongs to this genus, and in which the whorls may be quite indifferently totally evolute or closely joined.*

*Formation and locality.*—Lower part of the Stones River group, Murfreesboro, Tennessee.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

## Family MACLURIIDÆ, Woodward.

We have not been able to satisfy ourselves that this is a valid family and its acceptance here is chiefly in deference to the views of previous authors, We are, however, convinced that the natural affinities of the majority of the types usually referred here are with the *Euomphalidæ.* About twenty-four American species have been described, and all of these, though exhibiting considerable variation, have heretofore been placed into the single genus *Maclurea.*

Considering the great differences exhibited by the opercula of some of these species, it seems to us that their arrangement in one genus can only be justified as

* There may be some doubt concerning the specific identity of all the various forms referred by Lindström to his *Euomphalus gotlandicus*, but there can be none when it comes to their generic alliances.

a provisional measure. We admit that the time has not yet arrived when it will be possible to divide the whole genus into natural groups, but convenience demands that at least one section should be distinguished now. All definitions of *Maclurea* give, as perhaps the most essential feature, one character that is known to be absent in several species, which nevertheless are always classified without question under the *Maclurea*. Namely, two more or less prominent muscular scars or processes upon inner side of the operculum. As the absence of these projections in certain species certainly deserves some recognition in our classification, we propose to separate them as a distinct genus, under the new name *Maclurina*, which we have selected in order to facilitate recollection of their previous generic association. In breaking up the genus we deem it advisable to proceed with extreme caution, since the opercula, upon which the division rests, are fully known in only a few cases. We shall, therefore, change the generic designation at the present time in only three instances, and leave the arrangement of the remainder for future investigation.

## Genus MACLUREA, (Lesueur.) Woodward.

*Maclurites*, LESUEUR, 1818, Jour. Acad. Nat. Sci., vol. i, p. 312.
*Maclurea*, WOODWARD, Manual of Shells, p. 202; EMMONS, 1842, Geol. Rept., p. 276; SALTER, 1859, Can. Org. Rem., Decade 1, p. 7.

Shell thick, discoidal, few whorled, reversed, the under side flat or nearly so and exposing all the whorls, the upper side convex and deeply perforated in the center instead of raised into a spire; surface with lines of growth crossing the whorls almost directly, the peripheral portions not infrequently exhibiting a revolving set of lines also. Operculum more or less curved in a front view, set somewhat obliquely into the aperture, and made up of concentric laminæ with the nucleus, which is in the middle or near the outer angle of its lower part, projecting more or less forward, sometimes like a great vertically compressed horn; inner side excavated, with a prominent projection for the attachment of a muscle in the lower inner fourth of the excavation and a large muscular scar, little or not at all elevated, in the upper inner fourth. Type: *Maclurea magna* Lesueur.

It may be that the shells of this genus are, as supposed by Billings and others, really sinistral, in which case the flat side would be the spire and the umbilicated side the base, but we prefer for the present, to regard the ridge which usually surrounds the umbilicus as corresponding to the notch-keel of the *Euomphalidæ*. This view is supported by the fact that the lines of growth on the flat side of the whorls, are usually sinuated, while a somewhat similar form of shell is characteristic of *Ophileta*. Besides *M. magna*, we regard *M. bigsbyi* Hall, *M. logani* Salter, and *M. crenulata* Billings, as thoroughly in accordance with the requirements of the genus.

## Maclurea bigsbyi *Hall.*

PLATE LXXV, FIGS. 5—10.

*Maclurea bigsbyi* HALL, 1861, Geol. Rep. Wis., p. 37; WHITFIELD, 1882, Geol. of Wis., vol iv, p. 222, pl. VI, figs. 17 and 18; also 1895, Mem. Am. Mus. Nat. Hist., vol. i, p. 62, pl. VIII, figs. 14 and 15 (not 12 and 13).

Shell of medium size, ranging in diameter from 25 to 80 mm., usually 50 to 60 mm.; normal hight varying from five-twelfths to one-half of the width. Lower surface flat, the outer angle subacute; in casts more or less obtuse, and with the inner whorls somewhat rounded and the sutures generally much more distinct than on the shell itself. Umbilicus deep, rather abrupt, exposing half or more of each of the inner whorls, its width always greater than one-third of, and sometimes exceeding half the width of the entire shell; margin of umbilicus angular in shells, abruptly rounded in casts, the slopes convex on each whorl. Casts rarely retain traces of the surface markings. These consist of more or less obscure and irregular transverse lines and undulations, crossed on the peripheral region only by revolving lines a mm. or less apart. Operculum much as in *M. logani*, except that the nucleus is at the lower inner angle instead of in the center of the lower side.

The original localities for this species afford two closely allied species, a small one that is about 25 mm. in diameter, and a larger form that commonly is more than twice as wide. These two forms differ further in the relative size of the umbilicus, its width in the smaller form being in no observed case more than one-third of the width of the shell, while in the larger form it generally equals one-half. Under the circumstances it is highly probable that both forms were included by Hall in his *M. bigsbyi*, and it is a matter of considerable difficulty to decide as to which of the two is the better entitled to retain his name. The larger species being the more common and widely distributed, and undoubtedly the same as the best preserved and largest of the original types of the species figured by Whitfield in 1895, we have decided to restrict the application of the specific name *bigsbyi* to it, and to propose the new name *nitida* for the other.

*Formation and locality.*—Stones River group, Beloit, Janesville, Mineral Point, and other localities in southern Wisconsin; Dixon and La Salle, in Illinois; Lebanon and near Knoxville, Tennessee. Dr. F. W. Sardeson catalogues the species as occurring in the Vanuxemia bed in Minnesota, but we have not been able to verify its occurrence in the state.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, Nos. 7308, 7349.

## Maclurea bigsbyi var. dixonensis n. var., and Maclurea knoxvillensis *n. sp.* (*Ulrich.*)

(Not figured.)

Two other species of this type, both three inches or more in diameter, are known to us, in the one case from rocks holding *M. bigsbyi*, in the other in strata supposed to be equivalent or nearly so. The first, which was collected at Dixon, Illinois, is more depressed and has the margin of the umbilicus, which takes up about one-third of the diameter of the shell, moved farther inward so that its walls are almost vertical. As the form is easily recognized, we suggest the provisional designation *M. bigsbyi* var. *dixonensis*. The other was received from Prof. J. M. Safford, who collected the shell and opercula in the vicinity of Knoxville, Tennessee. As it deserves to rank as a distinct species, we propose the name *Maclurea knoxvillensis*. With a general aspect like *M. bigsbyi*, it differs decidedly in having less angular whorls and deep sutures on the flat side. The operculum, so far as the position of the nucleus is concerned, is more like that of *M. logani* than *M. bigsbyi*, but differs strongly from both in the fact that the nucleus is extremely prominent and twisted, recalling, somewhat feebly, a small ram's horn.

## Maclurea nitida, *n. sp.*

(Perhaps a small variety of *M. bigsbyi* Hall.)

PLATE LXXV, FIG. 11.

*Maclurea bigsbyi* (part) Hall, and Whitfield. (See description of that shell on page 1039.)

Shell rather small, 20 to 30 mm. wide, half as high, and resembling the young of *M. bigsbyi* in all respects save that (1) the umbilicus is narrower, in no case exceeding a third of the width of the shell, (2) less sharply defined, the turn into the umbilicus being abruptly rounded but never angular, (3) the transverse striæ between the umbilicus and periphery more regular and sharper, and (4) the transverse section of the whorls (see plate LXXV, fig. 9) a little different, the hight being relatively a trifle greater, and the section less obviously triangular. Remains of three or four revolving lines occur on the periphery of one specimen, but nothing of the kind is visible on any of the others.

*Formation and locality.*—Stones River group, Mineral Point and Beloit, Wisconsin; Dixon, Illinois, and Murfreesboro, Tennessee.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7356.

## Maclurea depressa, *n. sp.*

PLATE LXXV, FIGS. 1–4.

Shell of medium size, depressed, about 55 mm. wide, and 18 mm. high at the aperture; under side of whorls more or less distinctly concave, the outer and inner edges being somewhat elevated; inner edge forming a sharp ridge in casts of the interior; umbilical perforation abrupt, comparatively small though showing all the inner whorls, its width equalling less than a third of the diameter of the shell. Surface markings apparently as in *M. bigsbyi* Hall.

The concave under surface of the whorls, more depressed form, and smaller and more abruptly descending umbilicus are the differences relied on in distinguishing this species from *M. bigsbyi*. Variety *dixonenis* of that species, which might perhaps with better propriety be classed either as an intermediate species or as a variety of *M. depressa*, differs chiefly, if not solely, in the form of the under side of the whorls, these being flat or gently convex, as in *M. bigsbyi*, instead of concave.

*Formation and locality.*– Stones River group, Minneapolis, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 6858.

## Maclurea crassa, *n. sp.*, and var. macra, *n. var.*

PLATE LXXV, FIGS. 12–16.

Externally this species resembles *M. bigsbyi*, but, aside from the fact that it is a much heavier shell (on the outer and under sides of the last whorl it varies in thickness between the extremes of 3 mm. and 6 mm.), it differs in having the inner whorls convex and slightly elevated on the under side, the outer or peripheral angle more obtuse, and the umbilical depression wider. The width of the latter is to the diameter of the shell as 32 is to 58, the numbers representing the respective dimensions in millemeters of a testiferous example. Comparing casts of the interior of the two species, the differences are more obvious, the whorls of *M. crassa* being more slender and more rounded in section on the lower side especially, and the umbilicus open to such an extent that nearly the whole width of the inner whorl is exposed to view. Because of the extreme thickness of the shell, the suture, though very close on the exterior, is unusually deep in casts, while the mouth expands somewhat like a trumpet. Casts of the interior look very much like the exterior of the shell of *M. knoxvillensis;* yet even with this unequal comparison it will be observed that the umbilicus does not descend as abruptly as in that species, the convex slope being much more inclined giving a relatively greater width to the umbilicus at its narrowly rounded margin.

### Var MACRA, *n. var.*

PLATE LXXV, FIGS. 15 and 16.

The cast upon which this variety is based, was found at a lower horizon than that which holds the typical form. So far as we can see it differs only in being more depressed, the transverse and vertical diameters of the last whorl near the aperture being to each other respectively as four is to three. In the typical form the same dimensions are as four is to five. Part of this difference may be due to distortion—indeed we think it is, since at the inner end of the outer whorl the two dimensions are almost equal.

*Formation and locality.*—Of the typical form we have four specimens, from the Maclurea bed of the Trenton group, of which one was obtained from each of the following localities in Minnesota: Lime City, Stewartville, Pleasant Grove and Wykoff. One of these belongs to the Survey museum, the others to E. O. Ulrich. Var. *macra* was collected by the latter in the Fusispira bed at Hader.

*Museum Register*, No. 8442.

## Genus MACLURINA, n. gen.

This genus is proposed in accordance with our remarks on page 1038, for the reception of shells heretofore classed as *Maclurea,* but differing from the typical form of the genus in wanting the projections for the attachment of muscles on the inner side of the operculum. *Maclurea manitobensis* Whiteaves, the operculum of which is figured and described by Whiteaves in the Canadian Record of Science for April, 1893, is regarded as the type of the new genus. In this species the nucleus is at the junction of the lower and inner margin of the operculum, and we believe the same is true of *M. cuneata* and *M. subrotunda* of Whitfield, which with Whiteaves' species, are all that at the present time it seems safe to refer to *Maclurina.* Billings says of the operculum of his *M. oceana* that it has no muscular process, and he also figures the opercula of two otherwise unknown species which likewise are without such projections. But these opercula differ so widely from that of *M. manitobensis* that it seems highly improbable that they can belong to shells of the same genus.

### MACLURINA MANITOBENSIS *Whiteaves.*

PLATE LXXVI, FIGS. 4 and 5; PLATE LXXXII, FIG. 45.

*Maclurea manitobensis* WHITEAVES, 1890, Trans. Roy. Soc. Can., vol. vii, Sect. 4, p. 75; also 1893, Canadian Record of Science, p. 324.

*Original description.*—"Shell large, attaining to a maximum diameter of eight inches and a half, and consisting of about five somewhat slender volutions which increase rather slowly in size; outer volution nearly always distinctly angulated at the periphery. Left (under) side almost flat, but faintly depressed in the center in some specimens and as faintly raised in others; volution, as viewed on the flat side, very shallowly concave in the center and slightly raised on the outer margins; suture lightly impressed. Right (upper) side moderately convex (the greatest thickness or depth varying in different examples from two-fifths to one-third the maximum diameter); somewhat conical or subhemispherical, the outer volution obliquely flattened and narrowing very rapidly, but in a few specimens somewhat convexly, from the periphery to the umbilical margin; umbilicus deep, conical, and apparently about equal in breadth to one-fourth of the maximum diameter, though in all the specimens collected, the test is either imperfect or absent at the umbilical margin; aperture obliquely and rather narrowly subtrapeziform; outer lip apparently simple; test thick.

"Surface of the test on the left or flat side marked with irregularly disposed, but for the most part distant, transverse linear grooves or periodic arrests of growth, each of which curve gently backward in a very shallowly convex curve, and occasionally with a few striations which run parallel to them. In one of the specimens figured which is a little less than four inches in its greatest diameter, and in which the whole of the test is preserved on the flat side, there are six of these periodic arrests of growth on the outer volution, while the inner whorls are perfectly smooth. In larger but similarly preserved specimens, these arrests of growth which are not sufficiently deep to produce any impression on the casts, are somewhat more numerous and disposed at still more unequal intervals. On the right or convex side the test is ornamented with rounded spiral ribs of nearly equal size, and these are crossed by similarly shaped, straight and transverse costæ, in such a way as to present a somewhat nodulous appearance. The spiral ribs, however, seem to be rather broader than the narrow furrows between them while the transverse costæ are apparently equal in breadth to the regularly concave grooves which alternate with them."

The Minnesota specimens referred to this species are all, save one, mere casts of the interior, but they agree so well with Whiteaves' figures and descriptions that there is little room for doubt concerning their identity with the Manitoba types of the species. The excepted specimen preserves the shell on the inner whorls only, and shows that the first three or four turns are very small and rounded on the lower side. The specimen has a width of about four inches, and consists of nearly six whorls, at which rate the largest example should make about seven complete volutions. None of the examples seen retain any of the test of the convex side of the shell, nor have we seen good moulds of the exterior, hence we cannot say that they had revolving lines like those found on one of the specimens described by Whiteaves.

*Formation and locality.*—Maclurea bed of the Trenton group. Whiteaves (*loc. cit.*) mentions numerous localities in Manitoba. In Minnesota the species is not as abundant as the associated *M. cuneata*, but may be found at most localities in Goodhue, Dodge, Olmsted and Fillmore counties, where its particular horizon is exposed.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, No. 4105.

## MACLURINA CUNEATA *Whitfield.*

PLATE LXXVI, FIGS. 1–3; PLATE LXXXII, FIG. 46.

*Maclurea cuneata* WHITFIELD, 1878, Ann. Rep. Geol. Sur. Wis., p. 75; and 1882, Geol. Wis., vol. iv, p. 246, pl. IX, figs. 5—6.

The diameter in this species, as far as known, does not exceed three inches, while the umbilical perforation is very small; otherwise casts of the interior agree almost exactly with those of *M. manitobensis*. A single testiferous example belonging to Mr. Ulrich's collection has been observed. It is a very small specimen, being only 16 mm. in diameter, and embedded in the rock, but on being ground down so as to show a vertical section, it brings out as shown in fig. 46, pl. LXXXII, some interesting features. The specimen consists of three and a half whorls, all gently convex on the lower side but differing considerably in other respects. The first two and a half turns are coiled nearly in the same plane, so that they are almost entirely exposed on the upper or umbilical side. With the next turn, however, the umbilicus is greatly contracted and in the following half turn the normal or rather the specific characters of the shell are established.

*Formation and locality.*—Maclurea bed of the Trenton group. Casts are more or less abundant at Wykoff, Stewartville, Lime City and many other localities in the southern part of the state; Whitewater, Wisconsin; Dubuque, Iowa.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, No. 8440, 8441.

### MACLURINA SUBROTUNDA *Whitfield.*

(Not figured.)

*Maclurea subrotunda* WHITFIELD, 1878, Ann. Rep. Geol. Sur. Wis. for 1877, p. 75; and 1882, Geol. Wis., vol. iv, p. 246.

Two small casts, too imperfect for illustration, yet retaining enough characters to render their identification with this species almost certain, were found by Mr. Ulrich in the Maclurea bed at Stewartville, Minnesota. Evidently the species is not far removed from *M. cuneata*, but is a smaller shell, attaining, according to Whitfield, "a diameter of only about one and a half inches." The casts are proportionally higher than *M. cuneata* and the periphery much less acute, being almost vertical and rounded below where it joins the flat base. At Whitewater, Wisconsin, as in Minnesota, the species is associated with *M. cuneata*.

## Family TROCHONEMATIDÆ, n. fam.

Shells trochoid, turbiniform or somewhat planorbiform, perforate or imperforate; margin of aperture entire, simple, rarely trumpet-shaped, sometimes with a wide angled notch and carina in the upper or outer part; no slit nor distinguishable band; surface with several strong revolving ridges or more numerous spiral striæ; test very slightly or not at all nacreous. Operculum unknown, probably incapable of preservation.

While it is impossible at the present time to give a fair estimate of the probable limits of this family, we may yet say with confidence that it is connected on the one hand through *Trochonema* with the *Pleurotomariidæ* and *Euomphalidæ*, and on the other, through *Cyclonema*, with the *Turbinidæ*. We may say further that the *Trochidæ*, if we admit that the Gotland shells described by Lindstöm as of *Trochus* are really referable to that family, were derived from *Trochonema*. *Polytrophis*, DeKoninck, which because of its remarkable operculum deserves to rank as a separate family, also most probably was derived from certain members of the same genus. But as we will refer to these alliances in greater detail in our remarks on *Trochonema* and *Cyclonema*, it may suffice to say that to the best of our knowledge the *Trochonematidæ* may appropriately follow the *Pleurotomariidæ* and *Euomphalidæ* and precede the *Trochidæ*, *Polytrophidæ* and *Turbinidæ*.

Of described genera we place here *Trochonema* and the perhaps indistinguishable *Eunema* of Salter, *Cyclonema* and the closely related *Strophostylus* of Hall, and, with some doubt, *Holopea* of the same author; also *Craspedostoma*, Lindström. Besides these Mr. Ulrich proposes to establish and add two new genera which he regards as related to *Cyclonema*. The first of these he names DYERIA, in memory of the late C. B. Dyer, a former well-known collector at Cincinnati; the other BUCANOSPIRA, in allusion to the trumpet-like expansion of the aperture. Both of these genera may prove to have closer relations to *Platyceras* than we now believe.*

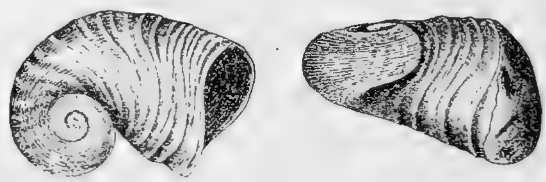

FIG. 8.—Two views of a large specimen of *Dyeria costata* James sp. from the upper half of the Lorraine group at Cincinnati, Ohio. Collection of E. O. Ulrich.

*Dyeria* is founded on a Cincinnati fossil originally described by Mr. U. P. James, as *Cyrtolites costatus*,† but since 1875 known to collectors as *Bucania costata*. Heretofore it was supposed that its whorls were coiled in the same plane, but, as may be seen from the accompanying illustrations of a full-grown specimen, this is not the case. Still, the coiling of the whorls may be more nearly in one plane than in the figured specimen—indeed, in one case before us the last whorl turns upward instead of downward According to our opinion *Dyeria costata*, as it should now be called, is in no wise related to any member of the *Bellerophontacea*, but on the contrary is not far removed from *Cyclonema*. The surface sculpture is of a type pertaining quite generally to that genus, even to the matter of the transverse wrinkles or undulations on the last whorl of old examples. It is true the margin of the lip and, therefore, the lines of growth, take a more undulating course in circling the whorls than in any *Cyclonema* known to us, but when a sinus does occur in the lip of a *Cyclonema* it is in a corresponding region or regions. However, *Dyeria* differs widely from that genus in the depressed—almost involute—form of its shell, in having a considerable part of the last whorl vagrant and nearly straight, and in the simple unthickened character of the inner lip. It remains to be seen whether the vagrant character of the last whorl is essential or not. If it is not then the genus may justly include forms like Lindström's *Euomphalus tuba*.

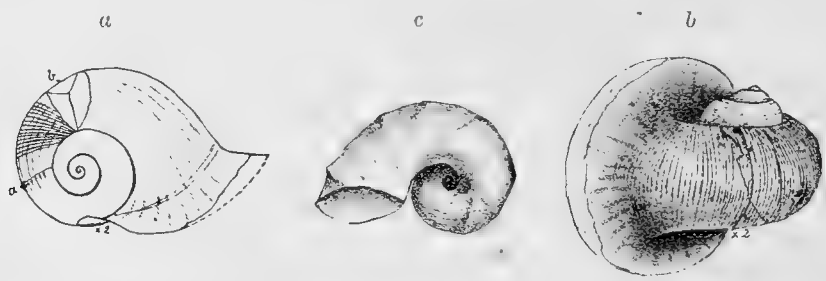


FIG. 9.—*Bucanospira expansa*, n. gen. et sp. (Ulrich), Niagara group, Wayne county, Tennessee. *a* and *b*, slightly restored views, X2, of a silicified shell, showing the expanded aperture, remains of preceding expansions (at *a* and *b* on fig. *a*), and surface markings; c, under side of the interior cast of a larger specimen with indications of numerous successive apertural expansions. The umbilicus is relatively larger and the spire lower in this specimen than in the first. Collection of E. O. Ulrich.

*Bucanospira* is based on an undescribed Upper Silurian shell from western Tennessee, for which we

* The *Platyceridæ* are greatly in need of revision. While the majority are doubtless referable to the capulids, many others belong near *Cyclonema* and *Dyeria* among the *Trochonematidæ*. Or, if that arrangement is not acceptable, then the latter family will have to be restricted to *Trochonema* and *Cyclonema*, and *Strophostylus* (which we extend so that it includes shells commonly arranged under *Cyclonema*), together with *Holopea*, *Dyeria* and *Bucanospira* removed to the *Calyptræidæ*; or a new intermediate family must be instituted for their reception.

† Amer. Jour. Sci. and Arts, 3d ser., vol. iii, p. 26, 1872; see also Meek, 1873, Pal. Ohio, vol. i, p. 150, pl. XIII, figs. 1a, 1e.

propose the specific name *expansa*. As we understand it, *Bucanospira* is a later modification of the type represented by *Dyeria costata*, differing mainly in this, that the aperture is abruptly and greatly expanded at intervals as growth proceeds. The old expansions are either all broken away, or, as is more likely, reabsorbed, giving a condition precisely as in *Tremanotus*. Each expansion, however, left its mark on the interior of the shell as may be seen from the cast of the interior figured above (Fig. 9c). In *Craspedostoma*, Lindström, which also has an expanded mouth, the expansion or border differs in being thick, cut out on the inner side so as to leave two projecting spurs, and in being developed at one—the closing—period only.

## Genus TROCHONEMA, Salter,

*Trochonema* and *Eunema* of SALTER, 1859, Can. Org. Rem., Dec. 1, p. 24.
? *Trochonemopsis*, MEEK, 1875, Pal. Ohio, vol. i, p. 219.
*Cyclonema* (part.) of HALL, SALTER and others.

Shell turbinate, umbilicated; spire varying in hight, base generally flattened yet sometimes quite ventricose; whorls not numerous (4—8), varying from strongly angular to rounded, always with two more or less prominent ridges or angles between which lies a broad vertical, usually flat or concave, peripheral space; a third ridge usually near the suture, while a fourth generally surrounds the umbilical cavity. Other, but smaller ridges may occur though chiefly on the basal half of the whorls. Lines of growth crossing the whorls from above obliquely backward, often vertical and not infrequently inclined in the opposite way on the peripheral band. In the last case the outer lip is broadly notched at the extremity of the upper peripheral angle. Aperture usually very oblique; peritreme complete; inner lip varying in thickness, not reflected. Type, *T. umbilicatum* Hall sp.

This excellent genus exhibits considerable variety in its contents. There is scarcely a single character that pertains strictly to all the species, yet, comparing one with the other, we find them so closely knit together that to separate them very far would mean nothing less than violence to natural classification. We do not mean to say that the genus may not be conveniently and yet naturally divided, or subdivided, if that is preferable. *Eunema*, Salter, the type species of which is scarcely more than a high and practically imperforate *Trochonema*, was established at the same time as *Trochonema*. As at present understood, *Eunema* is not a well-marked genus, while its employment even as a subgenus is attended with difficulties. It cannot be maintained on Salter's characterization, since in shells of this type the relative size of the umbilicus is a very unreliable generic character. However, if we will select another character of *E. strigillatum*, viz.: the very slight obliquity of its aperture, the group may have some value. A much better division may be instituted for the reception of the group of species typified by our *T. pulchellum* which eventually gave origin to *Cyclonema*. The separation of this group is certainly convenient since it leaves *Trochonema* (*s. s.*) as a more compact and sharply defined group. Brief definitions of these divisions follow:

Trochonema (*s. s.*), Salter.—Shells turbinate and more or less widely umbilicated; whorls angular, with a wide vertical peripheral band, marked off above and below by a more or less sharp angle or carina; often with a third carina at the suture and a fourth around the umbilicus. Aperture generally very oblique, chiefly in its lower part. Type, *T. umbilicatum* Hall.

Eunema, Salter.—In every respect like *Trochonema* save that the shells are generally higher, the umbilicus very narrow or closed entirely and the aperture very little oblique. Type, *E. strigillatum* Salter.

Gyronema, n. subgen. or gen.—Whorls generally more ventricose than in *Trochonema,* mouth only moderately oblique, umbilicus small, the surface, on the lower half especially, with numerous spiral ridges among which those corresponding with the two which bound the vertical peripheral band in *Trochonema* are sometimes not easily recognized. Type, *T.* (*G.*) *pulchellum,* n. sp.

Meek (Pal. Ohio, vol. i, p. 219) suggested, "at least as a subgeneric designation," the name *Trochonemopsis* for the Devonian shell which he called *T. tricarinata,* providing that the peritreme in this shell was really not continuous. He says of the inner lip that above the umbilicus "it seems to be nearly or quite obsolete." We have no evidence on the point in question, and, therefore, cannot say what should be done in the matter.

The various forms of *Trochonema* suggest affinities with several more or less widely different genera and families. In the first place we pass by rather easy gradations through *Gyronema* to *Cyclonema.* Our *G. pulchellum,* for instance, retains many of the typical characteristics of true *Trochonema.* The vertical peripheral band, despite the fact that it is traversed by a submedian carina, is still quite easily recognized. In *G. liratum* it is less apparent, but in this case we have considerable of an umbilical cavity, so that its relations to *Cyclonema* are not very apparent. In *G. percarinatum,* however, in which the umbilicus is very small, if not entirely wanting, the general aspect is decidedly like *Cyclonema varicosum* Hall. The only difference of any consequence is that the inner lip is thin and not reflected nor excavated as it should be in a true *Cyclonema.* But we have most positive evidence, showing that the development of the excavation of the inner lip was gradual in a species of *Cyclonema* from the Stones River group in Tennessee, closely related to *C. varicosum,* in which the inner lip is much thinner than usual and very little excavated. In short, this and other evidence before us, is such that we are fully satisfied that the best representatives of *Cyclonema* were derived from *Gyronema.*

On pages 962 and 989 we have already expressed our conviction that *Trochonema* and certain species provisionally referred to *Lophospira* are in some wise connected. That this is a fact can scarcely escape any one who will compare our figures of

*Lophospira trochonemoides* and *L. knoxvillensis* on plate LXXII with almost any of the species of *Trochonema* figured on plate LXXVII. As best suiting the purpose we may recommend *Trochonema bellulum*, *T. retrorsum* and *T. madisonense.* It will be observed that the two sets of shells agree closely in all respects save one, viz.: the former has the continuity of the lines of growth interrupted by a true "band" on the upper peripheral carina, while in the latter the angle is simple and does not interrupt the continuity of the lines.

Taking another set of species, *Trochonema* is brought into the closest kind of connection with some of the Upper Silurian shells which Lindström has placed in the genus *Trochus.* For instance, we ask, what marked difference exists between our *Trochonema arctatum* and *T. obsoletum* and Lindström's *Trochus dalli* and *T. wisbyensis?* There is none of any consequence that we can discover, so we are constrained to say if the first pair falls strictly within the limits of *Trochonema* then the second must also. And what is there about all four of them that will justify their separation from *Trochonema?* *T. arctatum* differs from our *T. robbinsi* and *T. niota* Hall sp., in having a narrower peripheral band. All of these three forms differ from the majority of the species of *Trochonema* in wanting the carina near the suture. But this deviation is surely not of more than specific importance since the absent carina is developed in our *T. simile*, a shell that, with a general aspect like *T. robbinsi*, has the upper side of the whorls concave instead of regularly sloping and a carina beneath the suture. Lindström's *Trochus lamellosus* also belongs to *Trochonema.* None of these species seems very intimately related to any of the other shells referred to *Trochus* by Lindström save perhaps his *T. fulminatus* and *T. mollis*, the latter of which is a modified *Cyclonema* not far removed from *C. transversum.* As to whether these other species are true *Trochidæ* or not, we have no opinion to offer at present, but some of them (*e. g.*, *T. lundgreni* and *T. stuxbergi*) doubtless stand in close genetic relationship with the Lower Silurian *Raphistomina.*

### Trochonema umbilicatum *Hall*, and varieties.

PLATE LXXVII, FIGS. 1–8.

*Pleurotomaria umbilicata* Hall, 1847, Pal. N. Y., vol. i, pp. 43 and 175.
*Trochonema umbilicata* Salter, 1859, Can. Org. Rem., Dec. I, p. 27, pl. vi, fig. 3.

There are several forms or varieties of this widely distributed species. The one that occurs in the Trenton limestone is usually regarded as the most typical of the species. It has rather low volutions, with a shoulder-like flat space bordering the suture and taking up about one-third of the width of the upper side, the remaining two-thirds being a concave slope to the peripheral band. This is almost exactly vertical and barely concave. The under surface from the lower peripheral angle to the subcentral ridge or angularity enclosing the umbilicus is a nearly flat slope. The shell is rather thin and the apertural margin in casts is much less expanded than in the similar *T. beachi.* Lower and inner portions of peritreme comparatively thin and not much reflected. Aperture very oblique. The surface markings are obscure on all save the last whorl, and here even they are never coarse, though often somewhat irregular. The lines are not quite vertical on the outer or peripheral face crossing it from above somewhat obliquely backward. On the lower side they sweep very strongly backward and grow stronger as they curve over the median angularity into the umbilicus. In the latter the surface is first flat, then convex. Specimens are usually not as large as the one shown in our fig. 2.

Many of the Stones River group specimens cannot be distinguished from the Trenton form, but occasionally we meet, in Tennessee especially, with a larger variety (see pl. LXXVII, figs. 7 and 8) which may be distinguished as var. *latum*. Its whorls are less concave on the upper slope and enlarge more rapidly than in the ordinary variety.

In Canada, at Pauquettes rapids, a variety occurs abundantly in the Black River limestone differing from the others in being relatively a little higher, very thin, with the lines of growth finer and more regular, and the umbilical carina sharper. Figures 4—6 are of a good, though rather young example of this variety. The same form was figured by Salter. It may be called var *canadensis*.

*Formation and locality.*—This species is found in the three beds of the Trenton group at many localities in Goodhue and Fillmore counties. We have not noticed it among the numerous Trochonemas of the Stones River group at Minneapolis and other points in the state, but it occurs in this formation in Wisconsin and Illinois; also in Kentucky, Tennessee, New York and Canada. While it is rather a common fossil through the greater part of the Trenton, and perhaps the Cincinnati period also, *good* specimens, of either casts or shells, must be counted as very rare. There is some doubt about the casts found at Cincinnati. They may or may not belong to this species.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, Nos. 7301, 8727.

## TROCHONEMA BEACHI ? *Whitfield.*

PLATE LXXVII, FIGS. 9—12.

? *Trochonema beachi* WHITFIELD, 1878, Ann. Rep. Geol. Sur. Wis., p. 74; also 1882, Geol. Wis., vol. iv, p. 213.

We have not been able to satisfy ourselves concerning the species intended by Prof. Whitfield to bear this name. It must be very closely related to *T. umbilicatum*, the only differences to be made out from the single view (dorsal) given by him being a thicker shell (producing the abrupt apertural expansion in the cast) and a slightly greater proportional hight of the volutions. The umbilicus is said to be much narrower and more abrupt, the spire higher and the shell smaller. On plate LXXVII, figure 11 represents a section of a small specimen from Dixon, Illinois, having apparently all the characters ascribed to *T. beachi*. The umbilicus, perhaps, is a trifle too large and the shell matter enclosing it somewhat thinner than in several other specimens that we refer here. The hight of the spire and general appearance of the shell is decidedly like the Canadian Black River variety of *T. umbilicatum* (see plate LXXVII, figures 4—6), but the lips are much thinner in that form. Except when the specimens are unusually good, it must always be a difficult matter to recognize *T. beachi*.

*Formation and locality.*—Stones River group, Minneapolis, Minnesota; Janesville and Beloit, Wisconsin, and Dixon, Illinois. A single example, apparently of the same form, from the Black River group at Curdsville, Kentucky.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

## TROCHONEMA BELOITENSE *Whitfield.*

PLATE LXXVIII, FIGS. 1—9.

*Trochonema beloitense* WHITFIELD, 1878, Ann. Rep. Geol. Sur. Wis., p. 74; and 1882, Geol. Wis., vol. iv, p. 212.

Though closely related to *T. umbilicatum*, this fine species is easily distinguished by its much more rapidly expanding and higher volutions, giving to the last whorl a much more ventricose appearance.

The test also is much thicker, the surface markings coarser, the angles more prominent, and the umbilicus smaller. The last whorl often shows a tendency to become disjoined, but this feature is never so pronounced as in our *T. vagrans.* Casts of the interior, because of the thick shell, have unusually rounded whorls, and these are even more readily distinguished from *T. umbilicatum* than are the shells. The upper of the two peripheral carinæ is always clearly indicated by a rounded ridge with minor revolving undulations as shown in our fig. 3. The lower carina, however, seems always to be but obscurely reproduced on casts. The umbilical ridge, on the other hand, is more distinct on casts than on the shell itself. As may be seen in fig. 4, it becomes quite obsolete with age. In the Minnesota form of the species the whorls seem always to be more slender than in specimens from Wisconsin.

*Formation and locality.*—Stones River group, Minneapolis and St. Paul, Minnesota; Mineral Point and Beloit, Wisconsin, and Dixon, Illinois.

*Collection.*—E. O. Ulrich.

## TROCHONEMA VAGRANS, *n. sp.*

PLATE LXXVII, FIG. 46; PLATE LXXVIII, FIGS. 10–13.

This form is closely related to *T. beloitense*—perhaps merely a variety of that species. It has more slender volutions, a thinner shell and, considering the size of the specimens, stronger surface markings. The shell being of only moderate thickness, the whorls of casts are also more angular. The last whorl is over half free and drops rapidly.

*Formation and locality.*—Stones River group, Vanuxemia bed, Minneapolis, Minnesota. Apparently a rare fossil.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

***Museum Register,*** No. 6865.

## TROCHONEMA RUGOSUM, *n. sp.*

PLATE LXXVII, FIGS. 19–22.

Shells of this species have a much smaller umbilical perforation than *T. umbilicatum.* This is due chiefly to the much thicker shell, the size of the umbilicus in casts of the two species being more nearly equal. For the same reason the mouth of *T. rugosum,* as seen on casts, appears to be abruptly expanded, especially upon the lower and outer sides. The upper side of the whorls (in casts) is also more strongly convex (not angular) in the inner half and more deeply concave in the outer. On both the cast and shell the two peripheral carinæ are more prominent, causing the space between to be more excavated. The surface markings are very coarse, turned backward on the upper side of the whorls, vertical on the concave peripheral face and again turned backward, though not as strongly as in *T. umbilicatum,* on the lower side. Here, particularly toward the aperture of adult examples, the striæ are often more numerous, sometimes two to one, than on the peripheral band.

*Formation and locality.*—Stones River group, Vanuxemia bed, Minneapolis and St. Paul, Minnesota; Beloit, Wisconsin.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

## TROCHONEMA ECCENTRICUM, *n. sp.* (*Ulrich.*)

PLATE LXXVII, FIGS. 17 and 18.

Young examples of this species must be almost indistinguishable from *T. umbilicatum,* the general aspect and surface markings being practically the same in both. Fully grown examples, however, are separated at once by the basal or umbilical ridge which, instead of maintaining a submedian position, is swung outward gradually in the latter half of the last turn until it is immediately beneath the periphery. This peculiarity results in well-marked differences in the shape of the mouth, the latter appearing more triangular than quadrangular in a ventral view though decidedly quadrangular in a basal view. The inner and lower lips also are more strongly reflected and thicker than in any other species of the genus known. And yet, the shell is not much thicker than in *T. umbilicatum.*

*Formation and locality.*—Upper division ("Glade limestone") of the Stones River group, near Lebanon, Tennessee.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

## Trochonema bellulum, *n. sp.* (*Ulrich.*)

PLATE LXXVII, FIGS. 26–29.

At first we were inclined to unite this species with *T. eccentricum,* but a more careful comparison revealed differences of sufficient importance to deserve recognition. In the first place the adult shell is much smaller, the width of the largest specimens being less than 25 mm. (in five out of six it is less than 20 mm.), while it is from 35 to 40 mm. in adult shells of *T. eccentricum.* Next, the apical angle is usually a trifle narrower, giving a proportionally higher spire. Finally, the lines of growth are finer and turn slightly forward instead of backward in crossing the concave peripheral space, thereby producing, with the retrally curved striæ of the upper side, a slight notch at the upper peripheral carina. Such a wide-angled notch occurs in three other species, viz.: *T. retrorsum, T. subcrassum* and *T. madisonense* of this report, but they are all readily distinguished from the present species by other characters. Compared with *T. umbilicatum, T. fragile* and other similar species, *T. bellulum* is distinguished at once by the eccentric sweep of the umbilical ridge and the subtriangular shape of the aperture resulting from it.

*Formation and locality.*—Lower division of the Stones River group, Murfreesboro, Tennessee.

*Collections.*—Prof. J. M. Safford; E. O. Ulrich.

## Trochonema fragile, *n. sp.*

PLATE LXXVII, FIGS. 13–16.

This is a small form, the greatest diameter averaging about 15 mm., the largest seen being only about 22 mm. wide. The specimens closely resemble young testiferous examples of *T. umbilicatum,* but it is to be noted that it is the internal cast that agrees in its general appearance with the exterior of that shell. We have not seen the exterior of *T. fragile,* but the unusual sharpness of the angles indicates a very thin fragile shell, probably similar, even to the surface markings, remains of very delicate equal lines of growth being retained by one of the specimens, to the variety of *T. umbilicatum* which we distinguish as var. *canadense.* The lower or umbilical side must be almost exactly as in that variety, but, judging from the differences exhibited between the interior and exterior of other species of the genus, the lower boundary of the vertical peripheral face must be even more prominent than in var. *canadense.* Further comparison brings to light another difference that we believe will serve to separate the species at all times from that variety. Namely, the uppermost of the four carinæ is proportionally much nearer the suture in *T. fragile,* being removed from it but little more than one-fifth of the width of the upper surface of the whorl; whereas in all the varieties of *T. umbilicatum* the distance equals at least a third. In this feature the speci s agrees with *T. subcrassum* and *T. retrorsum,* which see for comparisons. It is scarcely possible that *T. fragile* can be confounded with any of the other species here described.

*Formation and locality.*—Clitambonites and Fusispira beds of the Trenton group at various localities in Goodhue county, Minnesota. Also in beds equivalent to the latter horizon in Carroll county, Illinois.

*Collections.*—Geological and Natural History Survey of Minnesota (2 specimens); W. H. Scofield (3 specimens); E. O. Ulrich (7 specimens).

*Museum Register,* No. 8735.

## TROCHONEMA SUBCRASSUM, *n. sp.*

PLATE LXXVII, FIGS. 30–34.

The exterior of this form is in nearly all respects very similar to the internal casts of *T. fragile*, and the specimens were at first regarded as testiferous examples of that species. However, on removing the shell, it became evident that it is much thicker, especially at the angles, than it can possibly be in *T. fragile*, and that the internal cast is much less angular than are the casts of that species. Indeed, as is shown in fig. 33, the sharp external carinæ are only obscurely indicated on the interior cast. An equally important difference, and one that removes the species rather widely from all of the preceding species save *T. bellulum*, is the fact that the lines of growth, instead of continuing their general backward direction on the peripheral face, are here turned forward to form a wide-angled notch as in many species of *Lophospira*. The lines of growth are very fine on the whole with many that are readily discernible to the unassisted eye. On the base they are not as strongly turned backward as in *T. fragile* and most other species of the genus, so that the aperture is not as oblique as usual (compare plate LXXVII, figs. 15 and 30). The upper carina is very near the suture and sometimes scarcely removed from it.

The comparatively slight obliquity of the aperture in this and the next species (*T. retrorsum*) allies them with the forms included in the subgenus *Eunema*.

*Formation and locality.*—The types of this species are from the upper part of the Trenton group in Mercer and Boyle counties, Kentucky. A single cast of the interior, apparently belonging here, was found in the Fusispira bed near Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich (12 specimens).

## TROCHONEMA RETRORSUM, *n. sp.*

PLATE LXXVII, FIGS. 35—38.

In most respects like *T. subcrassum*, but the mouth is even less oblique, the umbilicus narrower and much more abrupt, the shell thinner, the inner lip straighter, and the lines of growth even finer and more regular. The almost vertical wall of the umbilicus and the very slight backward curve of the lines of growth on the base of the shell are two very striking features when the species is compared with *T. umbilicatum* and other species of that type. The mouth is pentagonal, the upper carina very near the suture.

*Formation and locality.*—Ctenodonda bed, Black River group, Goodhue county, Minnesota.

*Collection.*—E. O. Ulrich.

## TROCHONEMA MADISONENSE, *n. sp.* (*Ulrich.*)

PLATE LXXVII, FIGS. 23—25.

A large shell agreeing in most particulars with *T. umbilicatum*, but having relatively higher and more ventricose whorls, while the ridge, which generally surrounds the umbilical depression in this genus, is quite obsolete. The shell is thicker, the surface markings stronger, the mouth very oblique and with thicker lips. Casts of the interior of the two species are more alike than their exteriors, yet those of the present may be distinguished by the greater separation of the whorls due to the removal of a greater thickness of shell. There is a wide notch in the outer and upper portions of the peritreme which, with the somewhat triangular form of the aperture in a ventral view, suggests relations with *T. eccentricum*. Figures of that shell are given on the same plate with those of this species, so it is scarcely necessary to compare them further.

*Formation and locality.*—Richmond group, Madison, Indiana.

*Collection.*—E. O. Ulrich.

### TROCHONEMA NIOTA *Hall.*

PLATE LXXVI. FIGS. 16—18.

*Pleurotomaria niota* HALL, 1861; Geol. Sur. Wis. Rep. Prog., p. 33; WHITFIELD, 1895, Mem. Amer. Mus. Nat. Hist., vol. i, pt. ii, p. 60, plate VII, fig. 11.

*Original description.*—"Shell large, broadly subconical, the diameter through the last volution equal to about four-fifths of the hight, consisting of six volutions, which are flattened on the periphery, with a very slightly concave space upon the upper side, extending to the suture; lower side rounded into the moderately large umbilicus, the last volution large and ventricose.

"Surface character unknown, except a few undefined undulations near the extrémity of the last volution, which are more distinct below than above."

The above description is not very clear, and as Hall compares the species with his *Pleurotomaria subconica* and *P. bicincta*, saying that it is intermediate in form between them, we naturally failed to recognize the form until Whitfield (*loc. cit.*) figured the original type The specimen illustrated by us evidently is in better condition than the type, and shows clearly that it has no affinities with the two species with which Hall compares his specimen. It is nothing more nor less than a high-spired *Trochonema*, with a very small umbilicus for this genus. The upper slope of the whorls is more concave than shown in Whitfield's figure. The lower lip was broadly sinuated, the inner almost vertical, while the shell appears to have been thin and the surface markings not very strong.

*Formation and locality.*—Buff limestone (? Stones River group), Beloit, Wisconsin, where the specimen here used was collected by Mr. H. C. Powers.

*Collection.*—E. O. Ulrich.

### TROCHONEMA ALTUM, *n. sp.*

PLATE LXXVII. FIGS. 39—41.

The cast of the interior figured on plate LXXVII is all we have seen of this species. It evidently represents a *Trochonema* with an unusually high spire, minute umbilicus, wide peripheral band and slightly convex rather than concave upper slope. In some respects it reminds one of *T. niota* Hall sp., but has a wider peripheral band, more rounded whorls, and seems to have been a much smaller shell. We know of no other species near enough to require comparisons.

Both *T. altum* and *T. niota* form relatively high shells, and might therefore be referred to the subgenus *Eunema*, but as their mouths are oblique we think it best to leave them in the typical section of the genus.

*Formation and locality.*—Lower half of Fusispira bed, Trenton group, near Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich.

## Subgenus EUNEMA, Salter.

*Eunema*, SALTER, 1859, Canadian Organic Remains, Dec. I, pp. 24 and 29.

This term may be employed provisionally as a subgeneric designation under *Trochonema*. As defined on p. 1046, it will include, besides the type, *E. strigillatum* Salter, the following six species. In none of the latter is the spire as high as in Salter's species, but all have about the same kind of mouth, and that we deem of more consequence than either the hight of the spire or the size of the umbilicus. *E. pagoda* Salter and *E. prisca* Billings are widely different, being *Pleurotomariidæ* (see p. 1021).

## Trochonema (Eunema) salteri, *n. sp.*

PLATE LXXVII, FIGS. 42–43

Shell 20 to 30 mm. in hight; width across the body whorl about three-fourths of the hight; apical angle about 65°. Whorls four or five, angular, with a gently concave slope above nearly to the suture, and an equally wide vertical flat peripheral band; base moderately ventricose, umbilicus extremely small or wanting; close to the suture a slight angularity. Of the two peripheral angles the upper is the more prominent, the lower being comparatively obscure, especially near the aperture. Lines of growth fine, crossing the whorls somewhat obliquely backward and downward, the direction being almost uniform on all parts; slightly sinuate on the base. Aperture obscurely triangular in outline, somewhat effuse below, with the inner lip nearly straight.

*Eunema strigillatum* Salter is a higher shell, and differs more importantly in having the lines of growth turned forward instead of backward after crossing the upper of the two peripheral carinæ.

*T. salteri* resembles species of *Lophospira* very greatly, and collectors may find it difficult to recognize unless they are fortunate enough to meet with good specimens retaining either the mouth or some of the surface markings.

*Formation and locality.*—Lower half of Fusispira bed, Trenton group, Goodhue county, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota ; E. O. Ulrich.

*Museum Register*, No. 7375.

## Trochonema (Eunema) nitidum, *n. sp.* (*Ulrich.*)

PLATE LXXVII. FIGS. 44 and 45.

Related to *T. salteri*, but has a shorter and smaller spire, and proportionally larger and much more ventricose body whorl. The lower margin of the peripheral band also is more obscure, the upper slope more concave, the lines of growth very fine and more nearly vertical, the inner lip not so straight and the aperture less oblique and more ovate. The specimen illustrated may be said to be of the average size, though we have an interior cast of one that was fully twice as large.

*Formation and locality.*—Utica group, Cincinnati, Ohio, and localities in the vicinity of that city.

*Collection.*—E. O. Ulrich.

## Trochonema (Eunema) robbinsi, *n. sp.*

PLATE LXXVI. FIGS. 11–15.

This also is related to *T. salteri*, yet may be distinguished very easily by its more depressed, subconical, shape, much less ventricose base, perfectly even and longer upper slope, and more prominent and sharper lower angle. The umbilical perforation is very small and mostly covered by the reflexed inner lip.

The specific name is given in honor of Dr. C. H. Robbins, of Wykoff, who first brought the shell to our notice. We are indebted to this gentleman for many good specimens and courtesies while visiting his locality.

*Formation and locality.*—Fusispira bed, Wykoff, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7516.

## Trochonema (Eunema) simile, *n. sp.*

(Not figured.)

This form is in some respects intermediate between *T. salteri* and *T. robbinsi*, being more depressed than the former and not as much as the latter. The angles are slightly more prominent than in either, and the peripheral band is somewhat concave, while the upper slope shows a swelling in the upper half or a blunt ridge close to the suture and is concave for the rest. Care is required in distinguishing casts of this and several species of *Lophospira*.

*Formation and locality.*—Fusispira bed of the Trenton group, Wykoff, Minnesota.

*Collection.*—E. O. Ulrich.

### TROCHONEMA (EUNEMA) ARCTATUM, *n. sp.* (*Ulrich.*)

PLATE LXXVI, FIGS 9 and 10.

Shell small, about 9 mm. in hight, narrow, subconical, the apical angle about 58°; peripheral band unusually narrow, about half as wide as the upper slope, pitching inward, the upper margin being more prominently angular or keeled than the lower; upper slope slightly concave in the lower half and convex in the upper; base depressed convex, umbilical perforation small but distinct; aperture not very oblique, subovate, rounded on the inner side, higher than wide. The lines of growth are very fine. As near as they can be made out, they cross the whorls at about the same angle as in *T. robbinsi.*

The peripheral band is so narrow that the shell is very apt to be mistaken for one of the *Pleurotomariidæ.* Sardeson describes a *Pleurotomaria clivosa* from the Black River shales at Minneapolis that looks so much like *T. arctatum* that we suspect it belongs to this genus.

*Formation and locality.*—Upper part of Trenton group, near Burgin, Kentucky.

*Collection.*—E. O. Ulrich.

### TROCHONEMA (EUNEMA) OBSOLETUM, *n. sp.* (*Ulrich.*)

PLATE LXXVI, FIGS. 6–8.

Excepting the body whorl, this small shell would differ from *T. arctatum* only in being a trifle wider but with the last whorl it assumes a very different expression. The last whorl namely is relatively quite rounded, the upper slope being inflated and the base somewhat ventricose, while between the two the peripheral band is scarcely distinguishable. The lines of growth, while extremely delicate on the upper whorls and still fine on the last, are nevertheless much stronger here, with now and then a wrinkle that is distinctly visible to the naked eye. The axis seems not to be perforated, the central part of the base being merely sunken in.

*Formation and locality.*—Upper part of Trenton group, near Burgin, Kentucky.

*Collection.*—E. O. Ulrich.

## Subgenus (?genus) GYRONEMA, Ulrich.

This group of species occupies an intermediate position between the true *Trochonemas* and *Cyclonema.* (See remarks and definition pp. 1045 to 1047.) As we believe the division is important and well founded in nature, we shall employ it here in the sense of a full genus.

### GYRONEMA PULCHELLUM, *n. sp.*

PLATE LXXVIII, FIGS. 19–21.

Shell small, 9 to 17 mm. in hight; greatest width of body whorl, which constitutes much the greater part of the shell, equalling about three-fourths of the hight; apical angle about 85°. Whorls six and a half in an entire shell, the first two minute, rounded, glassy, and perfectly smooth, the third gradually assuming the angles of the following turns. Body whorl divided into three subequal regions; first, the upper slope, of which the inner third is almost horizontal and the outer two-thirds a strongly concave slope, a sharp angle or ridge dividing the two parts; second, the peripheral band, which is nearly vertical, margined on each side by a sharp carina and rendered somewhat bi-concave by a smaller carina, which first makes its appearance on the fifth whorl, lying slightly beneath the middle of the space; and third the basal part of the whorl is flattened rather than ventricose and traversed by five or six small revolving ridges and furrows, the last of which marks off the boundary of the small umbilical perforation. Surface showing very fine and rather regular lines of growth which cross the whorls from above somewhat obliquely backward. On one beautifully preserved example the whole surface, when highly magnified, is seen to be covered with a crowded set of extremely delicate revolving lines. Aperture subovate or somewhat hexagonal, its hight slightly exceeding the width; peritreme thin, the inner lip reflected partly over the umbilicus.

*Formation and locality.*—Ctenodonta bed of the shales of the Black River group, Minneapolis, Chatfield and near Cannon Falls, Minnesota; also in the limestones of this group in Mercer county, Kentucky.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 6854.

## GYRONEMA SEMICARINATUM *Salter.*

PLATE LXXVIII, FIGS. 17 and 18.

*Cyclonema semicarinata* SALTER, 1859, Can. Org. Rem., Dec. I, p. 27, pl. VI, figs. 2 and 2*a*, not 2*b*.

This species is distinguished from *G. pulchellum* by its stronger lines of growth, and the much greater prominence of the carina which corresponds with the upper boundary of the vertical peripheral band in that species. The lower boundary is only very slightly more prominent than the rest of the six or seven revolving carinæ which lie beneath the principal keel. The upper slope of the whorls also is somewhat wider than in *G. pulchellum*, and, furthermore, may be, as in the specimen figured, divided on the last whorl by an extra small median carina. This extra carina is probably not of much consequence since it occurs only on a part of the last whorl in our specimen, and is neither mentioned nor illustrated by Salter.

We have not the least doubt concerning the specific identity of the Minnesota specimen and the shell represented by Salter's figures 2 and 2*a* (*loc. cit.*), but we cannot say as much for his fig. 2*b*. The last might pass very well for our *G. pulchellum* since it gives the peripheral band as nearly vertical, the carina which forms its lower boundary being nearly or quite as prominent as the upper. The upper slope, however, is not as concave as it should be in our species.

*Formation and locality.*—Phylloporina bed of the shales of the Black River group, near Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich.

## GYRONEMA DUPLICATUM, *n. sp.*

PLATE LXXVIII, FIGS. 22—25.

Comp. *Pleurotomaria percarinata* HALL, 1847, Pal. N. Y., vol. i, p. 177, pl. XXXVIII, fig. 4.

This is distinguished from *G. pulchellum*, which it resembles in a general way much more closely than it does *G. semicarinatum* Salter sp., by its larger size, entirely closed umbilicus, and less angular whorls. The carina on the upper slope of the whorls is less prominent and smaller (in casts of the interior it looks more like a thick swelling than a carina), and on the last whorl it is apparently always divided into two thin lines. Between these and the upper peripheral angle, which is the strongest but not the most prominent on the whorl, the surface is concave, but not as deeply so as in *G. pulchellum*. The lower keel of the peripheral band is not always readily distinguished since it is followed on the slightly ventricose base by six or seven similar though generally somewhat smaller carinæ, while above it there is at least one prominent keel in the middle of the peripheral band. Occasionally this median keel is double, as in fig. 22, or there may be a smaller carina between it and the lower peripheral keel, as in figs. 23 and 24. The lines of growth are rather obscure on our specimens, but apparently they are not as fine nor as regular as in *G. pulchellum*. The duplication of some of the carinæ is a peculiar feature.

This species is generally identified with Hall's *Pleurotomaria percarinata*, an upper Trenton shell from New York that is now commonly referred to *Cyclonema*. Assuming that Hall's figure of his type specimen (*loc. cit.*) is correct, we would say that the northwestern form above described cannot possibly be the same species.

*Formation and locality.*—Stones River group, possibly also Black River group, at Beloit and other localities in Wisconsin, and Dixon, Illinois. We are informed that it occurs at Minneapolis and St. Paul, but have not succeeded in obtaining it from any point in Minnesota.

*Collections.*—University of Wisconsin; E. O. Ulrich.

### GYRONEMA LIRATUM, *n. sp.*

PLATE LXXVIII, FIGS. 14–16.

The peculiarities of this fine species are very well shown in our illustrations. It is related to *G. pulchellum* and *G. duplicatum*, but is distinguished at once from both by its much larger umbilicus and more rapidly spreading and rounder volutions. The specimen is a cast, partly of the exterior and partly interior. The former shows about fourteen revolving carinæ and thick lines on the last volution, among which the two which correspond with the upper and lower boundaries of the peripheral band in other species are distinguished with some difficulty. They are a little stronger than the others excepting one equally strong and a trifle more prominent which lies midway between them. Only these three are indicated on the interior of the body whorl.

*Formation and locality.*—Stones River group, Beloit, Wisconsin.

*Collection.*—E. O. Ulrich.

## Genus CYCLONEMA, Hall.

In part *Pleurotomaria* of CONRAD and HALL.

*Cyclonema*, HALL, 1852, Pal. of N. Y., vol. ii, p. 89; SALTER, 1859, Can Org. Rem., Dec. 1, p. 23. Not *Cyclonema*, (HALL) LINDSTRÖM, 1884, Sil. Gast. and Pter. of Gotland, p. 174

Shell turbinate or conical, never thick, composed of few more or less ventricose whorls; no umbilicus; surface sculpture consisting of numerous revolving lines and small ridges crossed obliquely by sharp lines of growth; aperture oblique, varying from rounded to subquadrate; inner lip more or less thickened, reflected, always excavated. Types, *C. bilix* Conrad and *C. mediale* Ulrich.

The principal characteristic of this genus is the excavation of the inner or columellar lip. This peculiarity distinguishes the genus at once from *Gyronema* which includes some otherwise not very different shells. In *Strophostylus* there is a fold on the inner lip, forming a similar excavation, but it is generally so much twisted that its upper end is not visible in a direct view of the mouth. As a rule also the inner lip is much thicker than in *Cyclonema*. It seems a little strange that the relations of *Cyclonema* and *Strophostylus* have not been recognized heretofore. They are certainly very closely related and in practice it is often difficult to distinguish them. But if we are correct in deriving *Cyclonema* from *Gyronema* then the two groups must have different roots. The oldest known shells (Stones River group) that are strictly referable to *Cyclonema* have relatively coarse revolving ridges. In our *Strophostylus textilis,* on the other hand, the revolving lines are very delicate. The difference is so marked that we cannot believe that *Strophostylus* came from the same immediate root as *Cyclonema.* In our opinion they represent two independent lines.

The composition of the shell of *Cyclonema* must be different from that of the majority of Lower Silurian Gastropoda. On the hills about Cincinnati, where thousands of specimens have been collected, the test is preserved when all the other shells occur as casts of the interior only. Indeed, we have never seen a natural cast of *Cyclonema.* Another point worthy of notice is the extreme rarity of specimens retaining the apical nucleus. Out of considerably over one thousand good shells before us only six retain the apex entirely. In nearly all of the other cases the evidence at hand seems to show that these minute whorls were lost during the life of the shell, or, at any rate, before fossilization, while in four of the six specimens preserving them they were covered and protected by an encrusting bryozoan.

The nuclei seen belong to four species, *C. bilix* var. *fluctuatum, C. gracile, C. mediale* and *C. inflatum,* the last of which may be but a well-marked variety of the third. In all the nucleus has a glassy appearance, with the first two whorls perfectly smooth, the third with distinct transverse lines only, and all three round and coiled so as to form a blunt apex to the shell. The generic and specific characters begin with the fourth whorl. In *C. bilix* and *C. gracile* the whorls decrease very gradually to the first two, but in *C. inflatum* the third and fourth whorls, with a part of the fifth, are wound into a subcylindrical coil on top of the rapidly expanding succeeding volutions. In *C. mediale* the conditions may be described as intermediate. Considering the character of the nucleus in these four representative species, it appears that the original stock from which *Cyclonema* sprang was a low-spired *Holopea*-like shell.

So far, but a single true *Cyclonema* is known to us from Minnesota. Other Minnesota shells have been placed in the genus, but in our opinion they do not belong here. In order that the reader may get an adequate and just idea of the genus, and also that the genus may be properly established, we have decided to include a number of species that have not yet been found in the upper Mississippi region.

Many species have been placed in *Cyclonema* that do not belong there. Some belong to *Gyronema,* as for instance, *C. percarinatum* Hall sp., *C. semicarinatum* Salter, *C. nodulosum* Lindström and *C. carinatum* (Sowerby) Lindström; others, like *C.*

*cancellatum* Lindström (not Hall's sp.), to *Strophostylus* as here understood. We have not had an opportunity to examine any of the Devonian species that are referred to *Cyclonema* by various authors, but judging from the literature alone we feel satisfied that not one has a sufficient right to maintain its position in the genus. Lindstöm's description of *Cyclonema* is incorrect since it is based principally or solely upon the Gotlandic species described by him. He places the genus into the immediate vicinity of *Polytropis* (*Oriostoma*) because he has found an operculum similar to the type prevailing in that genus in Hisinger's *Turbo striatus* which he places, together with several similar and other very different shells from Gotland, under *Cyclonema*. Though we have collected thousands of specimens of typical species of *Cyclonema*, not a single operculum of any kind has ever occurred in connection with them. We conclude, therefore, that *Cyclonema* had no operculum, at any rate none that could be preserved as a fossil.

### CYCLONEMA BILIX *Conrad.*

PLATE LXXVIII, FIGS. 35–42.

*Pleurotomaria bilix* CONRAD, 1842, Jour. Acad. Nat. Sci. Phila., vol. viii, p. 271; (part.) HALL, 1847, Pal. N. Y., vol. i, p. 305.
*Cyclonema bilix* HALL, 1852, Pal. N. Y., vol. ii, p. 89.
*Cyclonema bilix* (part.) HALL, MEEK, MILLER, and others.

Shell subconical, the hight and width equal, or the hight may exceed the width by as much as one-fifth or in rare cases even one-fourth; apical angle varying from 55° to 75°. Whorls generally three or four in number, the nucleus, consisting of three more, being absent in nearly every instance. In the typical form the whorls are depressed convex, flat or even a trifle concave in the central part of the exposed slope while at the top there is nearly always a small shoulder-like convexity which, with a similar convexity at the bottom, produces a distinctly impressed suture. Base of body whorl more or less flattened, narrowly rounded at the periphery; no umbilicus. Aperture oblique, somewhat triangular in a view of the base-subquadrate in a ventral view, the upper and inner sides of about the same length, and each about two, thirds as long as the lower side, while the outer side equals in length both the inner and upper sides; inner lip excavated, the excavated portion narrowly crescentic in shape, gently concave or straight on the inner side and strongly convex on the outer, usually 1.5 mm. across its widest part, rarely 2.0 mm. or more in old shells; inner margin of excavation sharp below, becoming more and more rounded toward the upper extremity where it turns sharply into the mouth. Surface marked by numerous, small, more or less regular revolving ridges and by much finer, sharply elevated, lines crossing the whorls from above obliquely downward and backward. On the outer surface of the upper whorls the revolving lines are mostly of the same size with from nine to twelve on each. On the body whorl where a new set is interpolated they generally alternate in size, with an average of ten or eleven in 5 mm. Of the oblique transverse lines, which run parallel with the margin of the aperture and are more closely arranged in this species than usual for the genus, the number in 5 mm. on the last whorl averages about thirty but varies between the extremes of twenty-five and forty. The last whorl of old examples usually exhibits more or less numerous irregula undulations and wrinkles of growth which generally cause some irregularity in the surface orna mentation.

The hight of specimens usually varies between 15 and 20 mm ; occasionally it may reach 30 mm.

We could not satisfy ourselves that *Cyclonema fluctuatum* James is more than a good variety of *C. bilix.* Mr. James included in his species some specimens that do not deserve to be distinguished even as a variety, but we believe the majority of his types are of an abundant variety that is generally quite easily distinguished from the typical form of the species,as above described, by having much finer surface markings and the outer surface of the whorls almost constantly concave. The undulations of the surface, though occurring more commonly in this form than in any other, are not considered of much importance. As the more delicately sculptured variety deserves some recognition we propose to retain Mr. James' name in a reduced sense for it, so it may be known hereafter as *C. bilix* var. *fluctuatum.*

Meek's *C. bilix* var. *lata* (Pal. Ohio, vol. i, p. 152) seems to rest on nothing more than an unusually depressed and somewhat abnormally coiled old shell of the typical form of the species. What *he* calls the typical form of the species is something quite different, being one of the forms of our *C. mediale*, while the high shell represented by his fig. 5*g* on plate XIII, which is the type of Miller's var. *conicum*, really belongs to the species as restricted by us. The spire in the last being higher than usual, the name *conicum* might be retained for it, but after an exhaustive study of a large number of specimens we are forced to the conviction that the relative hight of the spire is a very unreliable character, each species and variety exhibiting great variability in this respect. The form of the whorls is a better character, but of all the surface markings have served us best in separating the various species.

In the great confusion prevailing among collectors and authors concerning the species of *Cyclonema* occurring in the region about Cincinnati, we have found it no small task to select the particular form which has the best right to bear Conrad's original name, *bilix.* The significant points about Conrad's brief description are: (1) that the sides of the volutions are "suddenly contracted at the suture," (2) the periphery is abruptly rounded, (3) the base flattened and (4) the locality, Richmond, Indiana.*

We have a number of good specimens (about sixty, exclusive of an even greater number of the var *fluctuatum*) from Richmond and Versailles in Indiana, and localities in Ohio exposing equivalent horizons, agreeing in all essential respects with the specimen illustrated on plate LXXVIII, and which, to the best of our knowledge, are of the same species as the one figured by Conrad. A rare variety with more convex whorls occurs in the Lorraine group at Cincinnati, but this is not the same as either of the two from that locality which have been sent to all parts of the world as *C. bilix.* The typical form of the species was lost sight of and the more easily obtained Cincinnati forms, which careless or interested observers had said were the same, took its place. Excepting the variety mentioned, *C. bilix* is restricted to the Richmond group and, therefore, does not occur at Cincinnati.

We cannot agree with the practices of certain paleontologists who, either because they are incapable of separating the forms, or unwilling to take the trouble, would have us classify all the *Cyclonema* of the Cincinnati and Trenton periods as one species. The following forms are as good "species" as any, and as each represents a recognizable and sufficiently permanent stage in the evolution of the genus, each with its own set of varieties or mutations, they deserve the notice of the systematist. The more experienced and careful collectors long ago separated the common forms, not only because they were different but because they found them at different horizons.

*Formation and locality.*—Richmond group, Richmond, Versailles, and Madison, Indiana; Oxford Waynesville, Blanchester and numerous other points in Ohio. Fragments apparently of this species were seen at Sterling and Savannah, Illinois, and there is no reason known why it may not occur also in southern Minnesota.

*Collection.*—E. O. Ulrich.

## CYCLONEMA MEDIALE, *n. sp.* (*Ulrich.*)

PLATE LXXVIII, FIGS. 29 and 30.

*Cyclonema bilix* (part.) HALL, MEEK and other authors; not CONRAD.

Distinguished from *C. bilix* Conrad, by its more ventricose whorls and stronger revolving carinæ. The under side of the whorls is fuller and the outer side (seen in the spire) is always distinctly and uniformly convex, there being no sign of a shoulder at the suture, nor of the median concavity, both of

*The original description reads as follows:—

*P. bilix*, Pl. XVI, fig. 10.—Spire conical; volutions four; sides subrectilinear at base, suddenly contracted at the suture; surface with spiral raised striæ alternated in size; large volution abruptly rounded in its greatest circumference, base flattened and striated.

*Locality.*—Richmond, Indiana, in limestone of the age of the rocks of Salmon River series, New York. Lower Silurian which occur quite generally in Conrad's species. The suture is comparatively shallow. There are two common varieties, one having three widely separated strong carinæ on the upper slope followed below by smaller and gradually decreasing and crowding ridges or lines, the last occurring usually about the middle of the base. Much thinner revolving lines generally occur between the larger. In the other variety (see figures) the revolving ridges are more equal in size and distribution, and at least three more in number. On the body whorl they number between fifteen and twenty, but not more than eight or ten of these show on the next whorl above, while in the first variety but four are shown. The apical angle for the whole shell varies greatly but always is narrower for the upper turns than it is for the last two or three.

The strongly carinated variety resembles and probably was derived from *C. varicosum* Hall, but its whorls are less convex and the upper part of the spire more slender, the entire shell of *C. mediale* consisting of six or seven whorls, while *C. varicosum* probably never has more than five volutions. The columellar lip also is straighter and both the revolving and transverse ridges and lines stronger in Hall's species.

*Formation and locality.*—This is an abundant and highly characteristic fossil of the lower half of the Lorraine group in Ohio, Kentucky and Indiana. We have over two hundred specimens from the vicinity of Cincinnati.

*Collection.*—E. O. Ulrich.

## CYCLONEMA INFLATUM, *n. sp.* (*Ulrich.*)

PLATE LXXVIII, FIGS. 31 and 32.

Shell of medium size, consisting, as usually found, of about four rounded whorls; with the apex entire there are in all about seven whorls, the first four forming a narrow truncated cone, the two turns at the apex being coiled in a very wide angle; succeeding whorls spreading more rapidly, the angle increasing in some extreme cases from 40° to 90°; mouth rounded, quadrangular; surface strongly carinated spirally, the carinæ on the upper half of the whorls more distant than those on the lower, fifteen to twenty in all on the body whorl.

This species agrees closely in its surface markings with certain varieties of *C. mediale;* and perhaps it also should be regarded as an extreme variety of that species. Generally it is readily distinguished by its more convex whorls.

*Formation and locality.*—Lower half of the Lorraine group Cincinnati and vicinity

*Collection.*—E. O. Ulrich. (25 specimens.)

## CYCLONEMA VARICOSUM *Hall.*

PLATE LXXVIII, FIGS. 27 and 28.

*Cyclonema* (*ventricosa* in error for) *varicosa* HALL, 1870, Twenty-fourth Rep. N. Y. St. Mus. Nat. Hist., pl. VIII. (Not defined.)
*Cyclonema cincinnatiense* MILLER, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 230.

Though closely related to *C. mediale* this shell is still easily distinguished by its straighter columellar lip, fewer, stronger and sharper revolving and tranverse surface markings, deeper suture and more convex whorls. The revolving ridges, especially those on the outer side of the whorls, are very strong and prominent. Between each two there are usually several much thinner lines. Of the principal carinæ the body whorl has only nine or ten, and of these only five or six are shown on the whorls above the last.

*Cyclonema cincinnatiense* Miller is founded on small examples of this species obtained from the upper beds of the Trenton group opposite the city of Cincinnati.

*Formation and locality*—Two imperfect specimens of this species were collected at Wykoff, Minnesota, where they were found in the upper part of the Fusispira bed. The original type was obtained from the upper part of the Trenton group at Nashville, Tennessee. The species occupies the same position at Colby, Kentucky, and in the vicinity of Cincinnati.

*Collection.*—E. O. Ulrich. (15 specimens.)

## Cyclonema humerosum, *n. sp.* (*Ulrich.*)

PLATE LXXVIII, FIGS. 43–46.

The average size in this species is somewhat greater than in either of the preceding forms, while the apical angle is generally wider and more constant, the majority of the specimens varying comparatively but little either way from 85°. The principal feature, however, is a strongly developed shoulder, giving a deeper suture than in any other species of the genus. This shoulder may be rounded or, especially in the Richmond group form, quite angular. In the latter the slope of the outer side of the last whorl is very often distinctly concave, and not infrequently undulated in the direction of the lines of growth. The same conditions occur less frequently though quite as well marked in the Lorraine form. The surface markings are fairly constant. About ten principal subequal carinæ occur on the outer slope of the body whorl, and about the same number of smaller ones on the periphery and base. The larger ones usually alternate with a much thinner set.

*Formation and locality.*—Very abundant in the upper half of the Lorraine group at Cincinnati, and not rare at several horizons in the Richmond group, at Waynesville, Clarksville, Oxford and other localities in Ohio. Also at Richmond, Versailles and other points in Indiana.

*Collection.*—E. O. Ulrich.

## Cyclonema pyramidatum *James.*

PLATE LXXVIII, FIGS. 33 and 34.

*Cyclonema pyramidata* James, 1874, Cin. Quar. Jour. Sci., vol. i., p. 152.

In its typical form it is scarcely possible to confound this species with any other known, but there are varieties, one of which shows its derivation from *C. mediale*—the starting point for most of the Cincinnati species of *Cyclonema*—while another develops a shoulder at the top of the whorls, causing it to resemble *C. humerosum.* One of the best characters is the extension of the spiral striation over the entire base. In most of the other forms the spiral lines extend only about half across the base, the inner part having transverse striæ only.

*Formation and locality.*—Lorraine group, Cincinnati and vicinity.

*Collection.*—E. O. Ulrich.

## Cyclonema simulans, *n. sp.* (*Ulrich.*)

PLATE LXXVIII, FIG. 47.

Of this species we have about fifty specimens. These show that the shell is of medium size, with a general form about intermediate between *C. humerosum* and *C. mediale*, though rather nearer the former, there being usually a small shoulder and a flattening or even a slight concavity of the outer slope of the last whorl. It is distinguished from both by its surface markings. These consist as usual of revolving and obliquely transverse lines, but the former are much weaker on the last two whorls and often quite obsolete near the mouth, while the latter are more distant excepting in the last third of the body whorl of old examples. In the latter the mouth is sometimes irregularly expanded and thrown upward along the suture.

*Formation and locality*—Upper division of the Lorraine group at Cincinnati, Ohio.

*Collection.*—E. O. Ulrich.

## Cyclonema sublæve, *n. sp.* (*Ulrich.*)

PLATE LXXVIII, FIGS. 48 and 49.

The form of the shell and whorls in this species and the variations in the hight of the spire and in the expansion of the whorls, is precisely as in *C. mediale*, from which it is distinguished by its occasionally obsolete and always much thinner revolving striæ. In many specimens the upper half or more of the outer slope of the whorls is quite free of spiral lines, in others they are obscurely indicated. On the lower half the lines become gradually more distinct (occasionally the first beneath the smooth space is the strongest of all), but they are never very prominent or sharp. On the body whorl, where they are from one-third to one-half a millimeter apart, a partial alternation in size is usually apparent. *C. simulans* has more abruptly impressed sutures and more distant revolving lines.

*Formation and locality*—Not uncommon in the lower half of the Lorraine group at several localities in the vicinity of Cincinnati.

*Collection.*—E. O. Ulrich. (About 70 specimens.)

## Cyclonema transversum, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 65—67.

This may be an extreme variety of *C. sublæve*, but the six specimens which we refer here look so much alike and so different from the prevailing varieties of that species, that very few if any would hesitate in pronouncing them distinct. The specimens vary in width from 17 to 30 mm. The spire is imperfect in all, but, judging from what remains, the total hight cannot have equalled the width. Apparently it was about a sixth less. The apical angle is about 85°. The last whorl expands very rapidly, is gently convex in the upper slope and on the base, and abruptly rounded at the periphery. The aperture is very oblique and unusually large in a basal view, the excavated inner lip very wide. The surface is more or less strongly marked with oblique lines and wrinkles of growth without a trace of revolving lines except on the smallest specimen. In this the inner half of the last whorl presents several very obscure revolving lines on the lower half of the outer slope.

Aside from the almost total absence of revolving lines, the rapid expansion of the last whorl and shallow suture will distinguish *C. transversum* from most of the preceding species of the genus.

*Formation and locality.*—Lower half of the Lorraine group, Covington, Kentucky, and Cincinnati, Ohio.

*Collection.*—E. O. Ulrich.

## Cyclonema gracile, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 55—61.

Shell scarcely attaining medium size, perfect specimens consisting of five or six, more or less slender, rounded whorls; excepting the minute apical turns, the whorls increase regularly in size; either the whole or only the lower part of the whorls may be covered with fine revolving striæ, or these may be wanting entirely; when present a glass is usually necessary to show them clearly; lines of growth having the usual direction, very fine, scarcely distinguishable except on the last whorl; mouth rounded, oblique, inner lip comparatively thin and in many cases not distinctly excavated.

This neat and interesting shell is probably nearer *C. sublæve* than any of the others, but is readily distinguished by its more slender as well as more rounded whorls. It is also a smaller shell. We have before us five or six specimens of what appears to be a variety of *C. gracile.* They agree with the types, with which they were also found, in every respect save that the revolving striæ are much stronger and readily apparent to the unassisted eye. Specimens of this kind may be known as var. *striatulum.*

*Formation and locality.*—Lorraine group, Cincinnati, Ohio, and vicinity; not uncommon.

*Collection.*—E. O. Ulrich. (40 specimens.)

CYCLONEMA (? HOLOPEA) LIMATUM, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 62–64.

Shell 25 to 30 mm. in hight, the greatest width generally about a fifth less, consisting, without the nucleus which is unknown, of about four rapidly enlarging ventricose whorls; suture distinctly impressed though not deeper than necessitated by the uniform convexity of the whorls; aperture large, higher than wide, rounded below, somewhat acuminate ovate in outline; inner lip nearly straight, not as thick as usual in *Cyclonema*, while as a rule it is merely flattened instead of excavated, and turned inward so that the flat portion is not fully visible in a ventral view; surface smooth, sometimes polished, the lines of growth obscure; of revolving lines not a trace is to be seen except on two specimens where the surface is glossy as though they retained patches of epidermis that is generally not preserved.

In its general aspect this fine species reminds one strongly of *Holopea*, and it is possible that it would be more naturally placed in that genus. It has seemed to us, however, that the characters of the inner lip, which *is* sometimes excavated as in *Cyclonema*, would not permit its reference to *Holopea*, in which, as the genus is now understood, the inner lip is thin and simple. Perhaps *C. limatum* indicates a partial reversion to ancestral characters—in other words, a form in which larval characters are retained through adult stages.

*Formation and locality.*—Lower division of the Lorraine group, Cincinnati, Ohio.

*Collection.*—E. O. Ulrich.

## Genus STROPHOSTYLUS, Hall.

*Strophostylus*, HALL, 1859, Pal. N. Y., vol. iii, p. 303.

Shell turbinate to subglobose, consisting of three to six rounded and more or less ventricose whorls, with the spire elevated or low and the body whorl often very large; mouth rounded, outer lip thin, sharp, columellar lip not very thick, very little reflected, generally twisted and spirally grooved within; surface finely cancellated, with either the revolving or the oblique growth lines the stronger. Type, *S. elegans* Hall.

The earlier Lower Silurian species of this generic type have all comparatively slender whorls, and forms of the same kind continue on at least to the close of the Upper Silurian. These slender-whorled forms may at first sight look very different from those rapidly expanding subglobose species for whose reception Hall proposed the genus. But, that the latter were evolved from the former is, we think, sufficiently indicated by the range of variation occurring in a single species like *S. cyclostomus* Hall, of the Niagara. Specimens of this species before us approach our widest *S. textilis* very closely. As a rule the spiral element of the surface sculpture is the stronger in the slender-whorled forms, while the lines of growth predominate in the broader types.

Comparing the genus with *Cyclonema* we find that the inner lip is thinner and the fold on it more twisted, the whorls are more rounded and generally coiled with less constancy, most of the species exhibiting greater variation in the hight of the spire than occurs in *Cyclonema*. But, as we have already stated under *Cyclonema*, our principal reason for distinguishing the two groups of species lies in the conviction that they represent two separate lines of development.

Most authors place *Strophostylus* in the immediate vicinity of *Platyceras* and *Platystoma*. In a measure this arrangement is quite correct, but Lindström surely was not justified in reducing *Strophostylus* to synonomy under *Platyceras*. He quite ignores the close relations of the genus to *Cyclonema*—indeed it is evident that he did not recognize the most essential feature of either *Cyclonema* or *Strophostylus*, since he places at least one undeniable member of the present genus under *Cyclonema*. We refer to his *Cyclonema cancellatum*. Even his *C. delicatulum* and *C. adstrictum*, which do not belong to *Cyclonema*, may very well go under *Strophostylus*.

### STROPHOSTYLUS TEXTILIS, *n. sp.*

PLATE LXXXII, FIGS. 49–54.

Shell rather small, 12 to 25 mm. high, 11 to 20 mm. wide, obliquely conical; apical angle 60° to 70°; whorls, in casts, three or four, in entire shells, six or seven, increasing quite regularly in size from the acute apex, almost uniformly rounded, often with several widely separated, deep, oblique constrictions; suture deep; aperture subovate, oblique; inner lip appearing thin in a ventral view, but when a part of the outer wall is removed it is seen that it forms a moderately thick columella with a spiral fold beginning near the lower angle. In young examples neither the fold nor a spiral furrow just above it is very distinct, while in some cases the whole inner lip appears to be simple and thin as in *Holopea*. Surface beautifully cancellated by subequal, fine, sharp, revolving and obliquely transverse lines, the network growing strong enough on the last whorl to be distinctly visible to the naked eye.

This graceful and beautifully marked shell cannot be confused with any other known to us from the Lower Silurian rocks of America. There are several Upper Silurian forms that resemble it, but in all of these either the transverse or the revolving set of striæ is stronger than the other. *Cyclonema gracile* has about the same shape, but its inner lip and surface markings are quite different. The apex also is different, being conical in the *Strophostylus* and somewhat truncated in the *Cyclonema*.

*Formation and locality.*—Shales of the Black River group (Ctenodonta bed chiefly), Minneapolis, St. Paul, Cannon Falls, Chatfield and Fountain, Minnesota. Also, though very rarely, in the Clitambonites bed of the Trenton group, at St. Paul. In Kentucky it occurs near Burgin in the upper part of the Trenton.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, No. 233.

## Genus HOLOPEA, Hall.

*Holopea*, HALL, 1847, Pal. N. Y., vol. i, p. 169.

Though we have given considerable study to the matter, we prefer not to commit ourselves at present to a description of the generic characters. We may say, however, that *Holopea*, as now used, embraces much that does not belong here. Indeed, some of the following species doubtless will be removed when the contents of the genus are finally revised. Most diverse affinities are indicated by different sets of species, some evidently being true *Littorinidæ*, others are related to *Cyclonema* and *Strophostylus*, another set to *Platystoma*, while a few are difficult to place.

## Holopea insignis, *n. sp.*

PLATE LXXIX, FIGS. 1–5.

Shell thin, attaining a width of 40 mm.; average width about 32 mm.; hight about 28 mm.; hight in young examples relatively greater, nearly or quite equalling the width; spire low; volutions about four, casts of the interior usually consisting of two or two and a half, very rapidly expanding, ventricose, the vertical diameter greater than the transverse, subelliptical in cross-section, narrowly rounded above so as to form a deeply impressed suture, and perhaps even more abruptly rounded on the under side where the contour enters a small but distinct umbilical perforation; mouth very moderately oblique, subelliptical; inner lip thin, produced so that it turns partly around the umbilicus; exterior surface marked by rather regular lines, generally less than a mm. apart, crossing the whorls from above almost vertically, a tendency to turn slightly backward being apparent in most specimens; parallel with these, at intervals increasing with age, numerous more or less obscure undulations; indistinct revolving lines, one or two mm. apart, may be observed on the outer surface of good specimens, but on casts of the interior faint impressions of the wrinkles of growth only are visible.

This fine species is distinguished from most of its congeners by its low spire, relatively high and rapidly expanding volutions, and deeply impressed suture.

*Formation and locality.*—Stones River group, Minneapolis, Cannon Falls and Faribault, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota ; E. O. Ulrich; W. H. Scofield.

*Museum Register*, Nos. 5042, 5554.

## Holopea appressa, *n. sp.*

PLATE LXXIX, FIGS. 7–10.

This resembles *H. insignis* but has more slender whorls, a wider umbilical slope, more oblique and differently shaped aperture and more abruptly impressed suture. The whorls also are not nearly so full in the upper part of the outer side.

*Formation and locality.*—Clitambonites bed of the Trenton group, Goodhue county, Minnesota. A variety with more convex whorls occurs in the lower part of the Trenton group at Burgin, Kentucky.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 6765.

## Holopea ampla, *n. sp.*

PLATE LXXIX, FIGS. 22–25.

This is a large shell resembling in many respects both *H. insignis* and *H. appressa*. The spire is low but rises higher than in either of those species, the suture is less deeply impressed, the whorls on the whole more rounded in section and the surface undulations stronger. From the former it differs in addition in having a wider umbilicus and more oblique aperture, and from the latter in having the whorls much less sharply rounded on the upper side. *H. similis* is a smaller species and has a smoother surface.

*Formation and locality.*—Stones River group, Cannon Falls, Minnesota; Mineral Point and Beloit, Wisconsin. The Wisconsin specimens are smaller than those from Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; University of Wisconsin; E. O. Ulrich; W. H. Scofield.

*Museum Register*, Nos. 5836, 7355.

## HOLOPEA SIMILIS, *n. sp.*

PLATE LXXIX, FIG. 26

This shell might be described as a miniature *H. ampla*, were it not that its apical whorls rise higher above the last two, giving it a somewhat acute apex. Comparing it with young examples of that species we find that it has more slender whorls, a higher spire and smoother shell. There is a moderately wide umbilical depression in the base but the perforation is very small, the suture is distinct and sometimes slightly channelled, at other times the top of the whorls is merely flattened; the mouth is rounded and oblique, the exterior surface marked by fine lines of growth which curve rather strongly backward in crossing the whorls from the suture. The specimen figured is above the average in size.

At first we thought this species might be the same as Hall's *H. obliqua*, but after repeated and always fruitless efforts to identify that shell we have decided to give it a new name.

*Formation and locality.*—Ctenodonta bed of the shales of the Black River group, Minneapolis and St. Paul; also at localities in Goodhue and Fillmore counties. A similar form, but having a larger umbilicus, occurs in the Fusispira bed near Cannon Falls. We have also a specimen from the Lorraine group at Covington, Kentucky, which seems to agree exactly with the Black River form of the species.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7381.

## HOLOPEA ROTUNDA, *n. sp.*

PLATE LXXIX, FIGS. 20 and 21.

Shell thin, of medium to rather large size, with hight and width about equal, consisting of about four rather rapidly enlarging, strongly convex, ventricose whorls; umbilical perforation extremely small, probably closed in some specimens; suture distinct, sometimes faintly canaliculate on the last whorl; aperture somewhat oblique, subelliptical, the hight exceeding the width by about one-seventh; inner lip thin, curved, the edge reflected so as to almost cover the umbilical perforation; surface with obscure lines and an occasional faint wrinkle crossing the whorls from the suture with a slight backward direction.

The spire is not so high and the whorls more ventricose than in our *H. excelsa* and *H. concinnula*, while the umbilicus also is smaller and the aperture more oblique than in the latter. *H. similis* has less uniformly convex whorls and more of an umbilicus, while *H. paludiniformis* Hall seems to have a higher spire and to differ in other respects.

*Formation and locality.*—Stones River group, Dixon, Illinois; Trenton group, Hartsville, Tennessee.

*Collection.*—E. O. Ulrich.

## HOLOPEA CONCINNULA, *n. sp.*

PLATE LXXIX, FIG. 6.

Hight about 24 mm., width 18 mm., apical angle 72°. Volutions about five, rounded, with a barely perceptible angularity near the middle of the upper part shown in casts of the interior; umbilicus small; very faint undulations and lines of growth, crossing the whorls almost vertically, may be seen on the last whorl.

Of this species we have seen only the cast of the interior figured on plate LXXIX. In its form it resembles *H. paludiniformis* Hall, a Trenton limestone shell in New York, very closely, yet we are fully satisfied that it will prove quite distinct. At present the possession of an umbilical perforation by our species is the only differential feature that our limited knowledge of the New York shell permits us to mention.

*Formation and locality.*—Stones River group, Beloit, Wisconsin.

*Collection.*—University of Wisconsin.

## Holopea excelsa, *n. sp.*

PLATE LXXIX, FIGS. 11 and 12.

Similar to *H. concinnula* but larger and relatively higher in the spire, with the aperture more oblique (about as in *H. rotunda*), the whorls scarcely so ventricose, and the umbilicus much smaller and probably closed entirely in the shell. Perhaps it is not distinct from *H. paludiniformis* Hall, but if we may rely on Hall's figures of that shell, it differs, excepting the umbilicus, from *H. excelsa* about as *H. concinnula* does.

*Formation and locality.*—Fusispira bed of the Trenton group, Wykoff, Sumner and Hader, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 285. (A crushed specimen somewhat doubtfully referred to this species.)

## Holopea paludiniformis *Hall.*

(Not figured.)

*Holopea paludiniformis* Hall, 1847, Pal. N. Y., vol. i, p. 171, pl. xxxvii, figs. 3*a*, 3*b*.

A small specimen, apparently of this species, was collected by Mr. E. O. Ulrich in the Clitambonites bed of the Trenton group near Cannon Falls, Minnesota. The specimen is imperfect at the mouth and shows clearly that it has a small umbilical perforation, so it may belong to some other species, unless the prevailing impression that *H. paludiniformis* has no perforation proves erroneous. With this specimen a larger one was found which possibly is the same. We think not, however, since it has a wider umbilicus and an impressed suture, reminding one in both features of *H. appressa.*

## Holopea pyrene *Billings.*

PLATE LXXIX, FIGS. 13—18.

*Holopea pyrene* Billings, 1862, Pal. Foss., vol. i, p. 27.
*Holopea perundosa* Sardeson, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 336.

Shell obliquely turbinate, spire depressed conical, rising but little above the top of the last whorl; whorls three or four, the inner ones appearing slender, the last somewhat ventricose, subovate in cross section, the vertical diameter considerably greater than the transverse, the upper side of the outline more obtuse than the lower; umbilicus large; suture deeply impressed; aperture slightly oblique; whorls crossed by deep concave undulations separated by rather sharp ridges; lines of growth very obscure in the specimens studied, which seem to be, at least in part, casts of the exterior. Width 33 mm., hight about 27 mm.

It may be that Dr. Sardeson was justified in separating the Minnesota species here described from *H. pyrene*, especially since Billings says that his specimen, which does not show the under side, has a form "much like *H. obliqua* Hall," and comes from a lower geologic horizon than our specimens. It has, however, seemed so unlikely to us that such an extravagant character as the strong undulations of the whorls would appear in two distinct species of the same genus, that we have decided to refer the Minnesota specimens to Billings' species until the latter has been shown to be distinct.

*Formation and locality.*—Lower part of Fusispira bed, near Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich.

## Holopea parvula, *n. sp.* (*Ulrich.*)

PLATE LXXIX, FIG. 19.

Shell small, 6 to 10 mm. in width, the hight equalling about three-fourths of the width; spire depressed conical; whorls four, including two very small ones at the apex, neatly rounded, subcircular in section; suture distinct, very slightly canaliculate; umbilicus large, equalling about one-fourth of the diameter of the shell; aperture moderately oblique, rounded, slightly modified above by the preceding whorl; surface with very fine, obscure lines of growth and on the latter half of the body whorl a number of more or less obscure undulations running parallel with the apertural margin.

This shell resembles the inner whorls of *H. pyrene*, but its whorls seem to be proportionally more slender and more nearly circular in section. Though small, the specimens are evidently mature.

*Formation and locality.*—Upper part of Trenton group, near Burgin, Kentucky.

*Collection.*—E. O. Ulrich.

### Holopea supraplana, *n. sp.*

PLATE LXXIX, FIGS. 27 and 28.

Excepting that the whorls increase more rapidly in hight, the general appearance of this shell, especially in dorsal and ventral views, is greatly like *H. insignis.* However, in viewing the upper side, a marked difference will at once strike the observer. The upper side of the whorls, namely, instead of being rounded as in that species, is a sharply defined flat plane sloping gently downward to the suture and extending outward about half the width of the body whorl, as seen in the apical view. The spire is low, the outer side of the body whorl moderately convex, the base turning sharply into a small but undeniable umbilicus; inner lip very thin, reflected so as to form a semitubular prolongation from the umbilicus; aperture very little, if at all oblique; surface markings, excepting a few obscure vertical lines near the mouth, unknown.

We know of two other species of this type, one from the upper Trenton at Nashville, Tennessee, in which the upper plane is less sharply defined, the spire a little higher, and the umbilicus very small; the other from the Richmond group at Richmond, Indiana, and Oxford, Ohio, having the upper plane fully as well defined and wide, but not sloping downward, and the umbilicus much smaller or closed. In the latter the sutural edge of the plane is raised.*

*Formation and locality.*—Lower half of Fusispira bed, Trenton group, Kenyon, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, No. 7493.

## Family CAPULIDÆ.

## Genus PLATYCERAS, Conrad.

This genus is only provisionally employed for the following two capuloid shells, and as it includes a host of wonderfully diverse shells, upon which the opinions of paleontologists vary greatly, we have thought it best to use the genus without attempting to give either the synonomy or a diagnosis.

### Platyceras (?) wisconsinensis, *n. sp.*

PLATE LXI, FIGS. 49—54.

Shell rather small, capuloid, obliquely subconical, with the hight and width nearly equal; apex obtuse, not spiral, turned slightly to the right or the left, and situated immediately over or curving slightly beyond the apertural margin; aperture more or less obliquely rounded-quadrate, or broadly subovate, the peristome horizontal or irregularly sinuate. Surface of cast smooth or with a few obscure

* As these are both interesting and important species and easily recognized, I propose to call the first *Holopea nashvillensis* and the second *Holopea oxfordensis*. E. O. Ulrich.

wrinkles of growth; external surface unknown. Muscular scar horseshoe-shaped, situated a little above the midhight.

*Formation and locality.*—Stones River group, Vanuxemia bed, Beloit, Wisconsin. One of the authors believes he collected casts of this shell also in Minnesota, which is very probable, but as the specimens have been mislaid or lost, we cannot now verify the occurrence of the species in this state.

*Collections.*—University of Wisconsin; E. O. Ulrich.

### PLATYCERAS DEPRESSUM, *n. sp.*

PLATE LXI, FIGS. 55 and 56.

This form may be only a variety of *P. wisconsinensis.* So far as the limited material at hand admits of judging, it differs chiefly in being smaller and relatively lower. It is scarcely probable that either of these species really belong to *Platyceras.* Perhaps they are related to the shells for which Kayser has proposed the genus *Hercynella.*

*Formation and locality.*—Black River group, Ctenodonta bed, six miles south of Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich.

## Suborder SUBULITACEA.

Primarily this division is intended to include the Paleozoic *Subulitidæ* and *Loxonematidæ* and the more recent *Eulimidæ* and *Pseudomelaniidæ.* There are other Mesozoic and living shells that are more or less obviously related to the families mentioned and which might perhaps be advantageously classed with them, but it seems to us too early to attempt either a characterization of the suborder or an enumeration of its probable contents.

## Family SUBULITIDÆ.

Shell more or less elongate, subulate or fusiform, nearly or quite smooth; aperture elongate, narrow, canaliculate below; no inner lip; columella involute.

Following Lindström's suggestions, we place in this family *Subulites,* Conrad, *Bulimorpha,* Whitfield, *Fusispira,* Hall, and *Euchrysalis,* Laube. To these we add *Cyrtospira,* a new genus, founded on species heretofore regarded as curved forms of *Subulites.*

### Genus SUBULITES, Conrad.

*Subulites,* CONRAD, 1847, Pal. N. Y., vol. i, p. 182; LINDSTRÖM, 1884, Gastropoda of Gotland, p. 193.
? *Polyphemopsis,* PORTLOCK, 1843, Geol. Londonderry, p. 415.

Shell thin and unadorned, slender, subulate or somewhat fusiform in outline; whorls high, flat or very slightly convex on the outer side; suture linear, sometimes scarcely distinguishable, in no case greatly modifying the almost even slope of the slender spire; aperture elongate, narrow, acuminate above, widest and somewhat truncated below, much higher than wide, the width and hight about as one is to four;

outer lip thin, the edge straight above, and strongly recurved below, causing the lower extremity to be broadly arched in an end view; columella thin, involute, terminating abruptly below, above forming a small spiral axial canal; upper whorls of spire usually (?always) filled with organic deposit or shut off from the last three to five whorls by a deeply concave septum, in consequence of which casts of the interior are incomplete above. Type, *S. elongatus* Conrad.

As above described, *Subulites* cannot properly include species like *S. calciferus*, *S. psyche* and *S. daphne* of Billings, and *S. obesus* Whitfield. These agree much better with average forms of *Fusispira*. Of the remaining American species referred by authors to *Subulites*, we remove *S. parvulus* Billings, *S. abbreviatus* Hall, *S. notatus* Billings, *S. ventricosus* Hall, and *S. brevis* Winchell and Marcy, to our new genus *Cyrtospira*, which see. *S. richardsoni* Billings is not sufficiently known to us, but *S. inflatus* Meek and Worthen is a *Fusispira*, while *S. terebriformis* Hall and Whitfield, *S. gracilis* Miller, *S. directus* Fœrste, and *S. compactus* Whiteaves, evidently are good species of *Subulites*. Of European species, *S. attenuatus* Lindström belongs where its describer placed it, but *S. priscus* Eichwald, as figured by Koken, undoubtedly belongs to *Fusispira* and not to *Subulites*.

Of the following species, which, despite the close resemblances prevailing among them, are easily enough distinguished when the specimens are reasonably good, we are fully satisfied that all, with the possible exception of *S. nanus* and *S.* sp. undet., are strictly congeneric with *S. elongatus*. Testiferous examples are extremely rare, and good casts of the interior even are not by any means common. Under the circumstances it is to be regarded as very fortunate that we have succeeded in obtaining specimens showing the form of the aperture of nearly all of the species described. Without the aperture it is sometimes extremely difficult to decide whether a shell is to be called a *Subulites* or a slender, flat-whorled *Fusispira*. If the specimen is a cast and is obtusely terminated above as in figs. 1, 2 and 9, on plate LXXXI, the observer may be reasonably certain that it belongs to *Subulites* Another apparently constant, at any rate very reliable difference is found in the shape of the under side of the whorls. In *Fusispira*, namely, the lower part of the body whorl turns inward more rapidly, causing a stronger concavity in the columellar side of the aperture.

Concerning the systematic value of the characters relied on by us in separating the species, we wish to say merely this: if the value of a character is determined by the relative constancy of its repetition in individuals, and if it is allowable to assume that its value is about the same in all species of the same genus, then the following forms deserve to rank as good species. Of only one species have we more than fifteen good specimens, namely, *S. regularis*. These range in length from 40 to 100 mm., but in every other respect, as far as we can discover, they are absolutely identical. Moreover, the species is recognizable over a geographical range extending from Tennessee and Kentucky to Minnesota in one direction, and Ottawa, Canada, in another.

## SUBULITES CONRADI, *n. sp.*

PLATE LXXXI, FIGS. 4 and 5.

Shell extremely elongate-fusiform; the spire slender, long, and tapering not much more gradually than the base, which is somewhat truncated; outline on each side gently arcuate, the lower part of the middle third of the length perfectly cylindrical; whorls flat, about four and a half in casts of the interior, the uppermost of these having an obtuse termination and a diameter of about 6 mm. in a specimen whose greatest diameter is about 15 mm.; whorls preceding this not observed; suture linear; aperture long, very narrow, expanding gradually from the suture, but contracting again near the base; body whorl tapering very gradually.

This agrees rather closely with all that can be made out of Hall's poor figure (Pal. N. Y., vol. i, pl. XXXIX, fig. 5*a*) of Conrad's original type of *S. elongatus*, but as it differs from the other specimens figured by Hall, as well as from specimens obtained from Watertown, N. Y., said to be of Conrad's species, we have hesitated to identify our species with *S. elongatus*.

*Formation and locality.*—Stones River group, Goodhue county, Minnesota. A specimen recently received from Mr. W. R. Billings, of Ottawa, Canada, who collected it in rocks of the Black River group, associated with *S. canadensis*, near Ottawa, appears to be of this species.

*Collections.*—E. O. Ulrich (4 specimens); W. H. Scofield (6 specimens).

## SUBULITES CANADENSIS, *n. sp.* (*Ulrich.*)

PLATE LXXXI, FIG. 3.

Our figure of this species was made up from several fragments of a *Subulites* collected several years ago at Ottawa, Canada. At that time we supposed that the specimens belonged to *S. elongatus* Conrad, and the figure was prepared to show what we knew, or rather what we believed we knew, of that species. In going over the subject once more we concluded that it was certainly distinct from *S. elongatus*. Quite recently we received several specimens more of the same form from Mr. W. R. Billings, and learned that the species occurs at Ottawa, not in the Trenton limestone, as we supposed, but in the Black River group. As the species seems to be a well-marked form, and distinct from all others known to us, we propose to designate it as above. It is a more robust species than *S. conradi* (one of the fragments before us indicates a total hight of at least 120 mm.), with the aperture wider below, the whorls slightly convex in the spire, and the body whorl more ventricose and tapering more rapidly, while the spire tapers more regularly and more rapidly. The greatest diameter of the largest fragment is 22 mm.

*Formation and locality.*—Black River group, Lot 3, Con. 3 R., Gloucester, near Ottawa, Canada.

*Collection.*—E. O. Ulrich.

## SUBULITES DIXONENSIS, *n. sp.*

PLATE LXXXI, FIGS. 6–8.

This form is distinguished from *S. conradi* by its wider aperture and more distinct basal truncation; also by the peculiar fullness near the middle of the body whorl, and the more rapid taper downward caused thereby. These differences are shown very clearly by our figures of the two species on plate LXXXI.

*Formation and locality.*—Three specimens were collected at Dixon, Illinois, where they occurred in the upper part of the Stones River group.

*Collection.*—E. O. Ulrich.

## Subulites beloitensis, *n. sp.*

PLATE LXXXI. FIGS. 9—11.

The sides of the spire in this form are not arcuate as in *S. conradi*, and the aperture is wider, while the taper of the body whorl, as seen in a ventral view, is more gradual than in *S. canadensis* and *S. dixonensis*. In one specimen the outer lip, instead of running straight up to the suture, as shown in fig. 10, is turned rather strongly backward in the upper fourth. The same specimen preserves a small patch of the external surface of the shell. This is somewhat glossy and perfectly smooth to the naked eye, but with a good glass some extremely faint lines of growth may be observed; also a revolving line a short distance above the suture.

*Formation and locality.*—Stones River group, Beloit, Wisconsin.

*Collection.*—E. O. Ulrich.

## Subulites pergracilis, *n. sp.*

PLATE LXXXI. FIGS. 12—15.

Of this form we have seen nothing but fragments, like those figured, which were broken out of a solid block of limestone. The shell evidently was extremely slender, with the central and lower parts almost cylindrical. The body whorl tapers very gradually, and the outer lip is strongly recurved, forming a wide and deep canal. The suture is distinctly banded.

*Formation and locality.*—Fusispira bed of the Trenton group, Wykoff, Minnesota.

*Collection.*—E. O. Ulrich.

## Subulites parvus, *n. sp.* (*Ulrich.*)

PLATE LXXXI, FIGS. 16 and 17.

Shell small, scarcely 23 mm. in length and 6.5 mm. across the widest part, fusiform; spire tapering more rapidly than usual in the genus, consisting of three or four small, flat whorls; aperture large, comprising more than half the length of the whole shell.

*Formation and locality.*—Upper part of Stones River group, High Bridge, Kentucky.

*Collection.*—E. O. Ulrich.

## Subulites nanus, *n. sp.* (*Ulrich.*)

PLATE LXXXI, FIGS. 18 and 19.

Shell slender, smooth, fusiform, very small, the largest of three specimens having a hight of 15 mm. and a width of 3 mm.; whorls about five, the apex very acute; aperture elongate, very narrow, not quite half the length of the shell.

A smaller and more slender shell than *S. parvus.*

*Formation and locality.*—Stones River group ("Glade limestone"), Lebanon, Tennessee; High Bridge, Kentucky.

*Collection.*—E. O. Ulrich.

## Subulites regularis, *n. sp.*

PLATE LXXXI, FIGS. 35 and 36; PLATE LXXXII, FIGS. 47 and 48.

Shell 40 to 100 mm. in hight, 10 to 23 mm. in width; hight of aperture about one-third of entire hight of shell; spire tapering regularly, the apical angle 18° to 20°; whorls eight to ten, very gently convex, the hight and width, as shown in spire, about equal; body whorl contracting rapidly in the lower half, the columella relatively narrow; aperture comparatively wide, widest in the middle, the greatest width slightly exceeding a third of the length; outer lip sharp, nearly straight in the upper two-thirds, and strongly rounded, with also a moderate retral sweep, in the lower third; outer surface of shell perfectly smooth in the material at hand. On a fragment of the body whorl, which seems to preserve only the inner layer of the shell, some eight or ten revolving brown bands are shown.

This fine species is readily distinguished from most other species of the genus by its regularly tapering spire, and from others by the unusually abrupt contraction of the lower half of the body whorl. In the last feature, as well as in the resulting shape of the inner wall of the aperture, the species resembles *Fusispira*, particularly such species of that genus as *F. planulata* and *F. nobilis*.

*Formation and locality.*—Stones River group, Cannon Falls, Minnesota; Murfreesboro, Tennessee; and High Bridge, Kentucky. Also near Ottawa, Canada, where it is said to occur in the Black River limestone.

*Collection.*—E. O. Ulrich.

## SUBULITES, *sp. undet.*

PLATE LXXXI, FIGS. 33, 34, 36 and 37.

Compare *Fusispira? spicula* SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 336, pl. VI, figs. 10 and 11.

We have several specimens of a small *Subulites* agreeing with *S. regularis* in having a regularly tapering spire and rapidly contracting body whorl. The specimens consist of interior casts and testiferous fragments, and at first we thought they belonged to that widely distributed species. A careful comparison, however, shows that the whorls are almost perfectly flat in the spire instead of slightly convex, while the shell has a band at the suture that is not apparent in any examples of *S. regularis*. This banded suture allies the form with *S. beloitensis* and *S. pergracilis*, from which it is distinguished by the shape of its body whorl. The specimens in question are peculiar in one feature when compared with all true species of the genus, namely, the filling of the apical whorls is extremely limited, the casts of the interior being almost as acute at the apex as is the shell itself.

Sardeson's *Fusispira? spicula*, which came from the same bed, may be founded on an imperfect cast of this species, but as he describes the aperture as "subquadrate" and speaks of oblique lines of growth, we hesitate to say that it is. Still, he may be mistaken.

*Formation and locality.*—Shales of the Black River group, Minneapolis, St. Paul, Chatfield and Fountain, Minnesota. Also at Beloit, Wisconsin, and in the upper part of the Stones River group at High Bridge, Kentucky.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 4050.

## Genus CYRTOSPIRA, n. gen. (Ulrich.)

Like *Subulites* excepting (1) that the shells are shorter, especially in the spire, the length of the aperture generally exceeding half of the total hight of the shell; (2) that the shell is curved with one side of the outline straight, the other strongly arcuate, or the axis may be spirally turned so that the shell curves first in one direction and then in another; and (3) the truncation of the lower extremity of the aperture is not so apparent. Types, *C. tortilis* Ulrich and *Subulites ventricosus* Hall.

We have separated this type of shells from *Subulites*, to which it was hitherto referred, not only because it is strikingly different from the typical forms of that genus, but also for the reason that it proves to have been fully established as early as, if not before, the oldest known true *Subulites*;* also because it continues its peculiarities without material modification, and with no apparent tendency to pass into *Subulites*, from the base of the Stones River group to or near the top of the Upper Silurian. *C. tortilis* and *C. bicurvata* are from the first horizon, *C. parvula* Billings sp., from the Black River group, *C. wykoffensis* and *C. abbreviata* Hall sp., from the Trenton group, *C. notatus* Billings sp., from the Anticosti group, and *C. brevis* Winchell and Marcy sp., and *C. ventricosa* Hall sp., which may be the same, from the Niagara and Guelph formations. The vertical range indicated by this list of species having the characters required by *Cyrtospira* is precisely the same as for *Subulites*. Evidently the two groups of shells existed side by side as parallel but distinct genetic lines.

### Cyrtospira tortilis, *n. sp.* (*Ulrich.*)

PLATE LXXXI, FIGS. 24 and 25.

Shell 22 or 23 mm. in hight, about 10 mm. in width, straight on the side of the aperture and strongly curved on the opposite side, consisting of about four gently convex whorls, of which the apical three constitute but a small part of the whole shell; apical angle about 52°; aperture large, acuminate above, somewhat truncated below, widest in the middle, the length equalling about three times the greatest width and about two-thirds of the entire length of shell; columella rather strongly twisted, turning forward in its lower part.

The large size of the aperture, the strong twist of the columella, obtuse apical angle and slight convexity of the whorls, together form a shell that is readily distinguished from all other species referred to the genus.

*Formation and locality.*—Lower division of the Stones River group, Murfreesboro, Tennessee.

*Collection.*—E. O. Ulrich.

### Cyrtospira bicurvata, *n. sp.* (*Ulrich.*)

PLATE LXXXI, FIGS. 21 and 22.

This is a more slender shell than *C. tortilis* and is peculiar in having the apical part turned in the usual direction while the last whorl is curved in the opposite way. The body whorl, as seen in a view of the aperture, tapers very gradually to the lower extremity of the columella.

*Formation and locality.*—Upper part of Stones River group, High Bridge, Kentucky.

*Collection.*—E. O. Ulrich.

### Cyrtospira wykoffensis, *n. sp.*

PLATE LXXXI, FIG. 23.

Although the apex is broken away in both of the specimens upon which this species is founded, enough remains to satisfy us that it was more acute than in either of the preceding species. The body whorl tapers gradually as in *C. bicurvata*, but the curve of the shell is all in one direction, while we are convinced that the spire consisted of one or two whorls more than we find in that species.

*Formation and locality.*—Fusispira bed of the Trenton group, Wykoff, Minnesota.

*Collection.*—E. O. Ulrich.

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*As stated under the description of *Subulites*, *S. calciferus*, *S. daphne* and *S. psyche* of Billings, and *S. obesus* Whitfield, which are older than the Stones River group, are not, strictly speaking, good species of *Subulites*.

## Genus FUSISPIRA, Hall.

In part *Murchisonia* and *Subulites* of several authors.
*Fusispira*, Hall, 1871, Twenty-fourth Rep. N. Y. St. Mus. Nat. Hist., p. 229.

Shell fusiform, spire elevated; whorls generally convex, with distinct sutures, at other times nearly flat with shallow—or enamelled—sutures; aperture longitudinal, elongate ovate or subelliptical, acuminate above, produced below, forming a subrimate canal; outer lip sharp, its edge straight from the suture almost to the involute extremity of the columella; columella nearly vertical, slightly twisted, simple, thin; test varying in thickness, sometimes heavy with indications of broad revolving bands (?color bands); exterior surface smooth, or with rows of minute punctures arranged in either revolving or longitudinal lines. Type, *F. ventricosa* Hall, which seems to be a variety of *F. inflata* Meek and Worthen sp.

The principal difference between this genus and *Subulites*, Conrad, lies in the basal part of the aperture. This is relatively wider and more truncated in that genus. On page 1070 we give other details that may aid the student in discriminating between the two genera. These may be supplemented with the remark that the shell is perhaps always heavier in *Fusispira*, giving deeper and open sutures in clean casts of the interior.

### Fusispira inflata *Meek* and *Worthen*.

PLATE LXXX, FIGS. 17 and 18.

*Subulites inflatus* Meek and Worthen, 1870, Proc. Acad. Nat. Sci. Phila., p. 47; also 1875, Geol. Sur. Ill., vol. vi, p. 495.
*Fusispira ventricosa* Hall, 1871, Twenty-fourth Rep. N. Y. St. Mus. Nat. Hist., p. 229, pl. viii, fig. 6; Whitfield, 1882, Geol. Wis., vol. iv, p. 245, pl. ix, fig. 2.

Casts of the interior comparatively short-fusiform, ventricose, consisting of six or seven convex whorls, the apical angle expanding with each whorl after the third or fourth; average apical angle about 60°. Volutions strongly convex, the last very ventricose and constituting over two-thirds of the entire hight of cast; under side of whorls, as seen along the whole inner side of the aperture, strongly concave; the upper half of the outline meeting the vertical lower or columellar half at an angle of about 135° in the typical form and about 125° in the variety *ventricosa;* suture distinct without being channelled or impressed. Aperture oblique, narrow, the length more than twice the width and a little more than half of the entire length of the cast; base abruptly rounded, forming a shallow canal; outer lip sharp, directed slightly forward in the middle; columella vertical, nearly straight, less than half the length of the aperture, very slightly twisted. Surface of casts smooth, of the shell unknown.

This species is very constant in most respects, and yet a recognizable and apparently persistent difference obtains between the specimens of the Fusispira bed and those of the overlying Maclurea bed. In the latter, namely, and these agree most closely with the Wisconsin types of *F. ventricosa*, the under side of the body volution is slightly more ventricose and rounds in more abruptly where it joins the columella, forming a deeper angle than in the typical form of the species. In Hall's figure, however, the angle is deeper than we have seen it, and, considering the constancy of the part in other specimens, we are inclined to believe that it was drawn deeper than it should be.

*Formation and locality.*—Rather common in the Fusispira bed at Hader, Aspelund, Wykoff and other localities in Goodhue and Fillmore counties; also in the Maclurea bed (var. *ventricosa)* at Sumner, Stewartville, Wykoff and other localities. Hall's type came from De Pere, Wisconsin; Whitfield had it from Waupun and West Jefferson, in the same state; while Meek and Worthen's types are from Carroll county, Illinois.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, Nos. 286, 7390, 7407, 7428, 7472, 7481, 7495, 8390.

## Fusispira intermedia, *n. sp.*

PLATE LXXX, FIGS. 19—21.

This species is closely related to *F. inflata*, but as shown in our figures, has a much smaller body volution, and relatively higher spire, giving on the whole a much narrower shell. The inner outline of the aperture also is different, while the whorls are much less convex, and the shell smaller. The apical angle increases with growth from about 37° to 45°.

*Formation and locality.*—Maclurea and Fusispira beds of the Trenton group, Stewartville and nine miles south of Cannon Falls, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7451.

## Fusispira subbrevis, *n. sp.*

PLATE LXXX, FIGS. 11—16.

This form also is related to *F. inflata* but may be distinguished at once by the fact that its whorls are coiled so that the apical angle, instead of becoming wider with the growth of the shell, remains about the same for the whole spire. The spire also is not so acute in its upper part, the apical angle being about 50°, while it is only about 45° for the first four or five whorls of *F. inflata.* The differences mentioned result in forming a shell that is also much narrower across the middle. *F. intermedia* has a more elevated and slender spire.

*Formation and locality.*—Fusispira and Maclurea beds of the Trenton group, thirteen miles south of Cannon Falls, and Stewartville, Minnesota; Decorah, Iowa.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, Nos. 7362, 8728.

## Fusispira schucherti, *n. sp.*

PLATE LXXX, FIG. 1.

Shell subfusiform, consisting of about six or seven gradually increasing, depressed-convex volutions; aperture very narrow, oblique, lenticular in outline, its hight forming rather less than two-fifths of the length of the shell; body whorl contracting very gradually; columella thick, involute; test very thick, causing the suture, which is not very distinct on the exterior, to be very deep and open in casts of the interior. Both cast and shell exhibit, the latter the more distinctly, a limited number of distant revolving lines.

This species is widely removed from the preceding forms by its heavy shell. It is a very interesting form, and we regret that we cannot devote more space to its discussion. The specific name is to remind us of Mr. Charles Schuchert, one of our colaborers on the paleontology of Minnesota, who discovered the only specimen known.

*Formation and locality.*—Black River group, Beloit, Wisconsin.

*Collection.*—Geological and Natural History Survey of Minnesota.

*Museum Register*, No. 7322.

## Fusispira sulcata, *n. sp.* (*Ulrich.*)

PLATE LXXX, FIGS. 5–7.

Shell subfusiform, consisting of about six, gradually increasing and very depressed-convex whorls, the last one of which forms about two-fifths of the entire length of the shell; apical angle about 32°; suture deep in casts, scarcely distinguishable externally, the shell being thick; aperture elongate, obliquely subelliptical, strongly modified above by the preceding whorl, somewhat acuminate at both ends; surface of cast with several more or less obscure revolving furrows; exterior of shell appearing perfectly smooth and glossy to the naked eye, but under a good glass showing revolving rows of very minute punctæ, as shown in fig. 7.

The whorls are less convex in the spire, the last is more abruptly contracted below, and the test only about half as thick as in *F. schucherti.* The revolving furrows shown on the interior cast distinguish it from all previously described species of the genus.

*Formation and locality.*—From the base of the Utica group or top of the Trenton, at Roger's gap, Kentucky.

*Collection.*—E. O. Ulrich.

## Fusispira subfusiformis *Hall.*

PLATE LXXXI, FIGS. 38 and 39.

*Murchisonia subfusiformis* Hall, 1847, Pal. N. Y., vol. i, p. 180; also 1850, Third Rep. N. Y. St. Cab. Nat. Hist., p. 171, pl. iv, fig. 2.
*Fusispira subfusiformis* Hall, 1871, Twenty-fourth Rep. N. Y. St. Cab. Nat. Hist., p. 229.
? *Fusispira subfusiformis* S. A. Miller, 1874, Cin. Quar. Jour. Sci., vol. i, p. 316.

Casts of the interior elongate-subfusiform, the spire elevated, ascending with moderate rapidity, the apical angle 25° or 26°; volutions six or more, casts, however, rarely retaining more than four, very moderately convex and generally about a third wider than high in the spire; last whorl contracting rapidly below; aperture somewhat semi-elliptical, the length equalling about two and one-half times the greatest width, and only a little more than one-third of the total length of the shell; outer lip curving forward slightly in the middle; suture of very moderate depth in casts, from which we assume that the test was thin.

Hall's original figures in his 1847 work give, as he states himself in the museum report cited, "but a very imperfect idea of the species." Furthermore, we are satisfied that his original figures include more than one species, the apical angle and form of the aperture being quite different in figs. 2*a* and 2*c*, pl. XXXIX. In identifying the species we have relied chiefly upon Hall's figure of a better specimen in the third museum report. The species is reported from the Utica group at Cincinnati, but we are inclined to doubt that the form found there is strictly identical with the Trenton originals of the species.

*F. subfusiformis* is one of several closely related species. Of these *F. terebriformis* Hall, from the Utica group at Cincinnati, has a shorter spire, relatively longer aperture, and more convex whorls.

*Formation and locality.*—Rare in the Fusispira bed of the Trenton group, in Goodhue and Fillmore counties, Minnesota. Also in the middle portion of the group near Burgin, Kentucky. The species is frequently quoted in lists of Trenton fossils in New York and Canada, but as far as our experience is concerned, it appears that several species are there confused under the one name *subfusiformis*, among them the next described *F. convexa*.

*Collection.*—E. O. Ulrich.

## Fusispira convexa, *n. sp.*

PLATE LXXX, FIGS. 8–10.

This shell resembles *F. subfusiformis* Hall but differs in the following particulars: The apical angle is wider, being from 33° to 37°, the latter in the specimen regarded as the type of the species; the whorls are more depressed and more convex, the result being a deeper suture; the aperture is relatively wider and not so high, the length being but little more than twice the greatest width; and, if we may depend upon the appearance of the suture in casts, the test must have been thicker, though perhaps not greatly so. One of the specimens (pl. LXXX, fig. 8) exhibits four or five obscure revolving furrows on each of the two lower whorls. These probably indicate even closer relations with *F. schucherti*, *F. sulcata* and *F. nobilis*, but we doubt if any one will be likely to confuse the present species with any of those. *F. terebriformis* Hall is a more slender shell and has a longer aperture.

There may be some doubt concerning the specific identity of the two specimens referred to this species on plate LXXX. The larger, which is from Cannon Falls, Minnesota, retains only the mouth and a part of the last two whorls. As near as we can judge from these the apical angle was several degrees narrower than in the specimen from Trenton Falls, New York. In other respects, however, the two agree very well.

*Formation and locality.*—Trenton group, Trenton Falls, New York; Clitambonites bed, near Cannon Falls, Minnesota.

*Collection.*—E. O. Ulrich.

## Fusispira nobilis, *n. sp.*

PLATE LXXX, FIGS. 2–4.

Shell attaining a hight of 100 mm. and a width of 34 mm., the aperture in such a specimen having a hight of about 44 mm.; apical angle 27° to 30°; whorls six or seven, gently convex, the last sloping rather abruptly inward at the base; aperture acuminate above, narrowly rounded below, somewhat lozenge-shaped in outline, widest in the middle, the length slightly greater than twice the width; surface of cast sometimes showing about seven faint revolving lines on each whorl; test apparently very thin.

The apical angle is wider, the body whorl more abruptly contracted, and the whorls in the spire less convex than in *F. subfusiformis*. *F. convexa* has much more convex and more depressed whorls. In *F. schucherti* and *F. sulcata* the shell is much thicker, while in *F. planulata* the whorls are almost perfectly flat. None of the other species are very closely related.

We are indebted to Dr. C. H. Robbins, of Wykoff, Minnesota, for the best specimen seen by us.

*Formation and locality.*—Fusispira bed of the Trenton group, Wykoff, Pleasant Grove and Fountain, Minnesota.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

*Museum Register*, No. 7331.

## Fusispira planulata, *n. sp.*

PLATE LXXXI, FIGS. 26 and 27.

This species resembles, and doubtless is closely related to, *F. nobilis*, but a critical comparison brings out several good differences. It probably did not attain the size of that noble shell, while the spire is more slender—the apical angle is only 21° as against 27° or more in *F. nobilis*—and forms almost an even cone, the whorls being quite flat and the suture, even in the cast, very slightly impressed. The base of the body whorl also turns inward even more abruptly, the junction between the base and outer side being obtusely angular rather than sharply rounded.

*Formation and locality.*—Fusispira bed of the Trenton group, Wykoff, Minnesota, where we obtained a single example. It is of smaller size than the illustrated specimen, which we collected some years ago in apparently equivalent strata at Eagle Point, Iowa.

*Collection.*—E. O. Ulrich.

### Fusispira angusta, *n. sp.*, and var. subplana, n. var.

PLATE LXXXI, FIGS. 28–32.

This species is represented in the collections before us by fourteen or more casts of the interior. These are slender, with an apical angle of 18° to 20°, and consist of four or five volutions, the perfect shell probably having had several more at the apex. The whorls are unusually high, very slightly convex—almost flat—and separated by very oblique, deep and open sutures, indicating a rather thick shell. The aperture is narrow, somewhat lenticular in outline, and about three times as long as wide. The largest specimens indicate a total hight of about 100 mm.

Figure 32 represents one of two specimens that may be distinguished at least as a good variety, for which we propose the name *subplana*. It differs from the typical form of the species in having an apical angle of 25°, instead of 20° or less, and less distinct sutures, indicating a thinner shell.

*Formation and locality.*—Fragments of this species are not uncommon in the Clitambonites bed of the Trenton group, at various localities in Goodhue county, and more rarely in the lower part of the Fusispira bed near Cannon Falls and Fountain, Minnesota. It occurs also in the lower half of the same group of rocks near Burgin, Kentucky.

*Collections.*—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

*Museum Register*, Nos. 218, 7378, 7423, 8394.

## Family LOXONEMATIDÆ.

### Genus MEEKOSPIRA, n. gen. (Ulrich.)

Shell elongate conical or somewhat fusiform, consisting of smooth, nearly flat or more distinctly convex, and but slightly overlapping, whorls; aperture subovate, occasionally somewhat effuse below; inner lip slightly reflected, simple, without folds winding about the columella so as to pass out of sight opposite the middle of the aperture, lines of growth nearly or quite straight and vertical. Type, *Eulima?* (later *Polyphemopsis*) *peracuta* Meek and Worthen, Coal Measures, Illinois. Probably congeneric species have been referred to *Melania*, *Eulima*, *Polyphemopsis*, *Macrochilina* and *Subulites*.

We regard this genus as occupying an intermediate position between *Loxonema*, Phillips, and *Soleniscus*, Meek and Worthen (*Macrochilus* Phillips), two genera which in some of their extreme forms border closely upon the ground of the proposed genus. In another direction *Meekospira* approaches *Bulimorpha*, Whitfield, while the new genus on the whole reminds one considerably of the *Eulimidæ* of which some of its species may be the ancestors.

*Meekospira* will probably include beside the type species also *Polyphemopsis nitidula* and *P. inornata* of Meek and Worthen, of the Coal Measures, *P. louisvillæ* Hall and Whitfield, and *Melania antiqua* Goldfuss, Devonian, *Macrochilina bulima*, *M. cancellata* and *M. fenestrata* of Lindström and *Subulites* (*Polyphemopsis*) *planilateralis* Fœrste, Upper Silurian, and the Lower Silurian species about to be described, *M. subconica*.

If all these species are indeed genetically related, then *Meekospira* certainly deserves recognition as an independent and long-lived generic type. Of them all, the oldest two (*M. subconica* and *M. planilateralis* Fœrste sp.) are the most like the Carboniferous type of the genus. The others have more convex whorls.

### MEEKOSPIRA SUBCONICA, *n. sp.*

PLATE LXXXI, FIGS. 40 and 41.

Shell elongate subconical, apical angle about 33°; hight about 27 mm.; greatest width of body whorl 12 mm.: whorls six or seven, very slightly convex, separated by shallow sutures; base of body whorl somewhat flattened; aperture subquadrate, its width less than the hight; outer lip straight and nearly vertical, viewing it from the side; inner lip thin, passing out of sight a little above the middle of the aperture Surface smooth in the only specimen seen.

This is closely related to *M. planilateralis* Fœrste sp., from the Clinton group in Ohio, but is larger, has a wider apical angle and a more nearly quadrate aperture.

*Formation and locality.*—Richmond group, Spring Valley, Minnesota.

*Collection.*—E. O. Ulrich.

## APPENDIX TO THE GASTROPODA.

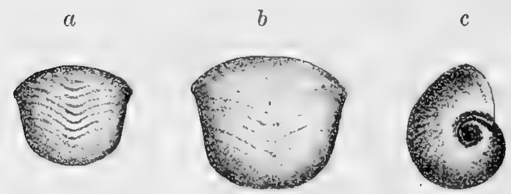



FIG. 10.—*Owenella antiquata* Whitfield sp., Upper Cambrian, Osceola Mills, Wisconsin. *a*, Dorsal view of a small specimen retaining surface markings and showing that there is no slit-band. *b* and *c*, Dorsal and lateral views of a larger specimen showing general form of shell and the umbilicus. The figures are magnified two diameters, and the specimens belong to the U. S. National Museum. (This cut should have appeared at the top of page 848.)

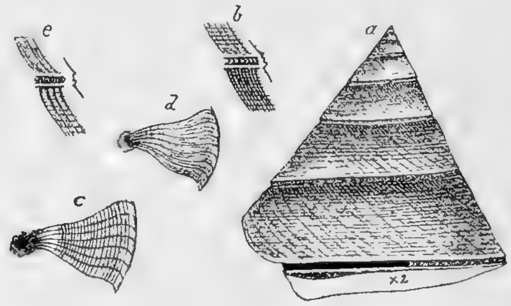



FIG. 11.—*a*, *b*, *c*, *Euconospira planibasalis*, n. sp. (Ulrich), Upper Carboniferous, Kansas City, Missouri. *d*, *e*, *Euconospira turbiniformis* Meek and Worthen sp., Coal Measures, La Salle, Illinois. *a*, Side view of an entire specimen of *E. planibasalis*, ×2, showing general form of shell, the flat base, surface

markings, apertural slit and band. The line beneath the figure shows the form of the basal side of *E. turbiniformis.* *b*, The band of the second to the last whorl of same specimen, with a small portion of the surface above and beneath it, ×3. *c*, Portion of the flat under surface of another specimen of *E. planibasalis*, ×2, showing the direction of the lines of growth and the revolving lines which cover nearly the whole of this surface. *d*, Similar portion of the under surface of *E. turbiniformis*, ×2, showing very delicate lines of growth but no revolving lines. *e*, Small portion of slope of spire of same for comparison with fig *b*. The surface markings are appreciably different and the sculpture and section of the slit-band widely at variance in the two species. (This cut should have appeared on page 956.)

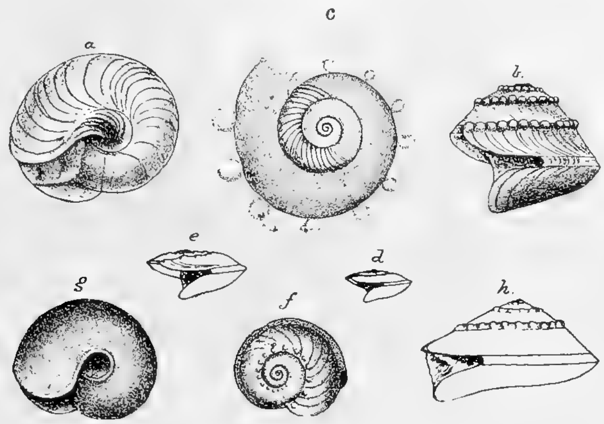



FIG. 12.—Several Carboniferous species of *Treposipra.* *a* and *b*, Two views of a perfect specimen of *T. sphærulata* Conrad sp., showing the depressed apex, short slit, projecting upper lip and other features characterizing in part this genus and species. *c*, Inner whorls of another specimen of this species, ×10, showing several changes which take place in the early development of the shell. Both specimens are from Springfield, Illinois. *d* and *e*, A small specimen of *T. convexa* Ulrich, natural size and magnified, viewed so as to show the depth of the apertural sinus and slit and the depressed convex spire. *f*, The same specimen viewed from above. *g*, Another specimen, also ×2, showing the under side. *T. convexa* is a new species, differing from the others in the gentle convexity of the upper side of the whorls. It is from the Lower Coal Measures at Seville, Illinois. *h*, Lateral view, ×2, of a specimen of *T. illinoisensis* Worthen sp., from Peoria, Illinois. (This cut should have appeared on page 957.)

*Errata for the chapter on Gastropoda.*

PAGE.

819, 15th to 17th lines from top. As this chapter has taken more space than was expected, it is necessary to omit the classification and summary spoken of in these lines.

846, 5th line from bottom, *C. subplanus.* This species is well figured on plate LXI (figs. 40 to 44), but unfortunately its description was overlooked.

847, add to last paragraph: For figures of Whitfield's species see appendix, page 1080.

871, 10th line from top, between third and fourth words insert inner.

956, add to first paragraph: For figures of species of this genus see appendix, page 1080.

957, add to second paragraph: For figures of this and other species of this genus see appendix, page 1081.

960, 4th line from bottom, for "page ——" read page 951.

978, 12th line from bottom, for "LOPHOSPIRA MULTIGRUMA *Miller*" read LOPHOSPIRA TROPIDOPHORA *Meek sp.*; and to synonomy of the species add: *Pleurotomaria (Scalites?) tropidophora* MEEK, 1873, Pal. Ohio, vol. i, p. 154, pl. XIII, figs. 6*a*, *b*.

979, 6th line from bottom, add: (Not HALL.)

982, 10th line from bottom, under LOPHOSPIRA SAFFORDI insert PLATE LXXIII, FIGS. 49—51.

995, 15th line from top, for "FIGS. 36—38" read FIGS. 35—38.

995, 27th line from top, the shell referred to in the paragraph beginning with this line is illustrated on plate LXXXII by figures 42—44, and is there named *Liospira modesta.*

## PLATE LXI.

PAGE.

Figs. 1 and 2 ARCHINACELLA CINGULATA Ulrich .................................................. 829

Dorsal and profile views of a silicified shell of this species. Black River group, Mercer county, Kentucky.

Figs. 3 to 5 ARCHINACELLA POWERSI U. and S. .................................................. 829

3 and 5 Profile and dorsal views of a cast of the interior showing muscular impressions in a very satisfactory manner. A, rostral scars; B, antero-laterals; C, the loop; D, a narrow pair flying just within the loop. Stones River group, Beloit, Wisconsin. Collection, University of Wisconsin.

4 Dorsum of same shell as shown by a gutta percha impression of its matrix.

Figs. 6 and 7 ARCHINACELLA RICHMONDENSIS Ulrich .................................................. 834

Dorsal and profile views of a gutta percha impression of the exterior of the shell which was overgrown by a bryozoan and subsequently dissolved away. Richmond group, Richmond, Indiana.

Figs. 8 and 9 ARCHINACELLA DEPRESSA U. and S. .................................................. 830

Dorsal and profile views of the type of this species. Stones River group, Minneapolis, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 5523.

Figs. 10 and 11 ARCHINACELLA SIMULATRIX U. and S. .................................................. 833

Profile and dorsal views of a cast of the exterior from the Phylloporina bed of the Black River group at St. Paul, Minnesota.

Figs. 12 and 13 ARCHINACELLA SEMICARINATA U. and S. .................................................. 833

Two views of a cast of the interior, showing the carinate umbo and usual form of the species. The linear muscular loop is faintly indicated. Clitambonites bed of the Trenton group, Cannon Falls, Minnesota.

Figs. 14 and 15 ARCHINACELLA VALIDA Sardeson sp. .................................................. 832

Two views of a rather small specimen of this species. Trenton group (Clitambonites beds), Cannon Falls, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 7417.

Figs. 16 to 20 ARCHINACELLA DELETA Sardeson sp. .................................................. 831

16 and 20 Two views of an unusually narrow specimen, from Minneapolis. This, like the original of figures 18 and 19, grew upon the inner surface of a spiral shell. A part of the internal cast of the latter now forms the under side of the specimen and gives it the appearance of a bivalved shell.

17 A specimen of the usual size and proportions. Goodhue county, Minnesota.

18 and 19 Two views of a wide cast of the interior. Near Fountain, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 4067.

All from the Ctenodonta bed of the Black River group.

Figs. 21 to 23 ARCHINACELLA INSTABILIS var. INCURVA U. and S. .................................................. 835

Three views of an imperfect specimen of this variety, the first of the natural size, the others magnified. Ctenodonta bed of the Black River group, Goodhue county, Minnesota.

Figs. 24 and 25 ARCHINACELLA ROTUNDA U. and S. .................................................. 835

Two views of the cast of the interior upon which this species is founded. The inner border of the continuous muscular loop is sharply preserved, but the extreme point of the rostrum and part of the margin on the left side is wanting in the specimen. Utica group, Graf, Iowa.

Figs. 26 and 27 ARCHINACELLA SUBROTUNDA U. and S. .................................................. 834

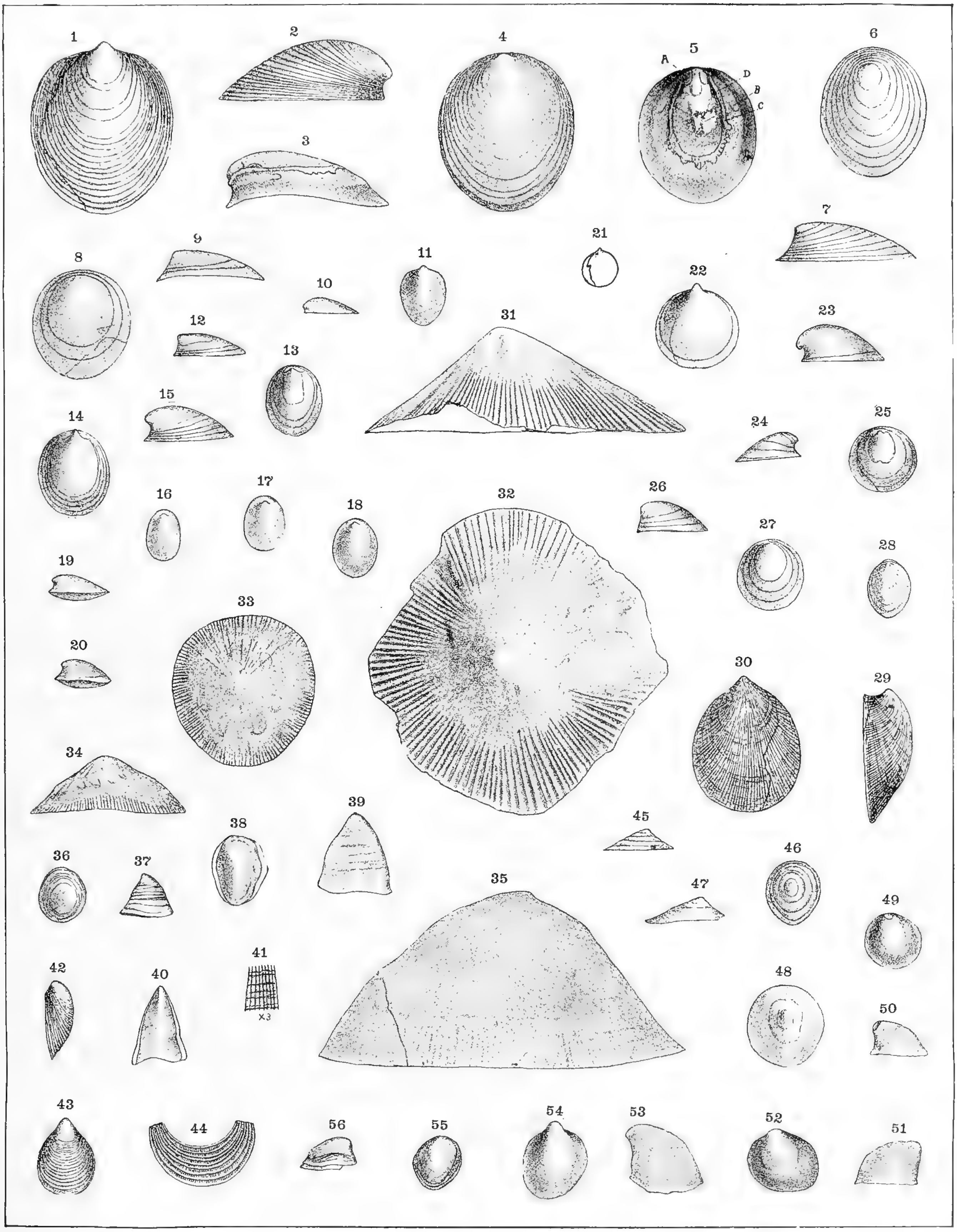
Profile and dorsal views of an entire shell of this species. Ctenodonta bed of the Black River group, near Cannon Falls, Minnesota.

Fig. 28 HELCIONOPSIS SUBCARINATA U. and S. .................................................. 827

Dorsal view of a partial cast of the interior of this species. The upper line represents the appearance of this part of the outline in another specimen. The radiating lines in the right upper fourth of the figure probably represent muscular imprints. Between these and the margin the specimen shows numerous very fine radiating lines, which we believe correspond with lines upon the external surface of the shell. The profile is very nearly as in figure 20 of this plate. Clitambonites bed of the Trenton group, Goodhue county, Minnesota.

(Gastropoda.)

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# PLATE LXII.

PAGE.

Figs. 1 to 4 CARINAROPSIS CYMBULA Hall .................................................. 927

1 Dorsal view of a specimen imperfect at the sides.

2 Diagramatic longitudinal section. The dotted line represents the outline of the lateral margins in a profile view.

3 and 4 Two views of a broken specimen showing the internal septum. Upper part of Trenton group, near Danville, Kentucky.

Fig. 5 CARINAROPSIS EXPLANATA Ulrich .................................................. 929

Dorsal view of the imperfect type of this species. It is a cast of the interior. Upper part of Trenton group, Covington, Kentucky.

Figs. 6 to 9 CARINAROPSIS ACUTA U. and S. .................................................. 928

6 and 7 Dorsal and profile views of a cast of the interior of a young shell. Black River group, near Fountain, Minnesota.

8 and 9 View of the interior of a very large example, and a diagrammatic longitudinal section of the same. Black River group, near Cannon Falls, Minnesota.

Figs. 10 to 13 CARINAROPSIS CUNULÆ Hall .................................................. 927

10 Dorsal view of an average shell. The margin restored from other specimens.

11 Diagrammatic longitudinal section of same showing outer surface only of the operculum (at "O").

12 Another specimen showing a sharply defined dorsal band.

13 Inner surface of original of figure 10, showing the septum and, above it, a triangular plate which we regard as the operculum. Trenton group, Nashville, Tennessee.

Figs. 14 to 18 CARINAROPSIS PHALERA Sardeson .................................................. 928

14 A cast of the interior of this species from the Ctenodonta bed at St. Paul

15 Diagrammatic longitudinal section.

16 and 17 Interior and profile views of an imperfect shell.

18 A specimen broken so as to show the inner surface of the septum. This, like the preceding, is from the Ctenodonta bed at Chatfield, Minnesota.

Fig. 19 CARINAROPSIS MINIMA U. and S. .................................................. 929

Dorsal view of the type and only known specimen of this species. Black River group, Cannon Falls, Minnesota.

Figs. 20 to 26 CYRTOLITES (?) DILATATUS U. and S. .................................................. 865

20 to 23 Four views of a large cast of the interior, Beloit, Wisconsin. Collection of the University of Wisconsin.

24 to 26 Three views of a smaller testiferous example, from the Ctenodonta bed of the Black River group, near Cannon Falls, Minnesota.

Figs. 27 to 29 CYRTOLITES ORNATUS Conrad .................................................. 860

27 Lateral view of a large specimen preserving some of the shell. The surface ornamentation is too delicate to be drawn of the natural size, and only a few of the transverse lines are represented in the figure to give an idea of their direction. Lorraine group, Cincinnati, Ohio.

28 Small portion of the surface markings on the dorsal slopes of another specimen from the same locality, $\times 10$.

29 Dorsum of a third example, from the same locality, $\times 4$.

Figs. 30 and 31 CYRTOLITES ORNATUS var. MINOR U. and S. .................................................. 861

Lateral and dorsal views of a specimen of this variety, $\times 2$. Clitambonites bed of the Trenton group, Cannon Falls, Minnesota.

Figs. 32 to 37 CYRTOLITES RETRORSUS Ulrich .................................................. 861

32 and 33 Two views of a large silicified example showing the usual characters of the species. The backward sweep of the transverse markings on the dorsum and the small sutural fold are the principal distinctive features when compared with *C. ornatus*. Trenton group, Tennessee.

34 Surface of a specimen from Kentucky, $\times 10$.

35 to 37 Three views, $\times 2$, of a smaller silicified shell. Trenton group, Mercer county, Kentucky.

Figs. 38 and 39 CYRTOLITES RETRORSUS var. FILLMORENSIS U. and S. .................................................. *

38 One of the largest and best specimens of this variety seen. It is chiefly a cast of the interior. Black River group, near Fountain, Minnesota.

39 The inner whorls of another specimen from the same locality magnified ($\times 10$) to show their rounded sides and the ornamentation.

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* Unfortunately the description of this new species was overlooked. Still, it is so well illustrated that it seems highly improbable that any one can fail to recognize it. Of its peculiarities we mention the surface markings and the form of the dorsum which at the center is merely angular instead of sharply keeled. The species is founded on several specimens found by Prof. J. M. Safford and kindly submitted by him to one of the authors for description.

PAGE.

Figs. 40 to 44 CYRTOLITES SUBPLANUS Ulrich .................................................... 862

40 and 41 Two views of an incomplete shell, preserving the surface ornamentation. Trenton group, Nashville, Tennessee.

42 and 43 Parts of the dorsal slopes of same, ×4 and ×2, showing the strong transverse lines and weak pittings characterizing the species.

44 Lateral view of a smaller but more complete example, with the surface markings indistinct; from the same locality.

Figs. 45 to 47 CYRTOLITES PARVUS Ulrich.................................................... 864

Three views of the type of this species, two of the natural size, the third ×2. Utica group, Covington, Kentucky.

Figs. 48 and 49 CYRTOLITES DISJUNCTUS U. and S.... .................................................... 864

Two views of a very perfect example of this species. The surface is ornamented almost exactly as in *C. ornatus*, so that figures 28 and 29 of this plate will serve equally well for both species.

Figs. 50 to 52 CYRTOLITES CARINATUS Miller .................................................... 862

Three views of a small but characteristic specimen of this species, ×2. Utica group, Newport, Kentucky.

Figs. 53 to 55 CYRTOLITINA NITIDULA Ulrich .................................................... 866

Three views, the first of the natural size, the others ×2, of one of the original types. The specimen is a cast of the interior but the shell was so thin that it preserves a distinct imprint of the surface markings. Upper part of Trenton group, Covington, Kentucky.

Figs. 56 to 61 BUCANOPSIS CARINIFERA Ulrich .................................................... 925

56 and 57 Dorsal and lateral views of a large specimen.

58 Apertural view of the largest example seen.

59 to 61 Three views of a third shell, this being of the usual size and proportions. Trenton group, near Danville, Kentucky.

Figs. 62 to 65 OXYDISCUS SUBACUTUS Ulrich.................................................... 913

(See also plate LXXXII)

62 and 63 Apertural and lateral views of a nearly perfect example of this species. The slit portion of the dorsum is broken in the specimen but has been restored in the figures.

64 Transverse section of a whorl, showing thickness of shell.

65 Lateral view of the remains of the largest of twenty-three specimens. All the specimens are from the upper part of the Trenton group near Danville, Kentucky. The figures are slightly magnified (about one and one-sixth).

Fig. 66 CONRADELLA FIMBRIATA U. and S.................................................... 907

(See also plate LXVII.)

Vertical section showing transverse sections of all the whorls and portions of former apertural expansions about two of the inner turns.

Fig. 67 CONRADELLA GRANDIS Ulrich .................................................... 908

Transverse section of the last whorl of specimen figured on plate LXVII.

Fig. 68 HELICOTOMA UMBILICATA U. and S..... .................................................... 1034

(See also plate LXXIV.)

Transverse section of the whorls of a specimen from the Stones River group at Dixon, Illinois.

Fig. 69 HELICOTOMA VERTICALIS Ulrich.................................................... 1035

Transverse section of the last whorl of the specimen figured on plate LXXIV.

Fig. 70 ECCYLIOPTERUS BELOITENSIS U. and S.................................................... 1032

(See also plate LXXIV.)

Transverse section of whorl.

Figs. 71 and 72 ECCYLIOPTERUS VOLUTATUS Whitfield sp.... .................................................... 1031

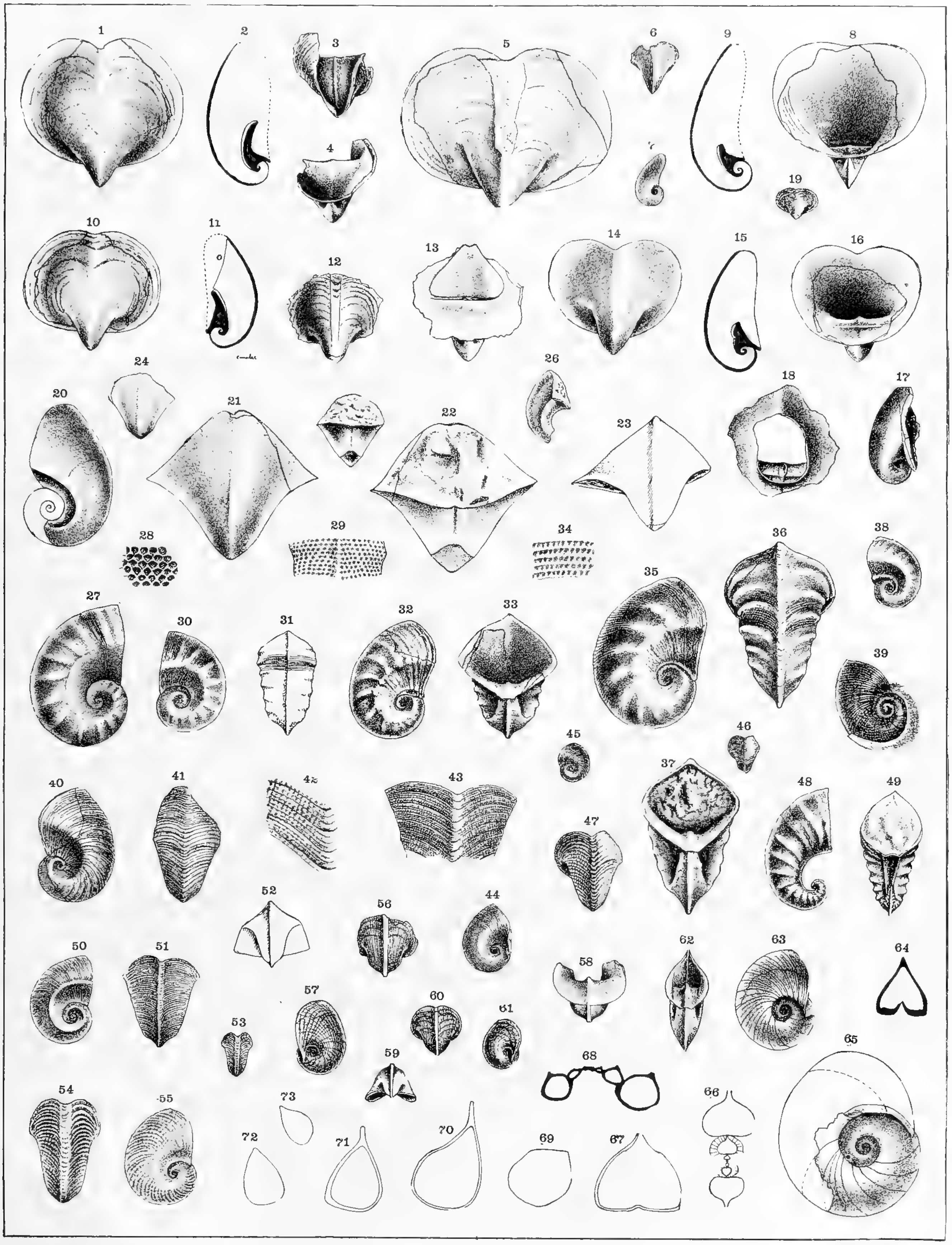
(See also plate LXXIV.)

Transverse section of the last whorl of two specimens, one with the shell, the other an internal cast only.

Fig. 73 ECCYLIOPTERUS TRIANGULUS Whitfield sp.... .................................................... 1031

(See also plate LXXIV.)

Transverse section of the outer whorl of a cast.



# PLATE LXIII.

PAGE.

Figs. 1 to 14 PROTOWARTHIA CANCELLATA Hall sp. .... 872

1 and 2 Two views of a large cast of the interior, retaining a little of the shell in the umbilicus and having several strong wrinkles of growth near the aperture. Ctenodonta bed of the Black River group, West St. Paul, Minnesota.

3 Apertural view of a shell having the mouth less expanded than usual. Ctenodonta bed, Goodhue county, Minnesota.

4 to 6 Three views of an entire shell, representing an average for the species in size and proportions. Ctenodonta bed, Chatfield, Minnesota.

7 and 8 Two views of a rather small cast of the interior from the Clitambonites bed of the Trenton group in Goodhue county. This is a fair sample of the species as it occurs in this bed.

9 Surface of a specimen from the Utica group at Covington, Kentucky. $\times 4.5$ and $\times 9$. In certain lights the longitudinal lines look more like a series of minute granules. The right side of the figure corresponds very nearly with the center of the sinus. These fine markings are but rarely preserved on Minnesota specimens.

10 Outline, in a dorso-lateral view, of left lobe of outer lip of an average example of the species from Covington, Kentucky.

11 Outline of sinus, lobes and dorsum of same, viewed from above.

12 Outline of same specimen in a view from below.

13 and 14 Surface of left lobe of outer lip, $\times 4.5$, and a dorsal view of a more globose and more delicately marked variety, occurring in the Utica group at Covington, Kentucky.

Figs. 15 to 20 PROTOWARTHIA RECTANGULARIS U. and S .... 868

15 Lateral view of a very large specimen—a partial cast of the interior—from the Stones River group, at Mineral Point, Wisconsin.

16 and 18 Lateral and basal views of a cast having the central part of the back unusually prominent and marked with wrinkles of growth. Beloit, Wisconsin.

17 Dorsal view of an average cast of the interior. Beloit, Wisconsin.

19 Outline of right lobe of outer lip of same.

20 Outline of sinus, lobes and dorsum of same viewed from above.

Figs. 21 to 27 PROTOWARTHIA PERVOLUTA U. and S .... 871

21 Basal view of an incomplete shell showing the granulose expansion which spreads from the aperture over the sides and back of the lower part of the shell. Black River group (Ctenodonta bed), St. Paul, Minnesota.

22, 24 and 25 Apertural and lateral views of a small but well preserved shell of the natural size, and the lateral view $\times 2$, showing the granulose layer spreading over the basal or inner half of the last whorl and the grano-lineate extensions curving around the umbilical callosity. Black River group, Chatfield, Minnesota.

23 Transverse section of the outer whorl of a cast.

26 and 27 Two views of an unusually large cast of the interior from the Black River group of Mercer county, Kentucky.

Figs. 28 to 30 PROTOWARTHIA GRANISTRIATA Ulrich .... 870

28 Dorsal view of an average example of this species. Utica group, Covington, Kentucky.

29 and 30 Apertural and lateral views of another specimen, from the same locality, showing the form of the mouth and the extent of the grano-striate expansion.

Figs. 31 to 35 PROTOWARTHIA PLANODORSATA Ulrich .... 871

31 and 32 Dorsal and lateral views of a specimen that has evidently suffered slightly from lateral compression.

33 Outline of same in a basal view. Utica group, Covington, Kentucky.

34 Dorsal view of another example, from the same locality, showing normal proportions.

35 Outline, as seen in a basal view, of another specimen from Covington, agreeing in all respects with other specimens of this species except that it is too wide.

Figs. 36 to 39 PROTOWARTHIA CONCINNA U. and S .... 874

Four views of the type of this species. Richmond group, Spring Valley, Minnesota.

Figs. 40 to 44 PROTOWARTHIA SUBCOMPRESSA Ulrich .... 873

40 to 43 Four views of the best specimen seen. It preserves the two inner layers of shell only and these even are absent in the upper part of the dorsum where the internal cast is exposed. Richmond group, Versailles, Indiana.

44 Part of the surface of a smaller specimen showing the great width of the sinus and the relative narrowness of the lateral lobes. Butler county, Ohio.

Figs. 45 to 47 PROTOWARTHIA OBESA Ulrich .... 874

45 and 46 Dorsal and lateral views of a good but rather small cast of the interior, showing a strong terminal constriction and several of minor depth farther down. Lower part of Trenton group, Danville, Kentucky.

47 View from above of another specimen showing one of the constrictions and lines of growth beyond it. Mercer county, Kentucky.

Figs. 48 and 49 BUCANIA SIMULATRIX Ulrich .... 892

(See also plate LXVII.)

Dorsal and upper views of a good cast of the interior, showing, among other features of the species, the deep sinus and long slit. Richmond group, Richmond, Indiana.

Figs. 50 and 51 BELLEROPHON CAPAX Ulrich .... 921

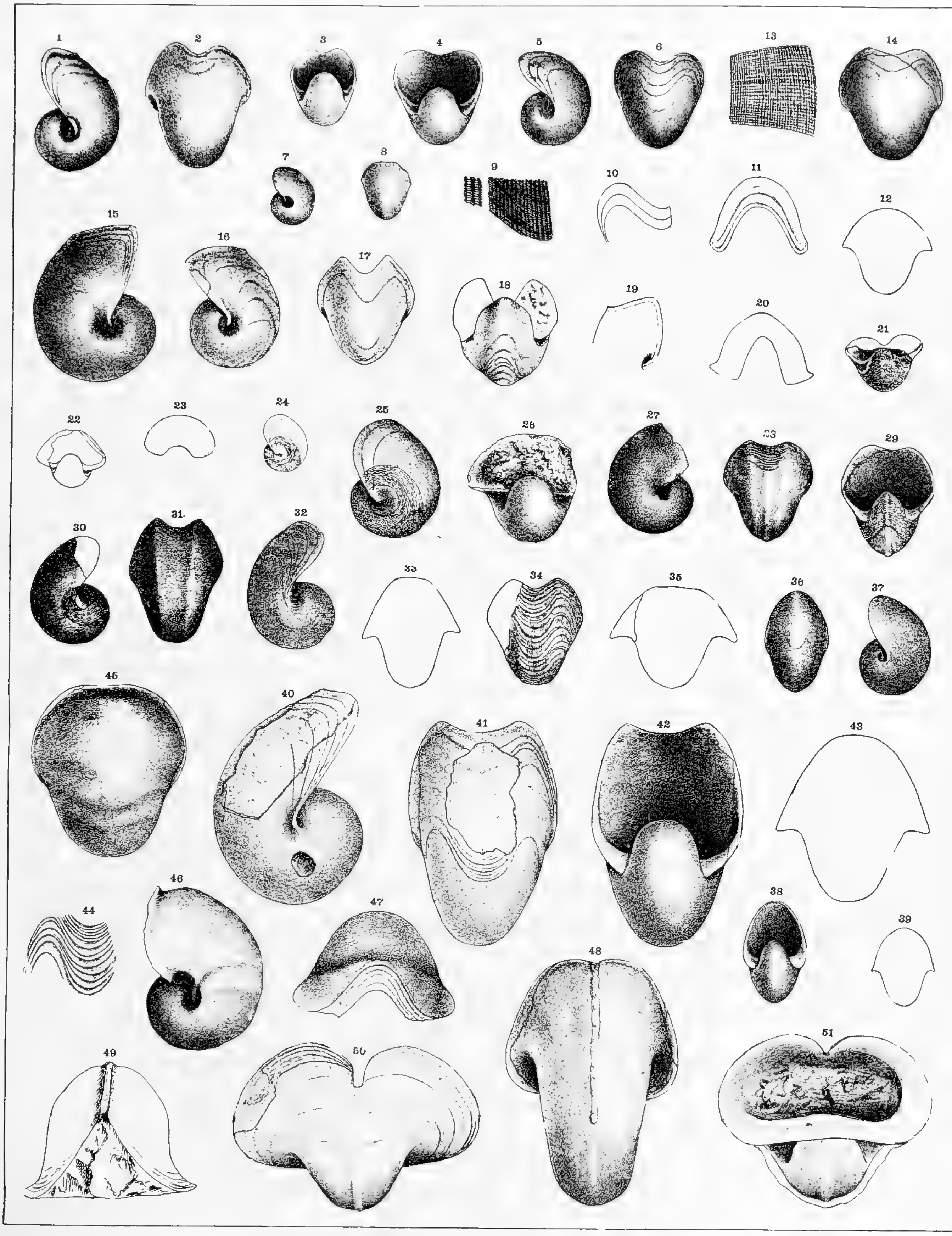
(See also plate LXIV.)

50 A specimen preserved in soft shale, from the upper part of the Utica group at Cincinnati, Ohio. The hight of this specimen has been considerably reduced by pressure, but it serves very well in showing the expansion of the aperture, the sinus and the surface markings.

51 Apertural view of a specimen from the Lorraine group at Covington, Kentucky, that is largely covered by an incrusting bryozoan. The outline and thickness of the latter is indicated by the irregular line about the lower part of the figure.

(Gastropoda.)

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# PLATE LXIV.

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Figs. 1 to 5 BELLEROPHON TROOSTI (D'Orbigny) Safford .......... 915
1 to 3 Three views of a nearly entire example from the Trenton group near Nashville, Tennessee.
4 and 5 Two views of a specimen from Danville, Kentucky.

Fig. 6 BELLEROPHON TROOSTI var. BURGINENSIS Ulrich .......... 916
Lateral view showing larger umbilicus and lesser reflection of the lower part of the lip than occurs in typical *B. troosti*. Trenton group, Burgin, Kentucky.

Figs. 7 to 10 BELLEROPHON CLAUSUS Ulrich .......... 916
7 and 8 Apertural and lateral views of a silicified shell showing the closed umbilici, strongly reflected and deeply excavated lower lip, the lunulæ on the slit-band, sharp and subequal transverse markings, and other peculiarities of the species when compared with *B. troosti*. Trenton group, middle Tennessee.
9 Dorsal view of a smaller specimen from the Trenton at Frankfort, Kentucky.
10 Portion of the back of the Tennessee specimen, ×2.

Figs. 11 to 13 BELLEROPHON RECURVUS Ulrich .......... 920
11 Dorsal view of a small specimen, probably of this species.
12 and 13 Lateral and dorsal views of the type, showing the marked backward sweep of the lines of growth on the back, with a rounded dorsal ridge as in *B. troosti*, and the lip reflected over and completely closing the umbilicus as in *B. clausus*. Lorraine group, Cincinnati, Ohio.

Figs. 14 to 16 BELLEROPHON SUBANGULARIS Ulrich .......... 920
Three views of a specimen preserving much of the shell and surface markings. In figure 14 the mouth is turned forward a little more than usual to show the hight of the dorsal carina. Richmond, Indiana.

Figs. 17 and 18 BELLEROPHON SUBGLOBULUS Ulrich .......... 917
Dorsal and lateral views of a silicified shell. Black River group, Mercer county, Kentucky.

Figs. 19 to 21 BELLEROPHON BILINEATUS Ulrich .......... 917
Three views of a silicified shell showing, of features characterizing the species, the open umbilicus and the concave slit-band with its distinctly elevated bordering lines. Upper part of Trenton group, Danville, Kentucky.

Figs. 22 to 30 BELLEROPHON PLATYSTOMA Meek and Worthen .......... 918
22 and 23 Dorsal and lateral views of a small cast of the interior with the lateral expansions of the aperture broken away. Fusispira bed of the Trenton group, Cannon Falls, Minnesota.
24 and 25 Two views of a similarly imperfect cast. This specimen was received from Prof. Worthen, who collected it from the Trenton (Galena) limestone at Dixon, Illinois.
26 An imperfect cast of the exterior preserving some of the surface markings. Clitambonites bed, Trenton group, Goodhue county, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 6765. The dorsal keel is quite prominent in this specimen and the slopes on each side distinctly concave.
27 to 29 Three views of another specimen, from the same horizon as the preceding, retaining part of one side of the outer lip.
30 Transverse section of whorl of original of figure 25, the inner line corresponds to the point marked "S" on that figure, the outer represents the section just within the apertural slit.

Figs. 31 to 39 BELLEROPHON SIMILIS U. and S. .......... 919
31 Transverse section of whorl. Compare with figure 30.
32 and 33 Lateral and basal views of two small imperfect casts of the exterior, showing distinct impressions of the external lines of growth. Fusispira bed, Trenton group, Cannon Falls and Wykoff, Minnesota.
34 to 36 Three views of a nearly perfect and large cast of the interior; from the same locality.
37 Dorsal view of another large specimen from the locality last mentioned. On the outer parts of this specimen the regular lines of growth are quite distinct, while on the left side several broad longitudinal folds are somewhat obscurely visible.
38 Part of the dorsum of another specimen showing the prominent dorsal ridge and the lines of growth curving backward to it.
39 View of the aperture of a small example retaining a portion of the inner lip. Clitambonites bed, Trenton group, Cannon Falls, Minnesota.

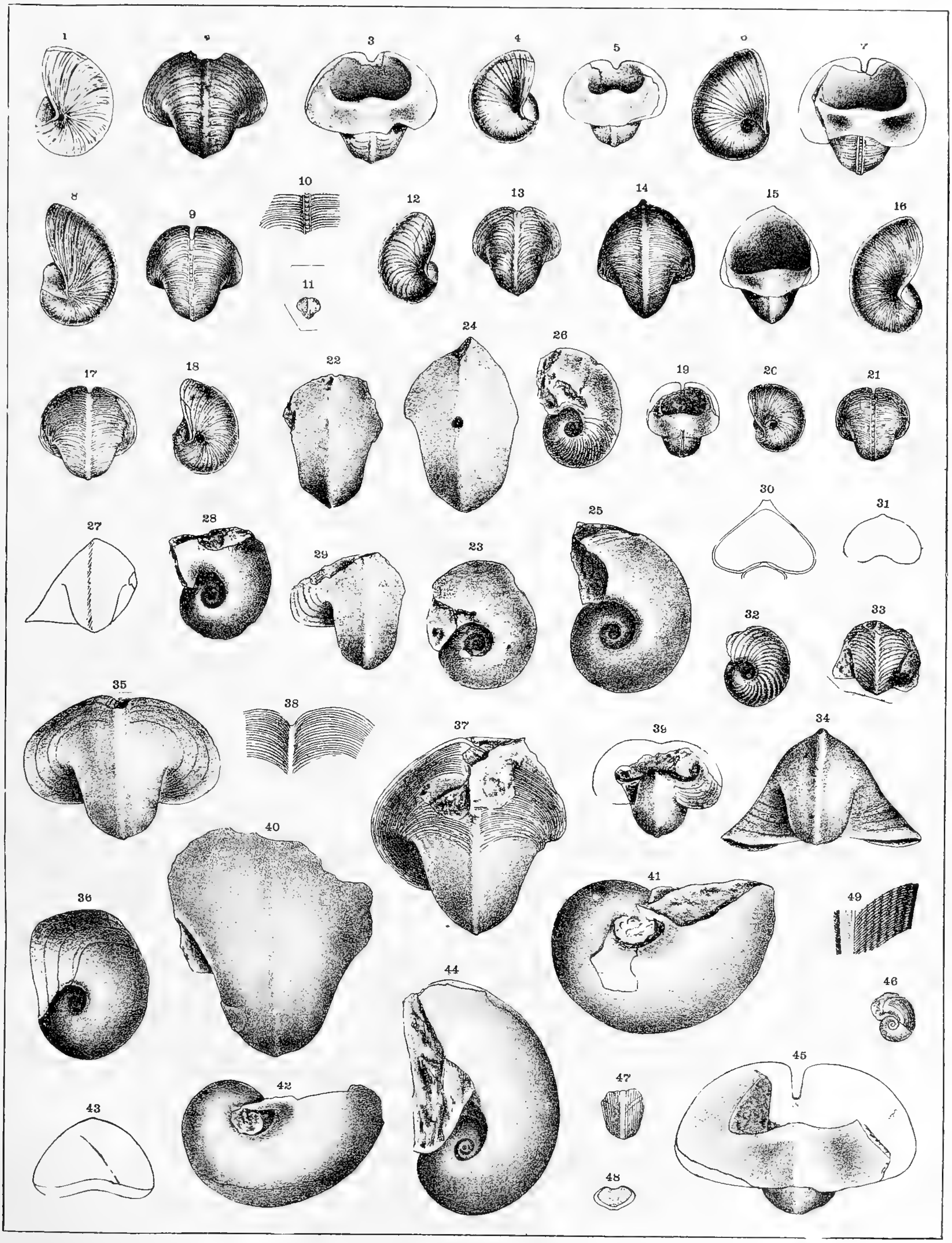
Figs. 40 to 43 BELLEROPHON CAPAX Ulrich .......... 921
(See also plate LXIII.)
40 and 41 Two views of a large cast of the interior, imperfect at the aperture. Lorraine group, Covington, Kentucky.
42 Lateral view of a smaller cast from the same locality.
43 Transverse section of whorl of this and the following species. The sections are taken from casts of the interior, the inner line representing the ventral side of the whorl in *B. mohri*, the lower that of *B. capax*. As shown by the outlines, the surface descends into the umbilicus much more abruptly in the former than in the latter.

Figs. 44 and 45 BELLEROPHON MOHRI Miller .......... 920
44 Lateral view of a large cast, imperfect at the aperture. Richmond, Indiana. (Compare with figures 41 and 42, and refer to explanation of figure 43.)
45 Apertural view of a testiferous example for comparison with figure 51 on plate LXIII.

Figs. 46 to 49 KOKENIA COSTALIS U. and S. .......... 882
46 and 47 Lateral and dorsal views, the inner whorls restored, of the type of this genus and species. Clitambonites bed, Trenton group, Cannon Falls, Minnesota.
48 Transverse sections of the last whorl. The lower side of the figure is the dorsal.
49 Portion of the broad dorsal band and of the right slope, ×3.

(Gastropoda.)





## PLATE LXV.

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Figs. 1 and 2 TETRANOTA MACRA U. and S. ... 879
Dorsal and lateral views of the type of this species. Stones River group, Minneapolis, Minnesota. The specimen is a good cast of the interior and shows the expanded mouth, the peculiarly lean appearance and strongly ribbed character of the fossil.

Figs. 3 to 9 TETRANOTA SEXCARINATA U. and S. ... 878
3 and 4 Two views of an excellent specimen from the Fusispira bed at Wykoff, Minnesota. Though a cast of the interior, the surface markings are clearly indicated.
5 and 6 Dorsal and lateral views of a cast of an early variety of the species. Stones River group, Minneapolis, Minnesota.
7 Sectional view of preceding specimen.
8 Section of a whorl of a specimen from the Stones River group, at Dixon, Illinois.
9 Section of whorl of Wykoff specimen.

Figs. 10 to 18 TETRANOTA BIDORSATA Hall sp. ... 877
10 and 11 Two views of a large cast from the lower part of the Fusispira bed near Cannon Falls, Minnesota. This specimen evidently has been somewhat compressed laterally.
12 Another cast tilted forward slightly to show the hight of the central ridge. Clitambonites bed, Goodhue county, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register, No. 7382.
13 and 14 Two views of a specimen with the apertural parts broken away. Clitambonites bed.
15 Another specimen from the Clitambonites bed preserving the apertural margin with some of the surface markings on one side.
16 Surface markings of same. $\times 3$ and $\times 5$.
17 Ventral side of fragment of outer volution showing transverse section of same below and four grooves produced by the dorsal ridges of the preceding whorl. Clitambonites bed.
18 Dorsal view of a small specimen. The majority of the specimens seen from the Clitambonites bed range in size between this and figure 13.

Figs. 19 to 23 TETRANOTA OBSOLETA U. and S. ... 880
19 and 20 Dorsal and apertural views of a testiferous example on which the slit-band has remained concave throughout the growth of the shell. Ctenodonta bed, Chatfield, Minnesota.
21 to 23 Three views of the specimen which we regard as the type of the species. Though retaining the shell, we have failed to discover any remains of surface markings. Ctenodonta bed, Goodhue county, Minnesota.

Figs. 24 and 25 TETRANOTA, sp. undet. ... 880
24 Dorsal view of a good cast of the interior from the Utica group at Cincinnati, Ohio. This specimen may represent a later variety of *T. bidorsata* Hall, but in the obsolesence of the latero-dorsal ridges, as may be seen from the basal outline, it agrees more closely with *T. obsoleta*.
25 Dorsal view of a cast of the interior of an undescribed species of this genus. Stones River group, Minneapolis, Minnesota. The ridges in this species, of which our material is not sufficient to warrant us in giving it a name, are unusually obscure.

Figs. 26 to 29 TETRANOTA WISCONSINENSIS Whitfield sp. ... 881
26 Dorsal view of a large and nearly perfect cast of the interior. Stones River group, Beloit, Wisconsin. Collection, University of Wisconsin.
27 View of same with the smaller volutions removed, showing the ventral side of the outer whorl with the four furrows which are always found here in species of *Tetranota*.
28 Lateral view of same.
29 Dorsal view of a very small specimen supposed to be the young of this species. Minneapolis, Minnesota.

Fig. 30 SCHIZOLOPHA TEXTILIS Ulrich ... 992
A specimen showing the slit in the outer lip and preserving some of the delicate surface markings. The enlargement of the latter ($\times 2$) represents part of the upper third of the last whorl to the suture line and above this the slit-band of the preceding whorl. Upper part of Trenton group, Nashville, Tennessee.

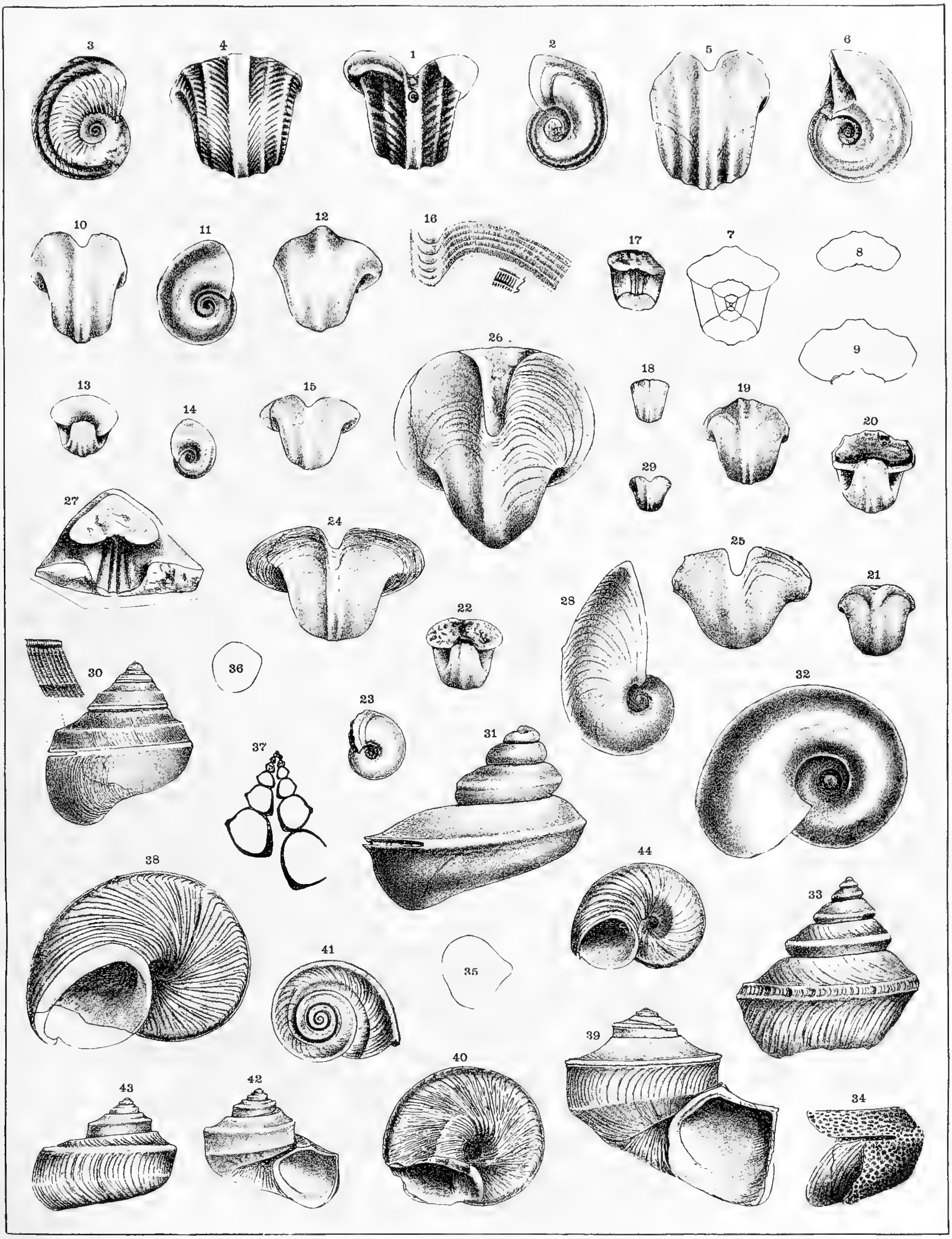
Figs. 31 to 37 SCHIZOLOPHA MOOREI Ulrich ... 992
31 and 32 Two views of a nearly perfect cast of the interior of the typical form of this species showing the slit, the great prominence of the carina on the last whorl, the umbilicus, and other characteristic features. Richmond group, Richmond, Indiana.
33 Gutta percha impression from a natural mold of the exterior, showing the coarse surface markings. Richmond, Indiana.
34 Outer third of the last whorl of a specimen overgrown by a species of *Protarea*, which originally covered all of the exterior of the shell excepting the slit in the aperture. Locality, same as preceding.
35 Transverse section of the last whorl of a cast from the same horizon and locality. The small indentation on the umbilical side (left side of figure) is characteristic for the typical form of the species.
36 Transverse section of the last whorl of a small variety occurring in the Lorraine group at Cincinnati, Ohio. In casts of this form the peripheral angle is less prominent than in the typical form, and there is no indentation on the umbilical side. (Compare with figure 35.)
37 Vertical section of an unusually high, testiferous example of the Cincinnati variety.

Figs. 38 to 40 LOPHOSPIRA (?) KNOXVILLENSIS Ulrich ... 989
38 and 39 Umbilical and apertural views of a specimen showing the general form of the shell, which is much as in *Trochonema*, with the distinct peripheral band of a *Lophospira*. Knoxville, Tennessee. (? Chazy group.)
40 View of the umbilical side of another specimen from the same locality.

Figs. 41 to 44 LOPHOSPIRA? TROCHONEMOIDES Ulrich ... 990
Four views of the type of this species.

(Gastropoda.)

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## PLATE LXVI.

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Figs. 30 to 33 BUCANIA FRANKFORTENSIS Ulrich .................................................. 891

Four views of the silicified shell upon which the species is founded. Top of Trenton group, Frankfort, Kentucky. The specimen has suffered from maceration, consequently the surface markings, the interrupted revolving lines especially, are more or less obscure.

Figs. 34 and 35 BUCANIA PERACUTA Ulrich .................................................. 896

Two views of the incomplete type of this remarkable species. Trenton group, DeKalb county, Tennessee.

Figs. 36 to 40 BUCANIA NASHVILLENSIS Ulrich .................................................. 893

36 Basal view of a macerated specimen from the Trenton at Nashville, Tennessee, possessing unusually thick inner lip.

37 Apertural view of another specimen from this locality.

38 and 39 Two views of an incomplete but otherwise well preserved shell from DeKalb county, Tennessee, showing form of aperture, the slit and surface markings.

40 Small part of dorsal surface of same showing the slit-band and surface markings.

Figs. 41 to 44 BUCANIA NANA Ulrich .................................................. 895

41 Lateral view of an average specimen of this small species.

42 and 43 Apertural and lateral views of same, $\times 2$.

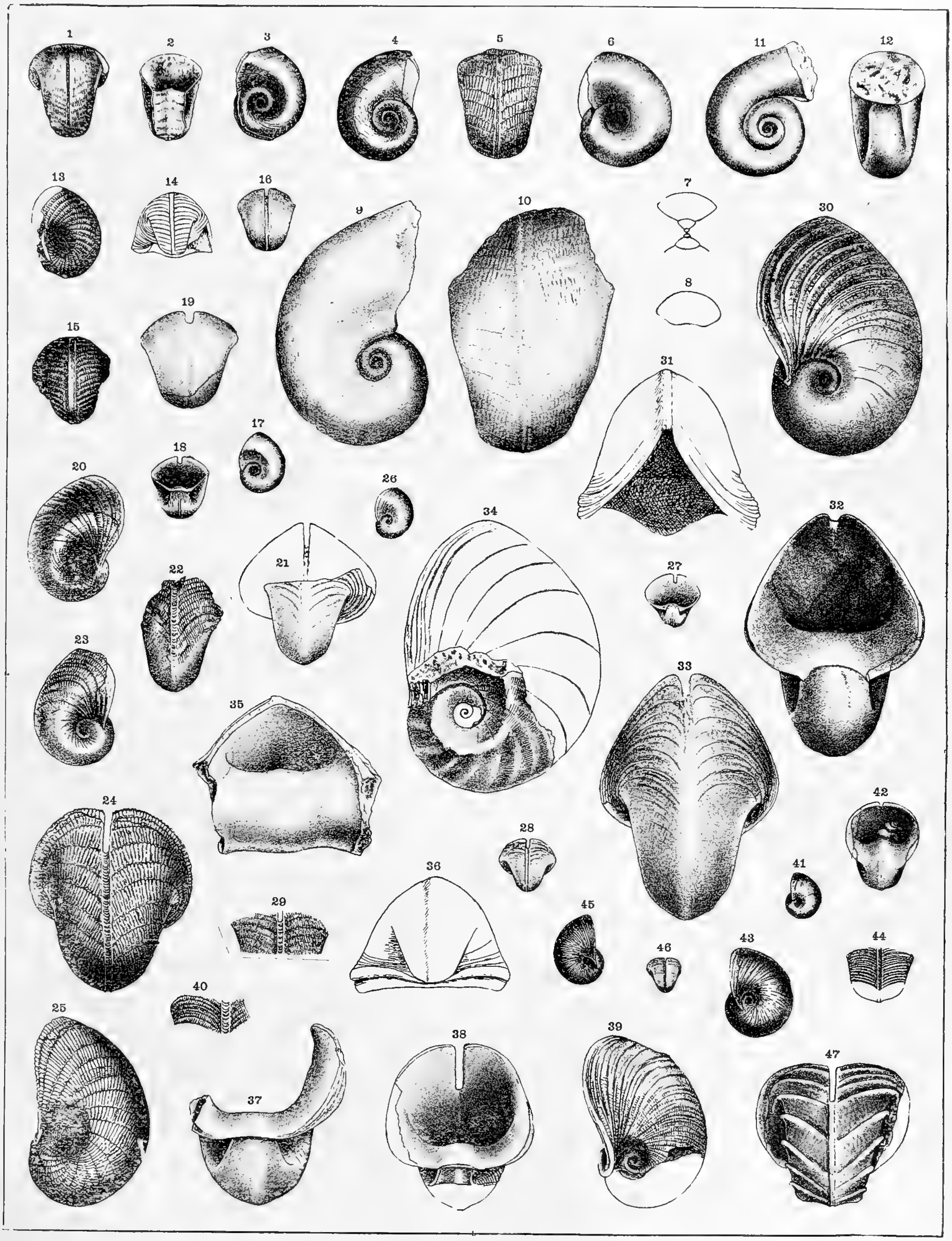
44 Part of the dorsal surface of another specimen, $\times 3$, showing exceedingly delicate striæ connecting the regular transverse lines. The line at the bottom of the figure shows the convexity of the dorsal surface. Trenton group, near Burgin, Kentucky.

Figs. 45 and 46 BUCANIA NANA var. SUBPATULA Ulrich .................................................. 896

Lateral view, $\times 2$, and dorsal view of the natural size of a specimen of this variety, showing a smaller umbilicus and wider aperture than pertains to the typical form of the species. Near Burgin, Kentucky.

Fig. 47 BUCANIA SINGULARIS Ulrich .................................................. 894

Dorsal view of a specimen that is largely overgrown by a delicate bryozoan, obscuring the finer surface markings. Upper part of Trenton group, Nashville, Tennessee.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## PLATE LXVII.

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| Figs. 1 to 6 | Conradella obliqua U. and S. | 906 |
| 1 | Lateral view of an almost perfect and unusually large specimen, showing the decided obliquity of the transverse lamellæ which characterizes this species. Shales of the Black River group, Cannon Falls, Minnesota. | |
| 2 and 3 | Two views of another specimen, slightly exceeding the average size. St. Paul, Minnesota. | |
| 4 | Parts of two whorls of another specimen from St. Paul, ×2, the slight denticulations of the edge representing the prominent lunulæ of the slit-band. The decline at the upper right-hand corner of the figure is at the beginning of the open slit. | |
| 5 | View of the back of part of the slit portion of a third specimen from St. Paul, ×2, having unusually prominent imbrications. | |
| 6 | Dorsal surface, ×4, of same specimen that furnished figure 4, showing salient slit-band with its distant lunulæ, and surface markings. | |
| Figs. 7 to 10 | Conradella fimbriata U. and S. (See also plate LXII.) | 907 |
| 7 and 8 | Two views of a large specimen. Stones River group, Minneapolis, Minnesota. The umbilicus is filled with stony matter and the left side of the apertural expansion broken away in the original of these figures, but as the missing and hidden parts are clearly shown by other specimens, no apology is necessary for restoring them in the drawings. | |
| 9 | Portion of the terminal expansion and of the broken bases of two preceding expansions of same, ×2.5, showing fine surface markings. The right margin of the figure represents the edge of the slit. | |
| 10 | Apertural view of a small specimen showing the expansion entire on one side. Geological and Natural History Survey of Minnesota, Museum Register No. 8724. | |
| Fig. 11 | Conradella imbricata Meek and Worthen sp. | 911 |
| | Lateral view of a small but highly characteristic specimen of this species. Trenton group, Alexander county, Illinois. | |
| Figs. 12 to 15 | Conradella elegans Miller sp. | 911 |
| 12 | Lateral view of a specimen of the usual size, Lorraine group, Cincinnati, Ohio. | |
| 13 and 14 | Lateral view of the natural size, and apertural view ×2, of the largest specimen seen; from the same locality. | |
| 15 | Small portion of the left dorsal slope of same, ×4. | |
| Figs. 16 to 18 | Conradella grandis Ulrich. (See also plate LXII.) | 908 |
| 16 and 17 | Two views of a large specimen of this species. Stones River group, Lebanon, Tennessee. The specimen occurred in solid limestone, one side being now a cast of the interior, while the other retains some of the shell with the broken bases only of the transverse lamellæ. | |
| 18 | Small part of the side of another specimen showing the imbricating lamellæ entire. | |
| Figs. 19 to 22 | Conradella triangularis U. and S. | 908 |
| 19 to 21 | Lateral views of three specimens showing very decided variability in the number of the transverse imbrications. All are from the Stones River group; the first, from Beloit, Wisconsin, has unusually numerous imbrications; in the second, from Dixon, Illinois, they are much fewer in number; in the third, from Minneapolis, Minnesota, their number is not far from an average for the species. | |
| 22 | Section of a specimen from Dixon, Illinois, cutting the whorls transversely. | |
| Figs. 23 to 26 | Conradella bellula Ulrich. | 910 |
| 23 and 24 | Lateral and apertural views, the first of the natural size, the second ×2.4, of an apparently perfect example. Lorraine group, Covington, Kentucky. | |
| 25 | Part of a dorsal view of same ×4, showing the slit-band and wavy surface imbrications. | |
| 26 | Small part of surface in a lateral view, ×4. | |

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Figs. 27 to 29 CONRADELLA DYERI var. CELLULOSA U. and S. .................................... 910

27 Lateral view, mostly in outline only, of a good specimen. Clitambonites bed, Trenton group, Cannon Falls, Minnesota.

28 and 29 Small portions of the sides of the outer whorl, $\times 4$ and $\times 8$, showing the peculiar surface markings. The right side of these figures is anterior.

Figs. 30 to 33 CONRADELLA DYERI Hall sp ................................................... 909

30 Lateral view, in outline, of a nearly complete shell. Richmond group, Butler county, Ohio.

31 Apertural view of another specimen, $\times 2$. This specimen, now incomplete, was perhaps a half turn larger than the preceding. It is from the same locality.

32 Part of the right side of same, $\times 4$.

33 Inner whorls of same, $\times 10$.

Figs. 34 to 38 SALPINGOSTOMA BUELLI Whitfield sp ............................................ 900

34 to 36 Three views of a fine cast of the interior, showing the expanded mouth, the open dorsal slit, and obscure indications of the external markings. Stones River group, Rockton, Illinois. Geological and Natural History Survey of Minnesota, Museum Register No. 7318.

37 Dorsal view of a specimen from Beloit, Wisconsin, retaining some of the external markings.

38 Apertural view of a specimen from the Vanuxemia bed at Minneapolis belonging to the Geological Survey collection (Museum Register No. 5544), and doutfully referred to *s. buelli.* In this specimen the apertural portion of the internal castas been removed and the remaining radially marked expansion therefore represents an impression of the *exterior* of the shell and not of the interior.

Figs. 39 and 40 SALPINGOSTOMA RICHMONDENSIS Ulrich .......................................... 903

Two views of a nearly complete cast of the interior, from Richmond, Indiana.

Figs. 41 to 44 BUCANIA PUNCTIFRONS Emmons .................................................. 894

41 Apertural view of a good specimen. The reticulated surface markings are omitted except on the umbilical slope on the right side of the figure. Lower part of Trenton group, Nashville, Tennessee.

42 Small portion of the markings of same, $\times 5$.

43 Lateral view of another specimen, from the same locality, showing several interruptions in the regular growth of the shell. The surface ornamentation was drawn on a portion of the outer whorl only.

44 Part of dorsum of same, $\times 2.4$, showing the slit-band and surface markings to the first interruption, the latter being at the top of the figure.

Fig. 45 BUCANIA SIMULATRIX Ulrich ........................................................ 892

(See also plate LXIII.)

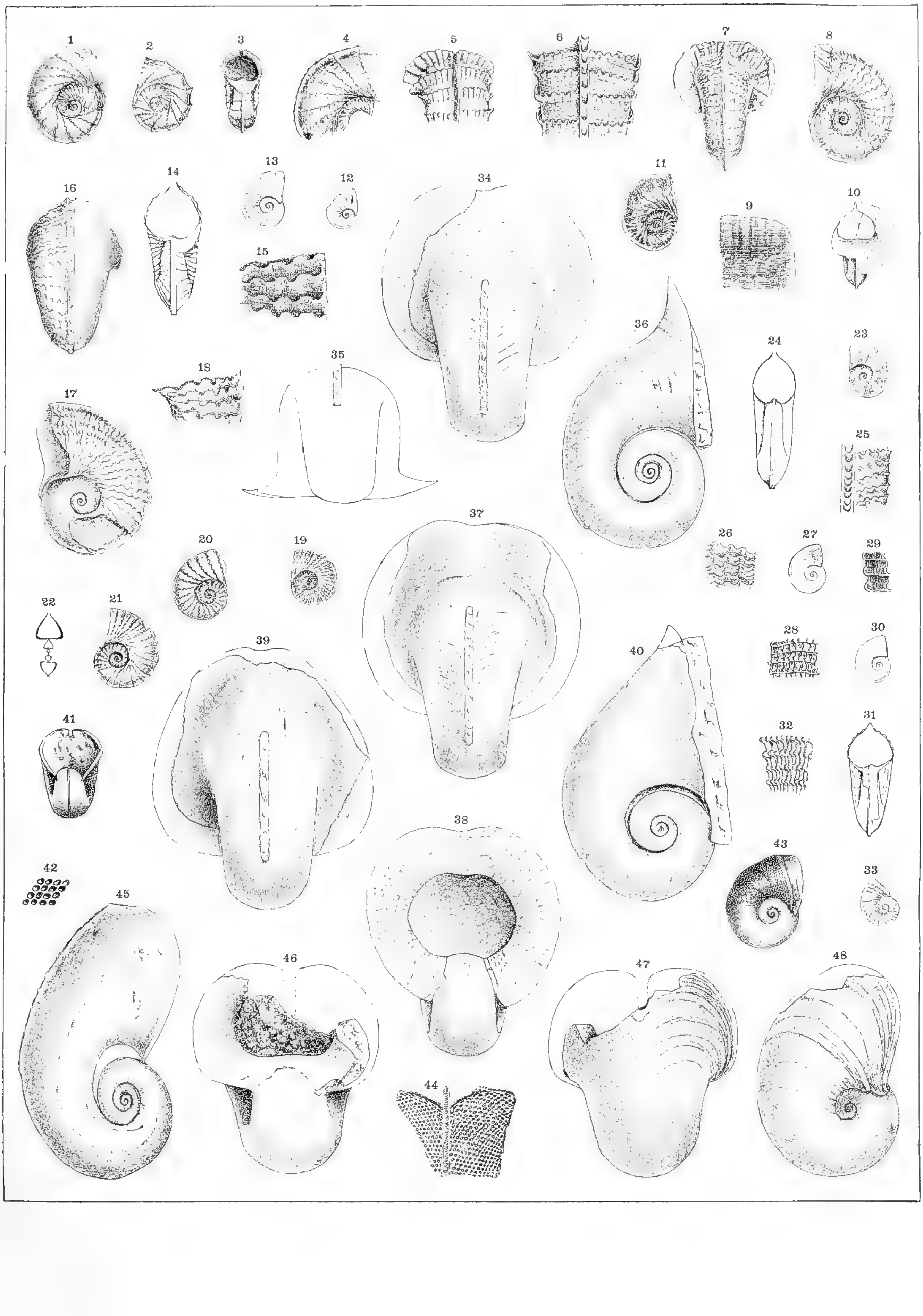
Lateral view of the specimen illustrated on plate LXIII. It is a cast of the interior and almost perfect. Imperfect specimens are very liable to confusion with the associated *Salpingostoma richmondensis* figured on this plate.

Figs. 46 to 48 BUCANIA CRASSA Ulrich ..................................................... 893

Three views of the most complete example seen, showing the thick shell and obscure remains of surface markings. Richmond, Indiana. This specimen has suffered considerably from maceration. Other, less complete, individuals exhibit a rounded dorsal band which, however, does not materially affect the almost uniform convexity of the back of the whorls.

(Gastropoda.)

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## PLATE LXVIII.

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Figs. 1 to 6 RAPHISTOMA PERACUTUM U. and S. .......... 940

1 Outline view of the flat side of a specimen preserving the shell with some of the surface markings. Ctenodonta bed, Black River group, near Cannon Falls, Minnesota.

2 Umbilical side of the same, $\times 2$.

3 Apertural view of same, $\times 2$, showing extremely acute periphery and slightly sunken spire.

4 Small portion of outer whorl of figure 1, $\times 5$, showing fine regular lines of growth of the delicate raised line interrupting their continuity about a third of the width of the whorl from the suture.

5 Apical side of another example, from the same locality.

6 Apertural view of same, $\times 2$. The spire is not sunken in this specimen.

Figs. 7 to 9 RAPHISTOMA RICHMONDENSE Ulrich .......... 941

7 and 8 Two views of a specimen retaining some of the shell. Richmond group, Richmond, Indiana.

9 Small part of the upper side of the last whorl of same, $\times 4$, showing curvature of the sub-equal striae and the wire-like peripheral edge. The latter forms the lower boundary of the figure.

Figs. 10 to 13 RAPHISTOMINA RUGATA U. and S. .......... 944

Four views, the last of the natural size, the others $\times 2$, of an entire cast, apparently of the exterior of the shell. The unusual strength of the transverse striae is the most striking of the specific peculiarities of this species. Trenton group, Clitambonites bed, Goodhue county, Minnesota.

Figs. 14 to 17 RAPHISTOMINA MODESTA Ulrich .......... 943

Four views, the first of the natural size, the others $\times 2$, of the silicified type of this species. The peripheral wrinkles shown in figure 16 may have extended all around originally. Stones River group, Murfreesboro, Tenn.

Figs. 18 to 20 RAPHISTOMINA LAPICIDA Salter sp. .......... 942

18 Umbilical side of a large specimen, the apertural portion restored in the figure. Black River group, near Lebanon, Tennessee.

19 Upper side of another specimen, from the same locality.

20 Apertural view, with the apical whorls restored, of a third specimen, from the same locality.

Figs. 21 to 23 RAPHISTOMINA DENTICULATA Ulrich .......... 943

21 and 22 Two views of a coarsely silicified shell of this species. The surface markings are very obscure except on a small portion of the upper part of figure 22 where the denticulations of the periphery also are shown. Black River group, Mercer county, Kentucky.

23 Dorsal view of a partial cast of the interior from the same locality, showing the obscure ridge beneath the peripheral angle.

Figs. 24 to 29 LIOSPIRA MICULA Hall sp. .......... 994

24 to 26 Three views of a large and nearly perfect example of this species. Utica group, Covington, Kentucky.

27 Portion of the under side of same, $\times 5$, showing surface markings and lower part of peripheral band. The portion of the latter exposed in this view is very narrow.

28 Portion of upper side of last whorl of same, $\times 5$, showing delicate lines of growth, the broad and faintly defined peripheral band, and obscure revolving lines on the latter. Such revolving lines often extend over the whole upper side of the whorls.

29 Peripheral portion of preceding more highly magnified ($\times 10$) giving an idea of the exceeding delicacy of the markings.

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Figs. 30 to 34 LIOSPIRA OBTUSA U. and S. .... 997

30 to 32 Three views of a large specimen, chiefly a cast of the interior, showing the obtuse periphery and in figure 32 the great thickness of the shell in the umbilical region. The latter, however, seems never to have been completely filled, a small perforation occurring in every case. Stones River group, Dixon, Illinois.

33 and 34 Profile and sectional views of a smaller specimen, the latter showing the umbilical perforation. Geological and Natural History Survey of Minnesota, Museum Register No. 687.

Figs. 35 to 37 LIOSPIRA ANGUSTATA U. and S. .... 997

(See also plate LXIX.)

35 and 36 Two views of a large specimen retaining considerable of the shell. Fusispira bed, Trenton group, Wykoff, Minnesota.

37 Vertical section of a small specimen showing narrow umbilical perforation and rapidly increasing shell surrounding it; from same locality.

Figs. 38 to 44 LIOSPIRA PROGNE Billings sp. .... 996

38 Under side of a specimen from the Fusispira bed of the Trenton group at Wykoff, Minnesota. This specimen presents the usual appearance of the species as it occurs in Minnesota. Of the shell it retains only the concave solid filling of the umbilicus.

39 Profile view in outline of a rather small silicified shell, showing the peripheral band. The sutures are very indistinct and the surface quite smooth. Lower division of the Stones River group, Murfreesboro, Tennessee.

40 Vertical section of a typical specimen from the Trenton at Burgin, Kentucky.

41 and 42 Basal and profile views of the solid axis of a large specimen. Trenton group, Hartsville, Tennessee.

43 Under side of another axis in which the callosity which fills the umbilicus is more distinctly outlined than usual.

44 Another Tennessee specimen in which the umbilical cavity is unusually narrow.

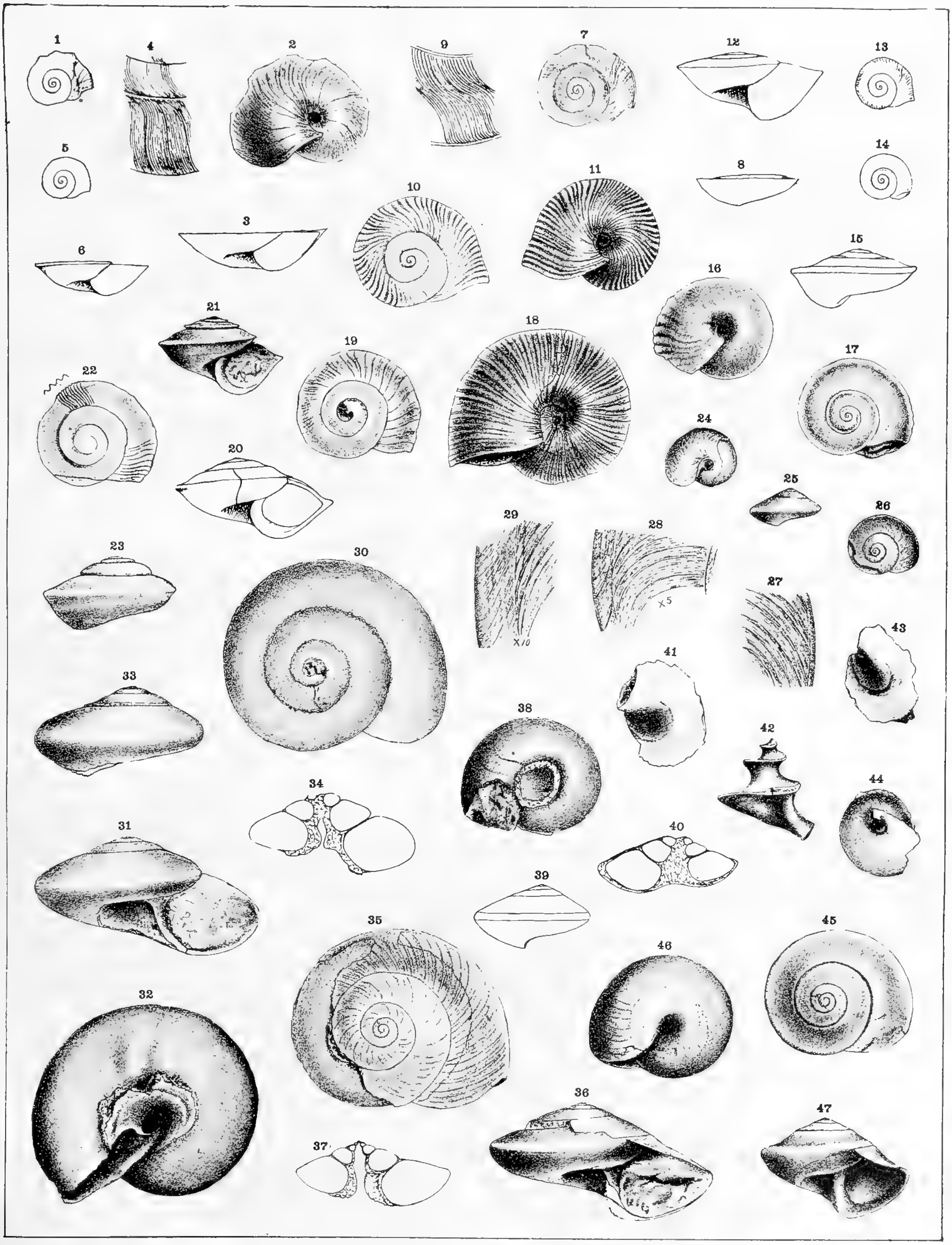
Figs. 45 to 47 LIOSPIRA PERSIMILIS Ulrich .... 998

45 Apical side of a specimen from the Trenton group at Hartsville, Tennessee.

46 and 47 Basal and apertural views of another specimen from the same locality showing the greatly expanded umbilical callosity which distinguishes this species from *L. helena* Billings sp.

(Gastropoda.)

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# PLATE LXIX.

PAGE.

Figs. 1 and 2 LIOSPIRA ANGUSTATA U. and S. .......... 997
(See also plate LXVIII.)

1 Vertical section of a large specimen, chiefly a cast of the interior, showing thickness of shell in the umbilicus. The sutures in this specimen are unusually deep. Trenton group, Wykoff, Minnesota.

2 Under side of the specimen figured on plate LXVIII (figures 35 and 36), showing the narrow umbilical perforation and thick shell surrounding it. Though the rest of this side of the specimen is a cast of the interior, the outer part of the last volution still gives a good idea of the surface markings.

Figs. 3 to 8 LIOSPIRA VITRUVIA Billings sp. .......... 995

3 to 5 Three views of a cast of the interior, from the Stones River group at Beloit, Wisconsin. The concavity of the upper side of the outer volution is usually somewhat less, while the hight of the casts is commonly a trifle greater among Minnesota specimens of this species.

6 Vertical section of the outer whorl of another specimen from Wisconsin, agreeing with the preceding and showing the outline generally pertaining to Wisconsin representatives of the species. Geological and Natural History Survey of Minnesota, Museum Register No. 7287.

and 8 Vertical sections of two specimens from the Vanuxemia bed of the Stones River group of Minnesota, the first from Minneapolis, the second from Cannon Falls. Both retain the shell in the umbilicus and show, one more distinctly than the other, the angular border of the large umbilical perforation which is characteristic of the species.

Figs. 9 to 14 EOTOMARIA CANALIFERA Ulrich .......... 1002

9 to 12 Four views of an average example of this species. Lowest division of the Stones River group, Murfreesboro, Tennessee.

13 Surface markings of the upper side and contour of same portion, $\times 2$, of a large specimen from the same locality. The upper slope of the contour line is a little too steep in the figure.

14 Outline view of a third specimen; the aperture is broken away but the spire is almost complete and shows the gradual increase of the apical angle.

Figs. 15 to 17 EOTOMARIA LABIOSA Ulrich .......... 1003

Three views of a nearly entire silicified shell, showing the great strength of the inner lip which distinguishes the species from *E. canalifera*. Stones River group, Murfreesboro, Tennessee.

Figs. 18 to 20 EOTOMARIA VICINUS U. and S. .......... 1003

18 Dorsal view of a cast of the interior from the Stones River group at Minneapolis, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 5106.

19 and 20 Apertural and basal views of a smaller and relatively higher cast from the same horizon at Mineral Point, Wisconsin. The species is closely related to *E. dryope* Billings sp., but has a more evenly conical spire.

Figs. 21 to 25 EOTOMARIA DRYOPE Billings sp. .......... 1003

21 Dorsal view of a large shell of this species from the Black River group of central Tennessee. Prof. J. M. Safford's collection.

22 Section of a whorl taken from a smaller specimen collected at the same locality as the preceding.

23 to 25 Three views of a good cast of the interior, the spire slightly lower than usual for the species. Stones River group, Cannon Falls, Minnesota.

Figs. 26 to 29 EOTOMARIA SUPRACINGULATA Billings sp. .......... 1004

26 Gutta percha impression from an incomplete natural mold of the exterior. Stones River group, Beloit, Wisconsin.

27 to 29 Three views of a large specimen from Dixon, Illinois, retaining the shell, in a macerated condition, however. Figure 29 shows the remarkable forward sweep of the outer part of the under lip.

Figs. 30 to 32 LIOSPIRA SUBCONCAVA Ulrich .......... 999

30 and 31 Two views of an average example. Stones River group, Murfreesboro, Tennessee.

32 The upper side of a large specimen, from the same locality, showing the fine surface markings. The latter are more delicate than they appear in the figure.

Figs. 33 to 36 LIOSPIRA (?) RUGATA Ulrich .......... 999

Four views of an average example of this species. The shell has suffered from maceration yet preserves distinct remains of the transverse wrinkles. Richmond group, McKinneys, Kentucky.

Figs. 37 to 41 LIOSPIRA (?) MUNDULA Ulrich .......... 999

37 and 39 Two views of a specimen, medium in size and proportions. As usual the surface markings are very obscure. Upper part of Trenton group, Danville, Kentucky.

38 Upper side of a similar specimen.

40 and 41 Two views of a large shell, imperfect at the mouth but preserving unusually distinct lines of growth. Formation and locality same as preceding.

Figs. 42 to 46 LIOSPIRA (?) ANGULATA Ulrich .......... 1000

42 and 43 Lower and upper sides of a silicified shell, showing the angular border of the umbilicus. Black River group, Mercer county, Kentucky.

44 Umbilical side of a cast of the interior from the same locality.

45 A large cast of the interior, the inner whorls restored from another specimen. Locality same as preceding.

46 Apertural view of original of figures 42 and 43.

Figs. 47 to 50 CLATHROSPIRA SUBCONICA Hall sp. .......... 1006
(See also plate LXX.)

47 and 48 Two views of a cast of the interior from the Stones River group at Beloit, Wisconsin, showing an unusual feature in the large pits in the peripheral band.

49 Another cast from Beloit with unusually strong ribs on the upper slope of the last volution.

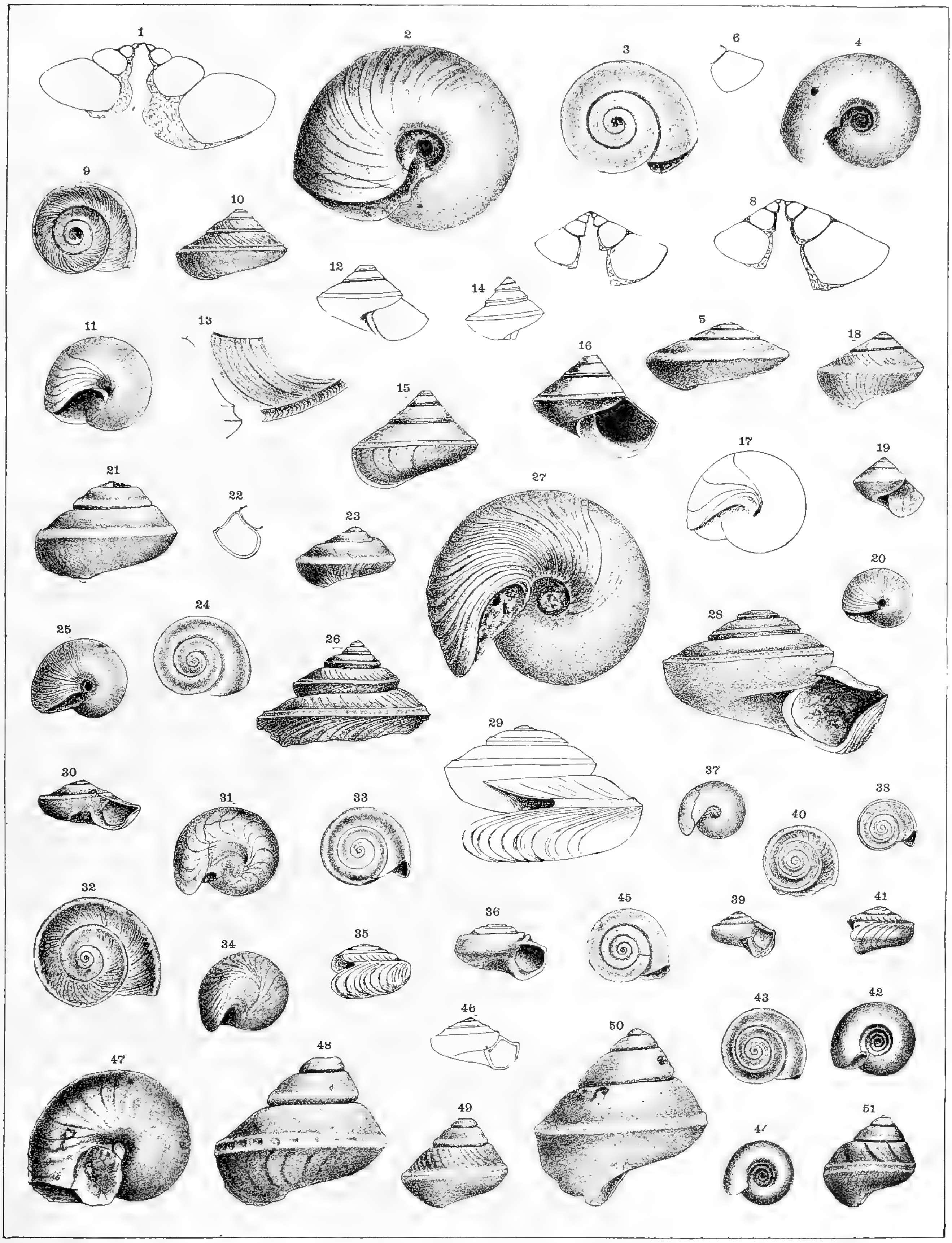
50 Cast of the interior of a large and typical shell from the Vanuxemia bed at Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 5037.

Fig. 51 CLATHROSPIRA CONVEXA U. and S. .......... 1007

Dorsal view of a specimen from the Stones River group in Calhoun county, Illinois. The upper slope of the whorls is more convex than in *C. subconica*.

(Gastropoda.)

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# PLATE LXX.

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| Figs. 1 to 4 | Clathrospira conica U. and S. | 1008 |
| 1 and 2 | Basal and dorsal views of a rather small cast of the interior. Trenton group (Fusispira bed), near Cannon Falls, Minnesota. | |
| 3 | A testiferous example from the Ctenodonta bed of the Black River group, at Chatfield, Minnesota. As usual the surface markings are very imperfectly preserved. | |
| 4 | Small portion showing weathered surface markings, and profile outline of last whorl, ×2, as shown in a specimen from Goodhue county where it was found in the Ctenodonta bed. | |
| Figs. 5 and 6 | Clathrospira subconica Hall. (See also plate LXIX.) | 1006 |
| 5 | Surface markings and profile outline of last whorl of a small but well preserved example, ×2. Black River limestone, Tennessee. | |
| 6 | Similar figures taken from a young example found in the upper member of the Stones River group near Lebanon, Tennessee. In this specimen the revolving lines on the upper slope appear not to cross the lines of growth. | |
| Fig. 7 | Plethospira striata Ulrich. Apertural view of an imperfect specimen, showing the comparatively low spire and coarse rib-like lines of growth which are characteristic of the species. Richmond group, Butler county, Ohio. | 1011 |
| Figs. 8 to 10 | Plethospira semele Hall. | 1010 |
| 8 | View of an incomplete example, preserving the surface markings. Utica group, near Graf, Iowa. | |
| 9 | Portion of last whorl of same magnified. | |
| 10 | A cast of the interior from the same locality, doubtfully referred to this species. Geological and Natural History Survey of Minnesota, Museum Register No. 7334. In another cast the peripheral band is not flat but almost as distinctly concave as on the exterior of the shell. | |
| Figs. 11 and 12 | Seelya mundula Ulrich. Two specimens of this species, the second somewhat shortened by pressure, from the lower half of the Lorraine group at Newport, Kentucky. | 1012 |
| Figs. 13 and 14 | Hormotoma trentonensis U. and S. Two views of a rather small but almost perfect cast of the interior, retaining, as shown in fig. 13, remains of the regular surface markings. Fusispira bed of the Trenton group, Wykoff, Minnesota. | 1017 |
| Figs. 15 to 17 | Hormotoma bellicincta Hall. | 1017 |
| 15 | An average cast of the interior of this species, showing that it has a wider apical angle and more depressed and, therefore, relatively more numerous volutions than *H. trentonensis.* Clitambonites bed of the Trenton group, Goodhue county, Minnesota. | |
| 16 and 17 | Another specimen, from the same locality, retaining some of the surface markings. The greater part of the last whorl is broken away so as to expose (see fig. 17) the filling of the small umbilical perforation. | |
| Figs. 18 to 36 | Hormotoma gracilis Hall, and varieties. | 1014 |
| 18 and 19 | Two views, natural size and a portion magnified, of a specimen of what we regard as the typical form of this species. Utica group, Graf, Iowa. Geological and Natural History Survey of Minnesota, Museum Register No. 7337. | |
| 20 to 22 | Three specimens selected from a number which were found in association with var. *multivolvis* in the Richmond group near Spring Valley, Minnesota. The first is very much like the var. *angustata* (Hall), the second is a typical *gracilis*, the third has unusually angular whorls and may be compared with var. *subangulata.* See figs. 42 and 43. | |
| 23 to 25 | Three figures of the var. *sublaxa.* The first is made up of the apical portion of one specimen and the lower whorls of another, and shows the relatively loose coiling of the whorls and the resulting obliquity of the sutures which distinguishes this variety from the others. The second figure represents the two lower whorls of same, ×2, while the third figure represents a portion of another specimen also ×2. Both of these figures show that the band is considerably wider than in other forms of the species. Trenton formation, Lincoln county, Missouri. | |
| 26 to 29 | Four figures of the var. *multivolvis.* The first represents an almost entire shell, the second and third opposite views of a less perfect example, the fourth an unusually small specimen. This variety is distinguished by its more numerous whorls. Richmond group, near Spring Valley, Minnesota. | |
| 30 to 36 | Seven figures of specimens which we have identified with the variety of this species which Hall described in 1847 as *Murchisonia angustata.* Fig. 30 represents a weathered example from the Stones River group, at High Bridge, Kentucky. The original of fig. 31 is a gutta percha impression of a natural mould in rock from an equivalent horizon at Beloit, Wisconsin; that of fig. 32 is from the Phylloporina bed of the Black River group near Cannon Falls, Minnesota. Fig. 33 shows two whorls, ×2, of a Black River limestone specimen from Tennessee. Figs. 34 and 35 represent opposite views of two specimens from the Utica group at Newport, Kentucky, and fig. 36 the lower part of a third specimen from this locality. The last shows the form of the apertural notch. | |

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Figs. 37 to 41 HORMOTOMA SUBANGULATA U. and S. ............ 1016

37 Cast of the interior, apparently of this species. Clitambonites bed of the Trenton group, Cannon Falls, Minnesota.

38 A small testiferous specimen from the Ctenodonta bed of the Black River group, Goodhue county, Minnesota.

39 and 40 Two views of a larger example. Ctenodonta bed at Chatfield, Minnesota.

41 Two whorls of the original of fig. 38, ×2, showing band and surface markings.

Figs. 42 and 43 HORMOTOMA GRACILIS var. GOODHUENSIS U. and S. ............ 1015

Two specimens found in the Phylloporina bed of the Black River group near Cannon Falls, Minnesota.

Figs. 44 to 51 HORMOTOMA SALTERI Ulrich ............ 1016

44 to 47 A series of four specimens selected from several hundred to show variation in the rim-like thickening of the upper edge of the whorls in the typical form of this species. Fig. 44 is the most like the var. *canadensis* (*Murchisonia* [*Hormotoma*] *gracilis* Salter, not Hall sp.) in which the rim is scarcely distinguishable. Upper part of Trenton group, Mercer county, Kentucky.

48 Two whorls of the original of fig. 47, ×2, to show the surface markings, band and outline of whorls more distinctly.

49 A small imperfect specimen, ×2, of var. *tennesseensis*, from the Black River limestone of Tennessee. Has finer and more equal lines of growth than the typical form of species.

50 Doubtful specimen from the same formation and state as the preceding. The shell is too thick and the whorls relatively too high.

51 A third fragment from this locality that is doubtful because the band is too wide. A fourth example from the same locality seems to be identical with the var. *canadensis*.

Figs. 52 to 55 SOLENOSPIRA PRISCA Billings sp. ............ 1022

52 Silicified specimen of var. *extenuata*. Lower division of the Stones River group at Murfreesboro, Tennessee.

53 Diagrammatic figure made up from gutta percha impressions of several incomplete moulds of the exterior collected at Beloit and Janesville, Wisconsin.

54 Two whorls of the Tennessee form, ×2.

55 Three whorls of the northwestern form, ×2, showing that they are relatively wider than in the Tennessee variety.

Figs. 56 to 60 SOLENOSPIRA PAGODA Salter ............ 1022

56 and 57 Two views of a fragment, showing the form of the mouth, the four revolving carinæ and several of the fine lines of growth. The latter show that the outer lip is notched and that the space between the central pair of ridges represents a true slit-band. Phylloporina bed of the Black River group, near Cannon Falls, Minnesota.

58 Same specimen in another view, ×2, to show the form of the volutions more clearly and to admit of easier comparison with *S. prisca*.

59 and 60 The apical portion, natural size, and two whorls ×2, of a specimen from an equivalent horizon at Porter's station in Wisconsin. Collection of Wisconsin State University.

Figs. 61 to 63 CŒLOCAULUS ŒHLERTI Ulrich ............ 1020

Two casts of the interior and the base of one, showing the numerous depressed whorls and the narrow umbilical perforation. Trenton group, Jo Daviess county, Illinois.

Figs. 64 and 65 OMOSPIRA LATICINCTA Ulrich ............ 945

64 A large testiferious example of this species, imperfect below and at the apex. Black River limestone, Tennessee.

65 A slightly oblique view from above of a portion of the last whorl of same, ×2, showing the course of the regular lines of growth.

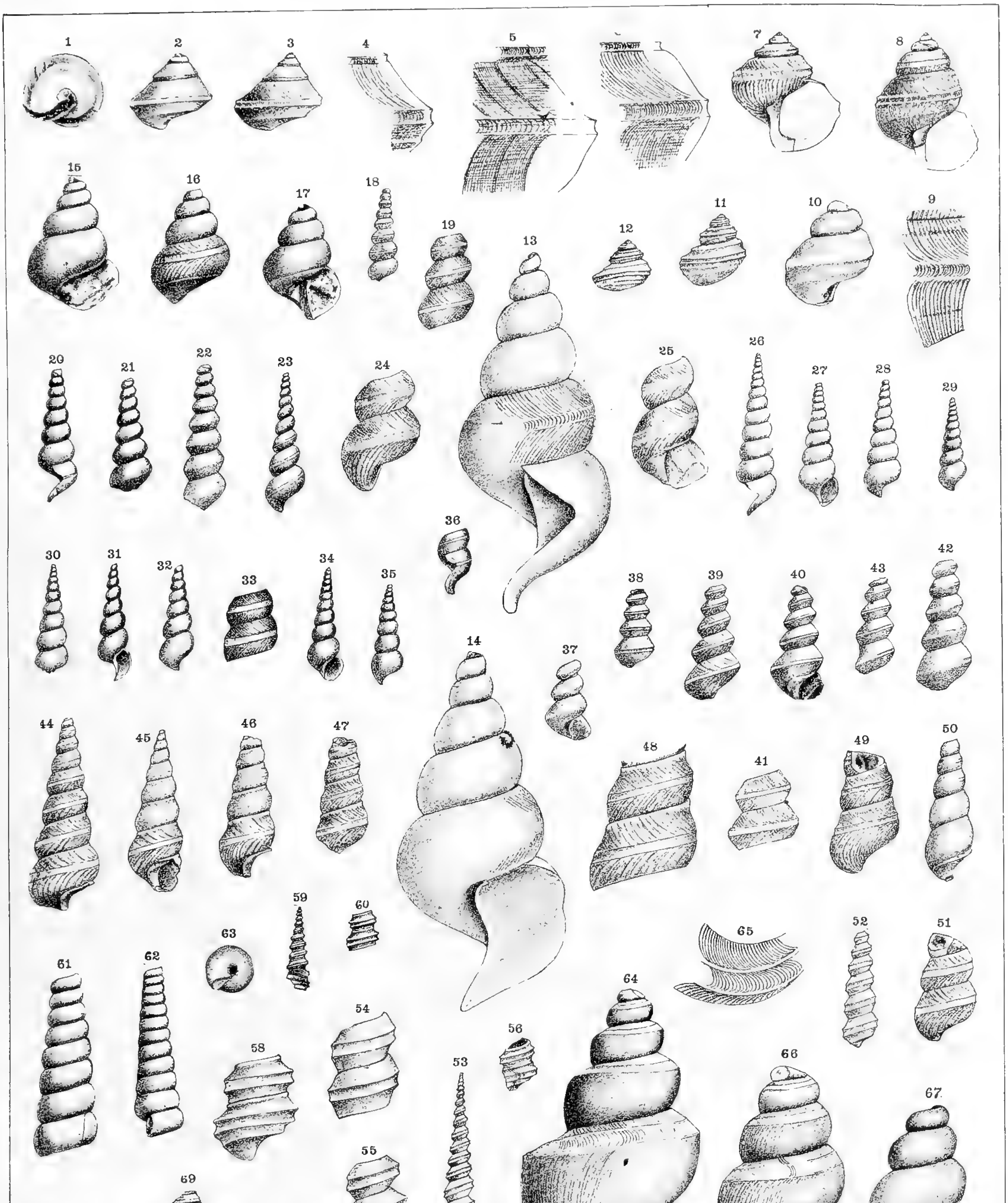
Figs. 66 and 67 OMOSPIRA ALEXANDRA Billings sp. ............ 946

66 An imperfect silicified shell of this species, from the top of the Black River limestone of Mercer county, Kentucky. The whorls are more rounded than in the preceding species.

67 A cast of the interior from the same formation at Dixon, Illinois, doubtfully referred to this species.

Figs. 68 and 69 EOTOMARIA ELEVATA Ulrich ............ 1005

Two views of the nearly entire type of this species. Trenton group, Hartsville, Tennessee.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## PLATE LXXI.

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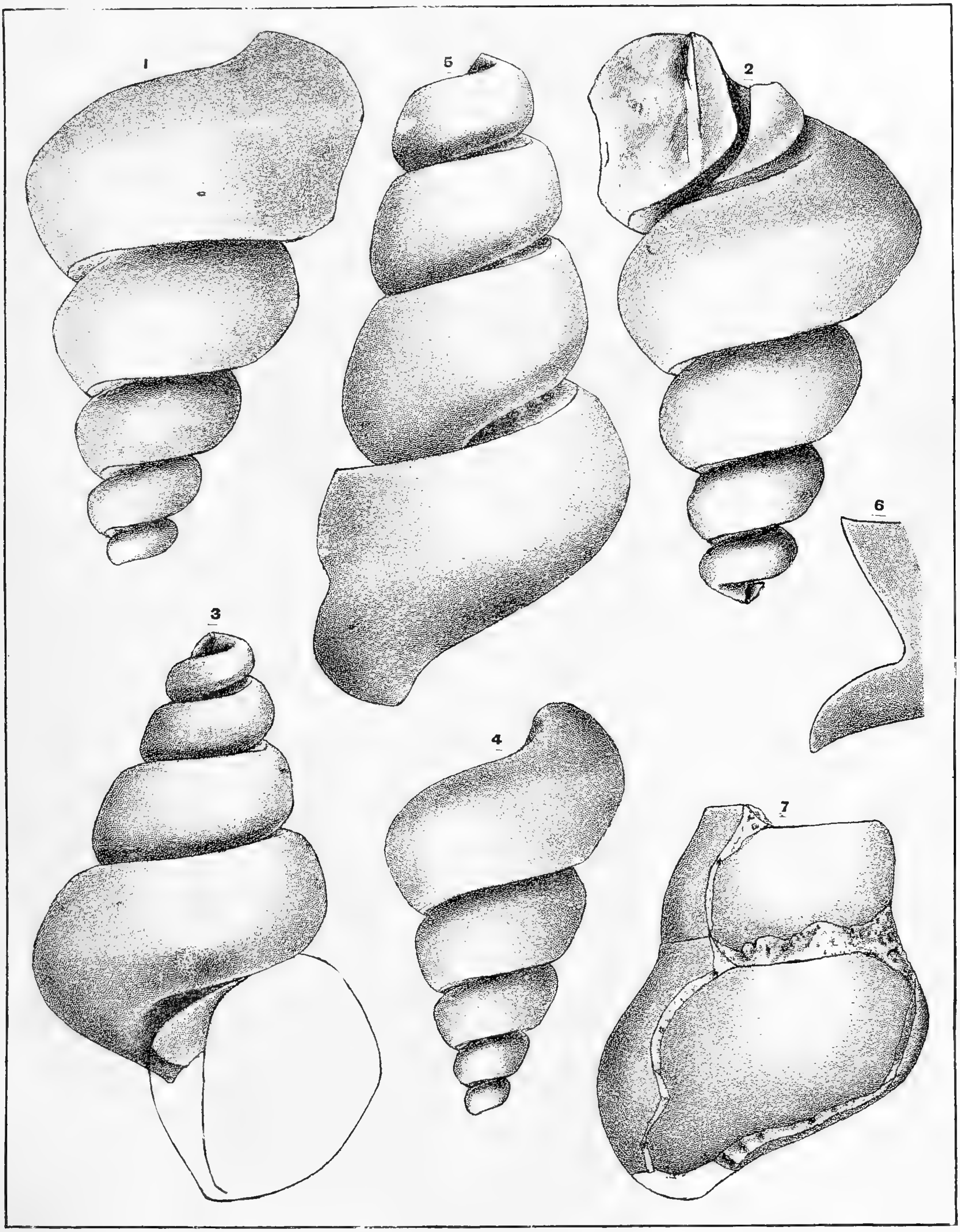
| Figs. 1 and 2 | LOPHOSPIRA AUGUSTINA Billings sp. Two figures of a rather large cast of the interior of the Minnesota form which we refer to this species. Fig. 2 shows the filling of the umbilical perforation. Maclurea bed of the Trenton group, Stewartsville, Minnesota. | 987 |
| Figs. 3 and 4 | LOPHOSPIRA AUGUSTINA var. MINNESOTENSIS U. and S. | 988 |
| 3 | A large specimen of this variety, from the same locality as the preceding. The outline restoration of the aperture may not be entirely correct. | |
| 4 | A smaller specimen, also a cast of the interior; from the same locality. The smallest two whorls are restored from another specimen. | |
| Figs. 5 to 7 | HORMOTOMA (?) MAJOR Hall sp. | 1018 |
| 5 | The last four whorls of a cast of the interior that we believe to belong to this species. Trenton group, Pike county, Missouri. Geological and Natural History Survey of Minnesota, Museum Register No. 7842. | |
| 6 | Outline of outer lip of same, showing the broad sinus or notch. | |
| 7 | Last two whorls of a specimen retaining part of the shell, but so ill preserved that not a trace of surface markings remains. The specimen is important, however, because it shows the external character of the sutures. Maclurea bed of the Trenton group, Olmsted county, Minn. Geological and Natural History Survey of Minnesota, Museum Register No. 7485. | |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# PLATE LXXII.

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| Figs. 1 to 5 | Lophospira bicincta Hall sp | 964 |
| 1 | A perfect silicified shell of this species, from the lowest member (Safford's Central limestone) of the Stones River group, at Murfreesboro, Tennessee. | |
| 2 | Portion of the last whorl of same, ×2, showing the direction and regularity of the lines of growth. | |
| 3 | Right side of last whorl of fig. 1, ×2. | |
| 4 | A large cast of the interior, on which some of the external lines of growth are obscurely preserved. Stones River group, Beloit, Wisconsin. | |
| 5 | Vertical section of an elongated specimen. Stones River group, Dixon, Illinois. | |
| Figs. 6 to 8 | Lophospira obliqua U. and S. | 967 |
| | Views of three specimens of this species. The general aspect is precisely as in *L. bicincta*, but the lines of growth are constantly more oblique beneath the peripheral angle and of a different character. Stones River and Trenton groups, Mercer county, Kentucky. | |
| Fig. 9 | Lophospira procera Ulrich | 968 |
| | View of the type of this species, the basal portion restored in outline. Stones River group, Murfreesboro, Tennessee. | |
| Figs. 10 and 11 | Lophospira quadrisulcata U. and S. | 967 |
| | Opposite views of an excellent example of this species. Richmond group, Spring Valley, Minnesota. | |
| Figs. 12 to 15 | Lophospira humilis Ulrich | 968 |
| 12 and 13 | Opposite views of a rather small specimen. Trenton group, near Burgin, Kentucky. | |
| 14 | Same specimen, ×2, to show the lines of growth. | |
| 15 | Right side of last whorl of fig. 12, ×6. | |
| Figs. 16 to 19 | Lophospira concinnula U. and S. | 966 |
| 16 | A testiferous specimen from the Ctenodonta bed at St. Paul, Minnesota, showing the usual size and appearance. | |
| 17 and 18 | Opposite views of a smaller specimen from the same bed near Cannon Falls, Minnesota. | |
| 19 | Portion of last whorl of same ×6, showing the direction and regularity of the lines of growth, the extremely fine revolving lines and the form and character of the peripheral band | |
| Figs. 20 to 24 | Lophospira fillmorensis U. and S. | 967 |
| 20 and 21 | Opposite views of two casts of the interior. Fusispira bed, Trenton group, Wykoff, Minnesota. | |
| 22 and 23 | A testiferous specimen from the same horizon near Fountain, Minnesota, natural size and a portion of the last whorl ×2. The latter shows the surface markings which consist of rather coarse and distant lines of growth and a much finer intermediate set. | |
| 24 | The last whorl of a cast from the Wykoff locality, on which the stronger set of surface markings are rather distinctly reproduced. | |
| Figs. 25 to 28 | Lophospira helicteres var. wisconsinensis U. and S. | 971 |
| 25 and 26 | Two views of a cast of the interior of medium size. The apertural portion is perfect but the closely coiled upper whorls are broken away. Stones River group, Beloit, Wisconsin. | |
| 27 | A smaller cast from the same horizon at Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 6858. | |
| 28 | Small portion of the last whorl of another cast of the interior, showing strong, even lines of growth. From the same horizon at Dixon, Illinois. | |
| Figs. 29 to 32 | Lophospira conradana U. and S. | 979 |
| 29 | A nearly complete cast of the interior. Stones River group, Minneapolis. | |
| 30 | Under side of another cast from the same locality, showing the strong convexity of the under side of the whorls and a faint indication of the ridge which surrounds the umbilical cavity on the exterior of the shell. | |
| 31 | Another view of the original of fig. 29 to show anterior outline of the outer lip. | |
| 32 | The body whorl of another cast from Minneapolis showing, besides obscure lines of growth, a faint ridge beneath the peripheral carina. The latter is rarely seen on casts. | |

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Figs. 33 to 35 LOPHOSPIRA (?) NOTABILIS Ulrich.......... 990

Three views of an almost perfect silicified shell of this remarkable species. Black River limestone of central Tennessee.

Figs. 36 to 39 LOPHOSPIRA TROPIDOPHORA Meek sp., instead of MULTIGRUMA Miller sp.*....... 978

36 and 37 Opposite views of a large specimen showing the usual characters of the species. Lorraine group, Newport, Kentucky.

38 Portion of the last whorl of a smaller example on which the surface markings are better preserved, ×2. Richmond group, Butler county, Ohio.

39 A variety from the Richmond group at Madison, Indiana, in which the whorls descend more slowly, causing a wider apical angle.

Figs. 40 to 43 LOPHOSPIRA BOWDENI Safford sp.......... 986

40 A large specimen, imperfect at both ends, presenting the usual characters of the species. Richmond group, Boyle county, Kentucky.

41 and 42 Two specimens, from the same locality, showing the extremes, respecting the relative hight of the spire, so far observed.

43 Last whorl, with aperture slightly restored, of the original of fig. 41.

Figs. 44 to 47 LOPHOSPIRA SPIRONEMA U. and S.......... 983

44 and 45 Opposite views of a specimen from the Ctenodonta bed of the Black River group, at Chatfield, Minnesota.

46 Another specimen from the same bed near Cannon Falls, Minnesota.

47 Portion of surface and outline of right side of last whorl of fig. 46, ×10, showing the delicate cancellation of the surface and the angular form of the peripheral band.

Figs. 48 to 50 LOPHOSPIRA TENUISTRIATA Ulrich.......... 983

48 Nearly perfect example from the Utica group at Newport, Kentucky.

49 The peripheral band of another specimen from the same locality, ×10. The fine revolving lines which occur both above and beneath the band are not shown in the drawing.

50 Small portion of the surface between the band and the lower angle, ×10, showing the strong lamellar lines of growth, fine intermediate lines, and an unusual degree of irregularity in the direction of the spiral lines. The remarkable preservation of the more delicate markings on these specimens is due to the fact that they were protected by a thin parasitic bryozoan (*Leptotrypa clavis* Ulrich) which, on being removed, left them as distinct as during the life of the mollusk.

Figs. 51 to 55 LOPHOSPIRA SERRULATA Salter sp.......... 968

(See also plate LXXIII, fig. 57.)

51 An average cast of the interior. Stones River group, Beloit, Wisconsin.

52 The empty mould of the exterior of a specimen of about the same size and character as that of which fig. 51 represents an internal cast. Beloit, Wisconsin.

53 Gutta percha impression of a natural mould of the exterior of a shell having the whorls in contact through a longer period than usual. Shows the wavy peripheral plate very distinctly. Janesville, Wisconsin.

54 A small cast of the interior from Minneapolis. The four or five other specimens of this species seen from the limestone at Minneapolis are all like this in size and character.

55 The cast of the last whorl of an unusually large shell, figured so as to show the anterior outline of the outer lip. (Compare with fig. 26.) Janesville, Wisconsin.

Figs. 56 to 59 LOPHOSPIRA (? SEELYA) LIRATA Ulrich.......... 988

56 A specimen with numerous spiral ridges on the basal part of the volutions. Utica group, Newport, Kentucky.

57 Portion of the lower part, including the band, of the last whorl of same, ×3.

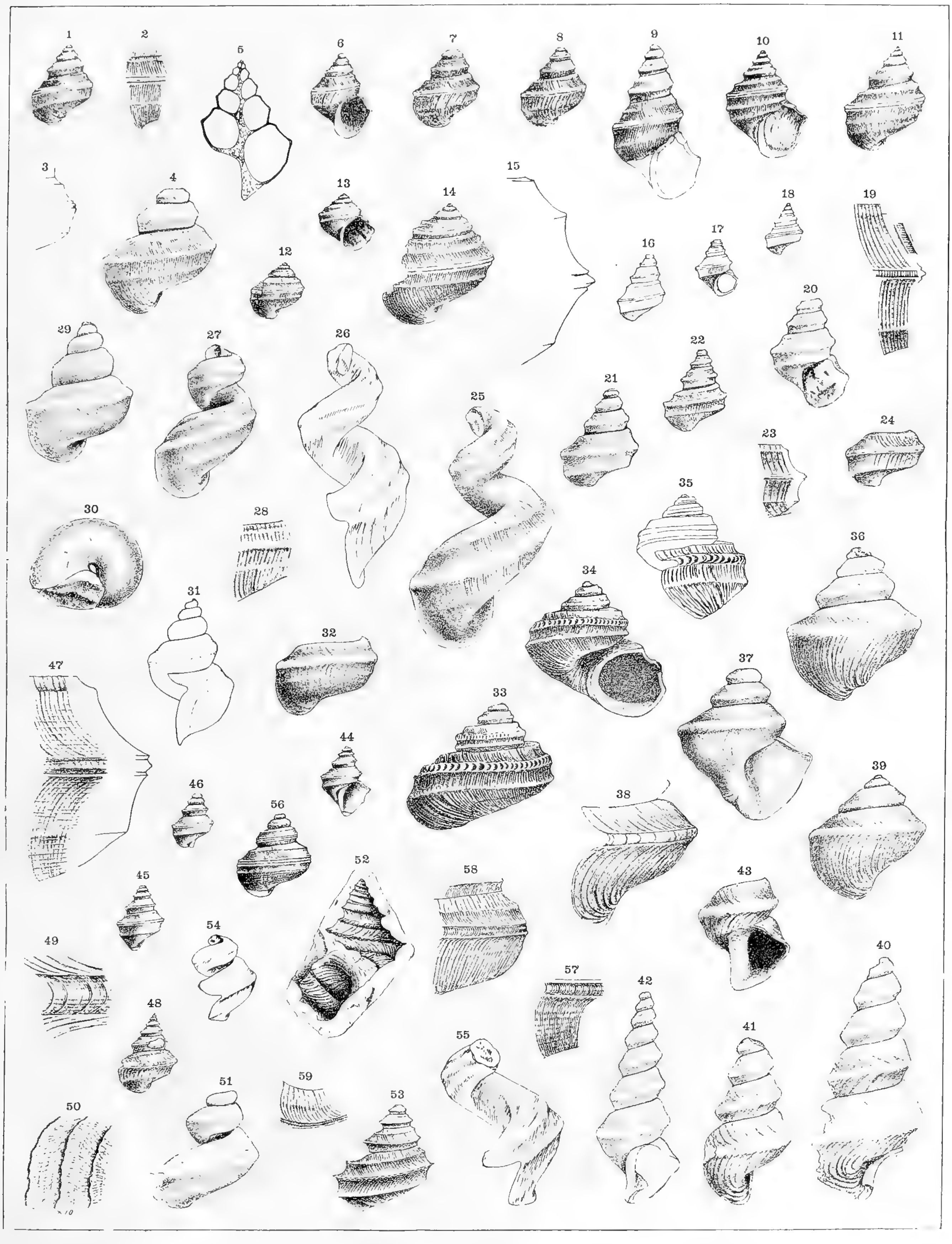
58 Part of the last whorl of a specimen of the form (var. *obsoleta*) having but a single spiral line beneath the peripheral band, ×3. Also from Newport, Kentucky.

59 Upper surface of whorl viewed from above, ×3, showing interpolation of striæ.

* Since page 978 was printed we have come to the conclusion that this species is not distinct from Meek's *Pleurotomaria tropidophora* (Pal. Ohio, vol. 1, p. 154, pl. XIII, figs. 6a and 6b). Our references to the shell should therefore be corrected by changing the name to *Lophospira tropidophora* Meek sp.

{Gastropoda.}

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# PLATE LXXIII.

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Figs. 30 and 31 LOPHOSPIRA MEDIALIS var. BURGINENSIS Ulrich ..................................... 974

30 An average example of this variety, $\times 2$, showing that it differs from the typical form, with which it is associated, in having a distinct lower carina.

31 Represents a specimen that agrees very well with this variety excepting that it is much larger than the average and has a wider apical angle. Burgin, Kentucky.

Figs. 32 to 35 LOPHOSPIRA PERFORATA U. and S........................................................ 984

32 Cast of the interior, almost entire. The hight of the lower whorl is somewhat less than normal, because of pressure. Trenton group (Galena limestone), Jo Daviess county, Illinois.

33 to 35 Three views of the last whorl of another cast from the same locality, with dimensions normal. A thin spiral line should have been drawn in the middle of the base of the body whorl in fig. 35.

Figs. 36 to 40 LOPHOSPIRA ABNORMIS Ulrich ........... ........................................ 974

36 to 38 Two casts of the interior in lateral and basal views, the former showing the decided increase of the apical angle with the growth of the last whorl. Top of Trenton at Covington, Kentucky.

39 Surface markings of last whorl of a testiferous example, magnified.

40 Contour of right side of a whorl of same, magnified.

Figs. 41 to 45 LOPHOSPIRA OWENI U. and S..................................................... 980

41 Outline view of a specimen from the Ctenodonta bed of the Black River group at Chatfield, Minnesota.

42 The lower whorl of a specimen from the same horizon near Cannon Falls, Minnesota, showing the ridge-like swelling about the minute umbilicus.

43 A second specimen from this locality having an unusually strong swelling or ridge along the upper edge of the whorls.

44 and 45 Opposite views of an average example. Near Cannon Falls, Minnesota.

Figs. 46 to 48 LOPHOSPIRA PULCHELLA U. and S.......... ......................................... 982

46 and 47 Two specimens, $\times 2$, showing the features which readily distinguish this pretty shell from *L. medialis* var. *burginensis*, with which it is commonly associated. Upper Trenton, Burgin, Kentucky.

48 One of a number of specimens from the Richmond group at Spring Valley, Minnesota, which we cannot distinguish from this species; $\times 2$. The angles are rounded through maceration.

Figs. 49 to 51 LOPHOSPIRA SAFFORDI Ulrich...................................................... 982

49 A specimen with half of the last whorl missing, yet showing all the essential characters of this fine species. Both the upper and lower angles are constantly developed, and therein lies the most obvious of the differences between *L. saffordi* and *L. oweni*. Trenton group, Davidson county, Tennessee.

50 A more perfect and somewhat wider specimen from the same locality.

51 A third example from the locality mentioned.

Figs. 52 to 54 LOPHOSPIRA AMPLA Ulrich...................................................... 981

52 Apertural view of a large specimen that, excepting that its spire is unusually depressed, may be considered as fairly typical of the species. Richmond group, Boyle county, Kentucky.

53 and 54 Opposite views of a rather large example of the lower variety. Lorraine group, Newport, Kentucky.

Figs. 55 and 56 LOPHOSPIRA PERLAMELLOSA Ulrich................................................ 985

A specimen of this species, natural size and $\times 2$, showing the strongly lamellose surface markings and the remarkably produced and twisted basal extremity. Richmond group, Butler county, Ohio.

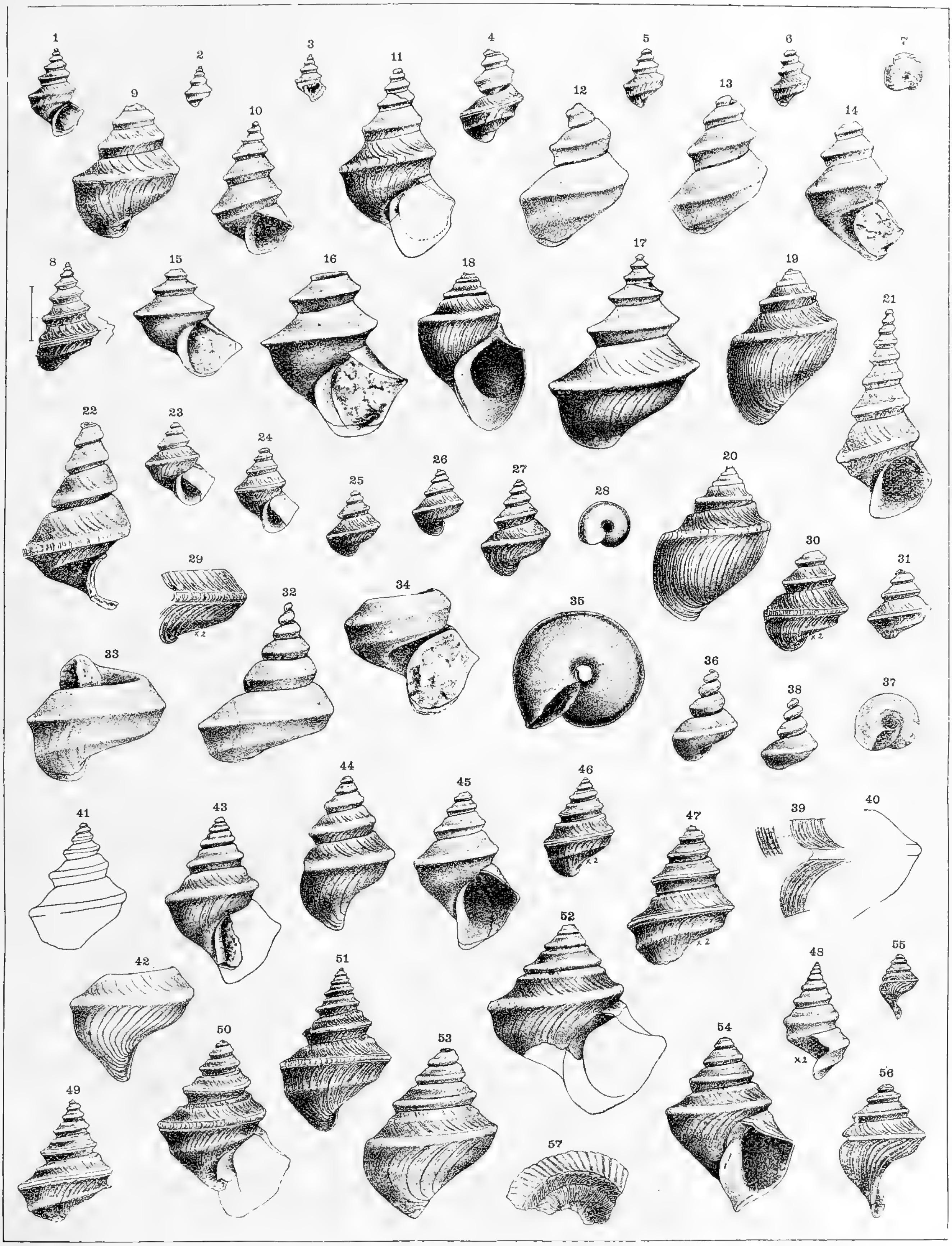
Fig. 57 LOPHOSPIRA SERRULATA Salter sp.................... ............................ 968

(See also plate LXXII, figs. 51-55.)

Fragment of a natural mould of the exterior, showing the lines of growth on somewhat less than half of the under side of the last whorl and an impression of the broad peripheral frill with its oblique plications. Stones River group, Dixon, Illinois.

(Gastropoda.)

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## PLATE LXXIV.

PAGE.

Figs. 1 to 4 ECCYLIOPTERUS BELOITENSIS U. and S. .......... 1032

(See also plate LXII, fig. 70.)

Four views of a cast of the interior. Lines of growth are indicated on the outer half of the last turn, somewhat obscurely, it is true, yet unmistakably. Stones River group, Beloit, Wisconsin.

Figs. 5 and 6 ECCYLIOPTERUS TRIANGULUS Whitfield sp. .......... 1031

(See also plate LXII, fig. 73.)

Two views of a cast of the interior. There is some doubt respecting the character of the inner whorl. It may form a closely coiled nucleus, but we doubt it. Calciferous formation, Providence Island, Vermont.

Figs. 7 to 9 ECCYLIOPTERUS VOLUTATUS Whitfield sp. .......... 1031

(See also plate LXII, figs. 71-72.)

7 Lateral view of a cast of the interior, preserving a portion of the "collar-like" upper carina. Calciferous formation, Fort Cassin, Vermont.

8 Under side of another cast from the same locality.

9 Small portion of the shell from the inner or rather upper slope, beginning at the inner basal angle and extending upward almost to the base of the "collar." Shows the strong anterior convexity of the lines of growth. Fort Cassin, Vermont.

Figs. 10 to 14 ECCYLIOPTERUS OWENANUS Meek and Worthen sp. .......... 1032

10 Lateral view of a cast of the interior including the enormous "collar." The stony matter which lies upon the concave spire is not represented in the drawing, causing the latter to appear like the shell itself. Fusispira bed of the Trenton group, Wykoff, Minnesota.

11 Vertical section of another specimen from Wykoff.

12 and 13 Lateral and basal views of a cast of the interior from the same locality. This specimen represents the usual mode of occurrence, very few of the examples seen giving any idea of the high "collar" into which the outer angle is continued in the shell itself.

14 Upper side of a specimen from the shaly portion of the Fusispira bed in Goodhue county. Shows an impression of the "collar" on the inner turns.

Fig. 15 HELICOTOMA PLANULATA var. ROBUSTA U. and S. .......... 1033

Lateral view of the specimen described.

Figs. 16 and 17 HELICOTOMA PLANULATA Salter .......... 1033

Lateral and basal views of a typical example of this species. Black River limestone, Pauquette's Rapids, Canada.

Figs. 18 and 19 HELICOTOMA VERTICALIS Ulrich .......... 1035

(See also plate LXII, fig. 69.)

Basal and lateral views of a cast of the interior. Stones River group, High Bridge, Kentucky.

Figs. 20 to 24 HELICOTOMA TENNESSEENSIS Safford .......... 1034

20 Upper side of a good silicified shell, showing the small channel along the inner edge of the whorls which appears to be always present and readily serves in distinguishing this species from *H. planulatoides*. Stones River group, Murfreesboro, Tennessee.

21 to 23 Three views of another specimen, from the same locality.

24 The upper angle and portions of the surface on each side of it, $\times 2$.

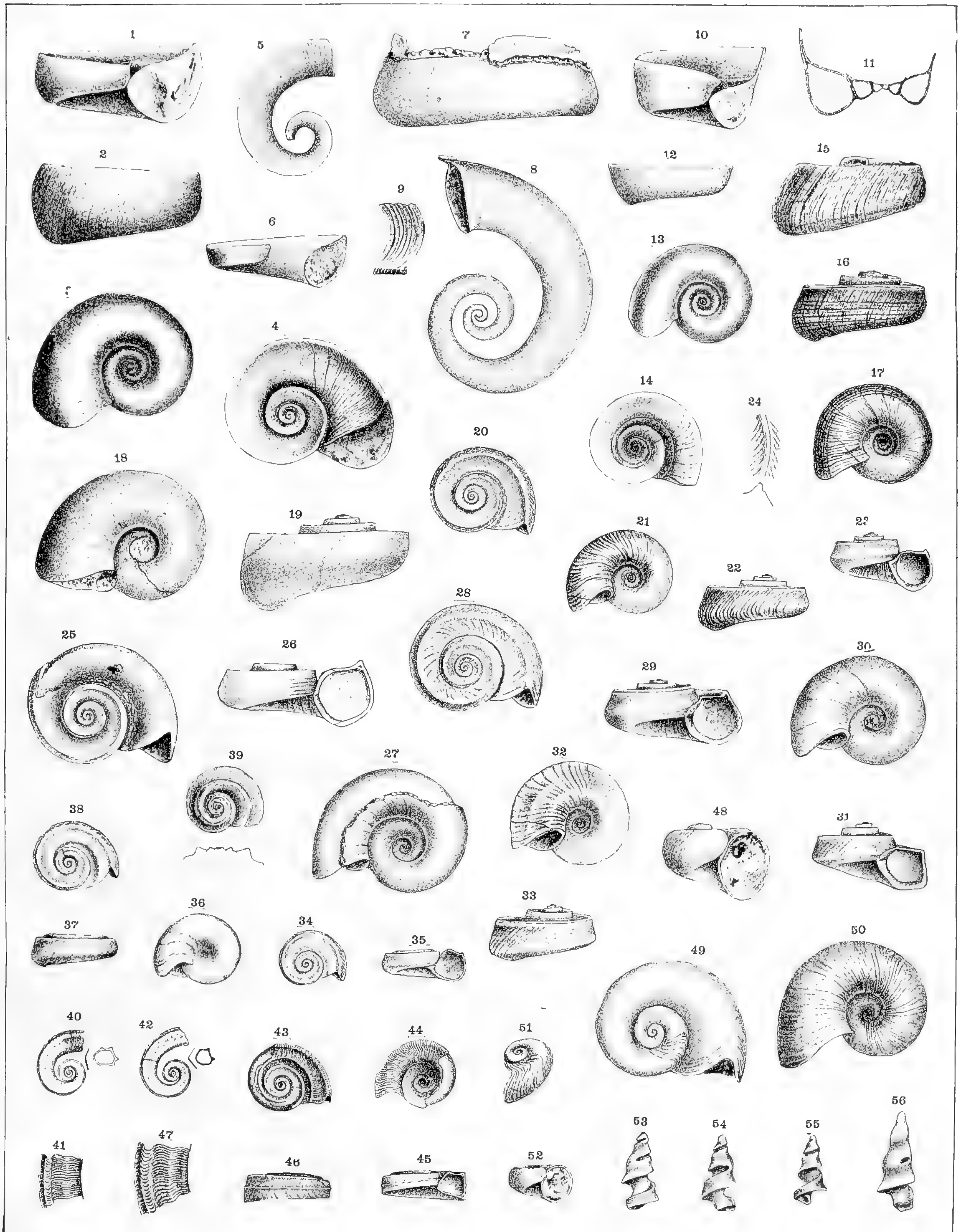
Figs. 25 to 27 HELICOTOMA UMBILICATA U. and S. .......... 1034

(See also plate LXII, fig. 68.)

Three views of the largest specimen seen. Stones River group, near La Salle, Illinois.

Figs. 28 to 30 HELICOTOMA PLANULATOIDES Ulrich .......... 1034

Three views of an entire silicified specimen. Black River group, Mercer county, Kentucky.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# PLATE LXXV.

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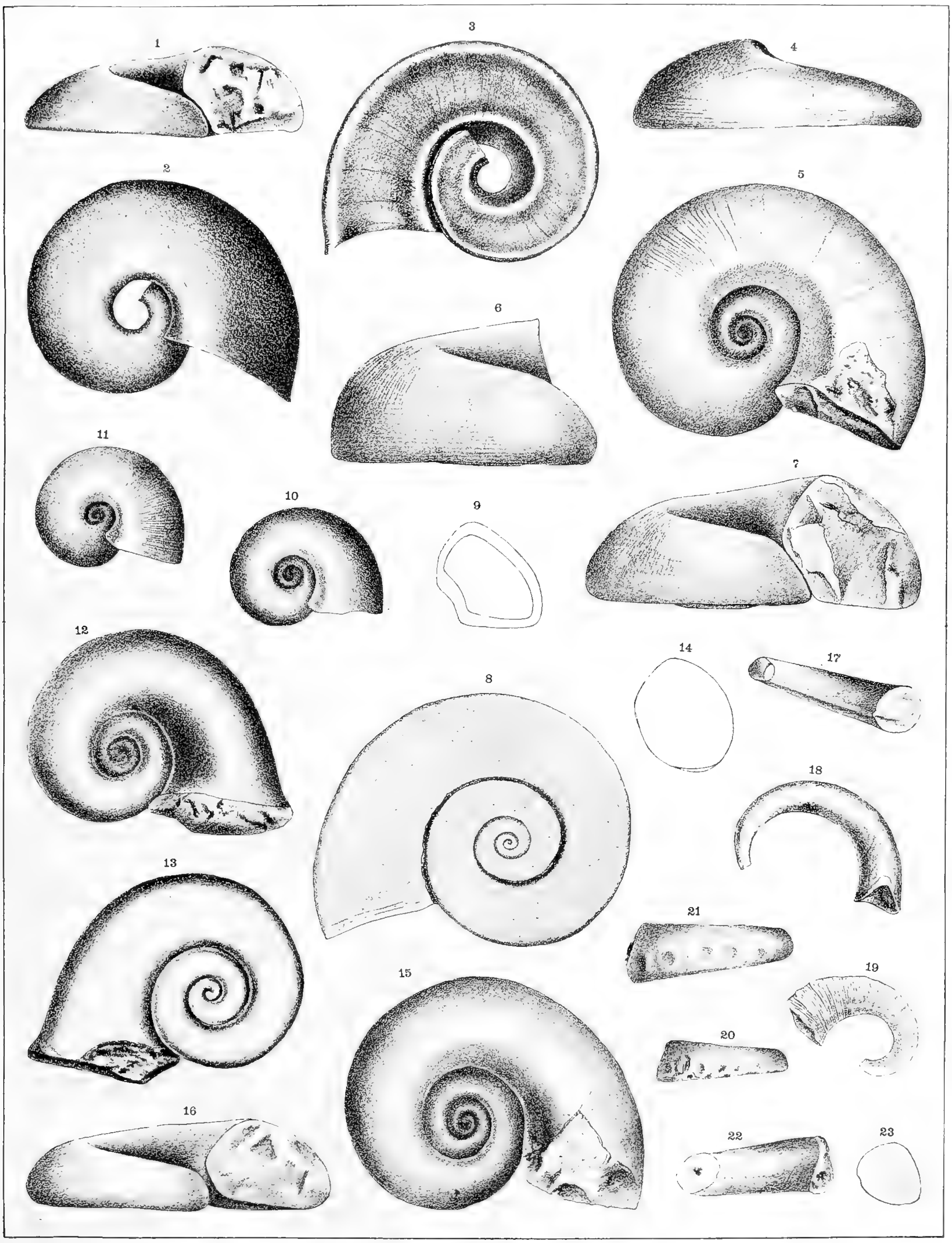
| Figs. 1 to 4 | MACLUREA DEPRESSA U. and S. | 1040 |
| 1 | Lateral view of a cast of the interior. Stones River group (Vanuxemia bed), Minneapolis, Minnesota. | |
| 2 to 4 | Three views of another cast from Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 6868. | |
| Figs. 5 to 10 | MACLUREA BIGSBYI Hall | 1039 |
| 5 to 8 | Four views of a specimen, from the Stones River group at Beloit, Wisconsin, somewhat better preserved than usual. A considerable portion of the upper side is a cast of the exterior and therefore retains some of the surface markings. Geological and Natural History Survey of Minnesota, Museum Register No. 7308. | |
| 9 | The outer line represents a transverse section of the outer whorl of the same specimen, while the inner lip is a similar section of a specimen of *M. nitida* U. and S. | |
| 10 | A small specimen from Dixon, Illinois, figured for comparison with *M. nitida*. It may be well to point out that the umbilicus is wider and the whorls lower than in that species. | |
| Fig. 11 | MACLUREA NITIDA U. and S. | 1040 |
| | Upper side of one of the largest specimens, showing the rather small umbilicus and regular lines of growth. Stones River group, Mineral Point, Wisconsin. Geological and Natural History Survey of Minnesota, Museum Register No. 7356. The inner line of fig. 9 represents the outline of the aperture of this specimen. | |
| Figs. 12 to 14 | MACLUREA CRASSA U. and S. | 1040 |
| 12 and 13 | Upper and lower sides of an entire cast of the interior. The obtuse central angulation of the whorls is not quite as abrupt in fig. 12 as it should be (see top of fig. 14). Trenton group, Lime City, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 8442. | |
| 14 | Transverse section of the outer whorl of same. The lower line at the bottom of the figure represents the outline of this part of the whorl in a specimen from Wykoff, Minnesota. | |
| Figs. 15 and 16 | MACLUREA CRASSA var. MACRA U. and S. | 1040 |
| | The upper side and a lateral view of the type of this variety. Fusispira bed of the Trenton group, Hader, Minnesota. | |
| Figs. 17 and 18 | ECCYLIOMPHALUS SUBROTUNDUS U. and S | 1037 |
| 17 | Lateral view of a cast of the interior, showing the rounded section of the shell and the elevated line near the base of the inner side. Fusispira bed of the Trenton group, Wykoff, Minnesota. | |
| 18 | Upper side of same, showing the deep sinus in the upper lip. | |
| Figs. 19 to 23 | ECCYLIOMPHALUS UNDULATUS Hall | 1036 |
| 19 | The lower side of a specimen which retains some of the shell in good condition. Stones River group, Lebanon, Tennessee. | |
| 20 | Lateral view of same showing cicatrices where foreign particles had formerly been attached. | |
| 21 and 22 | Opposite lateral views of an incomplete cast of the interior. Beloit, Wisconsin. | |
| 23 | Transverse section near the mouth of same. | |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## PLATE LXXVI.

| | | Page. |
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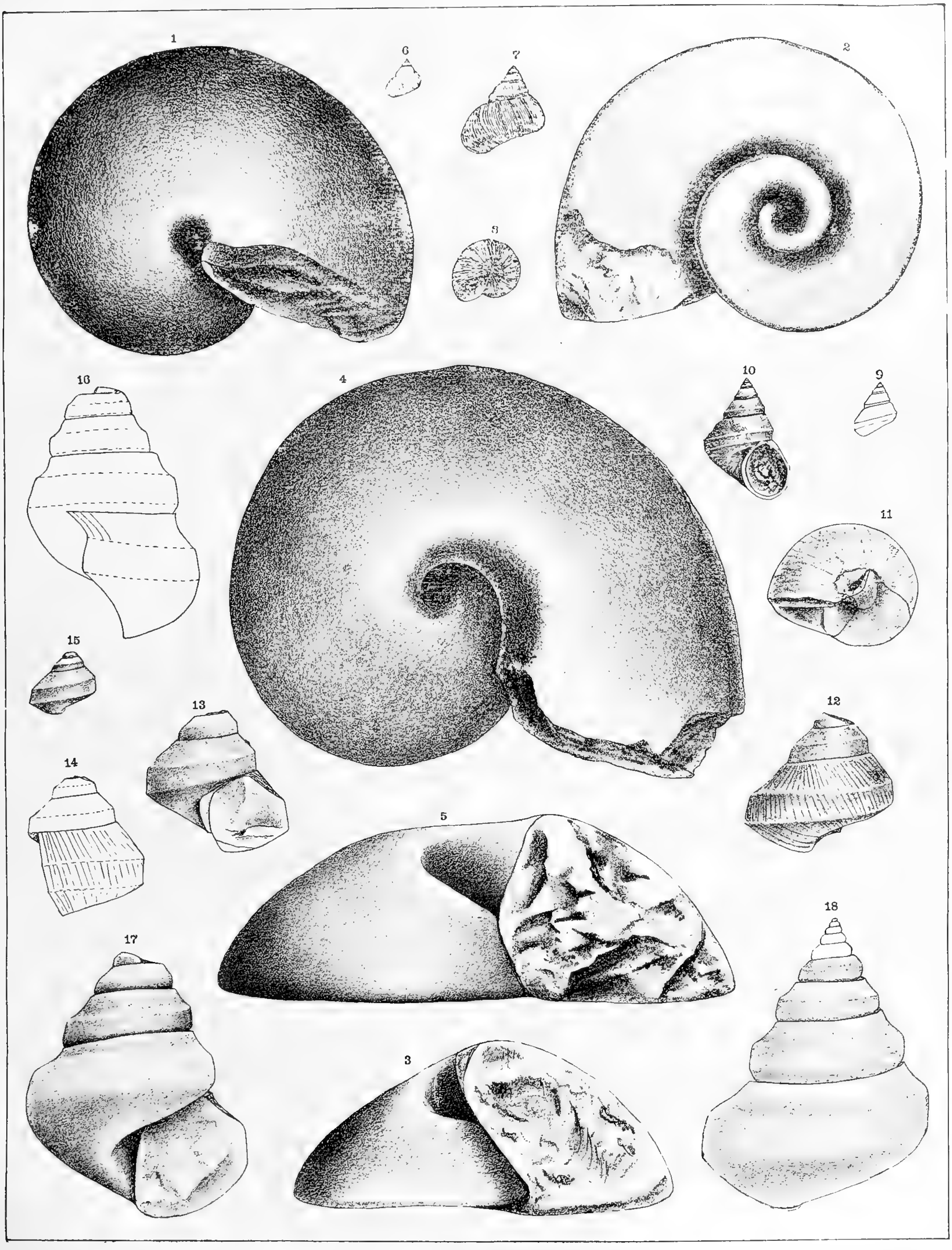
| Figs. 1 to 3 | Maclurina cuneata Whitfield (See also plate LXXXII.) | 1042 |
| 1 | Upper side of an average cast of the interior of this common species, showing the small umbilicus. 7 mm. less than natural size. Geological and Natural History Survey of Minnesota, Museum Register No. 8440. | |
| 2 and 3 | The lower side and a lateral view of another specimen. 5 mm. less than natural size. Maclurea bed of the Trenton group, Stewartsville, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 8441. | |
| Figs. 4 and 5 | Maclurina manitobensis Whiteaves (See also plate LXXXII.) | 1041 |
| | Two views of a cast of the interior. Trenton group, Lime City, Minnesota. Geological and Natural History Survey of Minnesota. Museum Register No. 4105. | |
| Figs. 6 to 8 | Trochonema obsoletum Ulrich | 1054 |
| 6 | A finely preserved example of the natural size. Upper Trenton, near Burgin, Kentucky. | |
| 7 | Lateral view of same ×2.5, showing surface markings and obsolescence of revolving ridges on the last whorl. The ridges are quite distinct on turns preceding the last. | |
| 8 | Basal view of same ×1.8. | |
| Figs. 9 and 10 | Trochonema arctatum Ulrich | 1054 |
| 9 | Outline view of the type of this species. Trenton group, near Burgin, Kentucky. | |
| 10 | Apertural view of same ×2. A few of the fine lines of growth are faintly indicated. The peripheral band is unusually narrow for species of this genus, and might easily be mistaken for the band of a pleurotomarian shell. | |
| Figs. 11 to 15 | Trochonema robbinsi U. and S. | 1053 |
| 11 to 14 | Four views of a large cast, in part both interior and exterior, imperfect at both extremities. The even slope of the surface from the suture to the peripheral band is one of the most striking features. Fusispira bed, Wykoff, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 7516. | |
| 15 | A small cast of the interior from the same locality. | |
| Figs. 16 to 18 | Trochonema niota Hall sp. | 1052 |
| | Three views of the nearly entire cast of the interior upon which this species is founded. Stones River group, Beloit, Wisconsin. | |

{Gastropoda.}





## PLATE LXXVII.

PAGE.

Figs. 1 to 8 TROCHONEMA UMBILICATUM Hall................................................ 1047

1 Under side of a cast of the interior, Maclurea bed, Trenton group, Stewartsville, Minnesota.

2 Lateral view of another cast; from the same horizon at Hader, Minnesota.

3 Gutta percha cast of the exterior, the lower part of the figure restored; from the same horizon near Galena, Illinois. The surface markings, excepting occasionally on the base, are always fine and generally obscure in the Trenton variety.

4 and 5 Front and basal views of an excellent, though rather small, silicified specimen of the variety *canadensis*. Black River or Stones River group. Pauquette's Rapids, Ottawa river, Canada.

6 Small portion of last whorl of same; magnified somewhat more than two diameters, showing the character and direction of the surface markings between the upper and lower carinæ.

7 and 8 Basal and lateral views of a large cast of the interior of a Stones River group variety from middle Tennessee. The whorls spread more rapidly than they should in *T. umbilicatum* but otherwise, especially in the direction of the lines of growth across the vertical face of the whorls, the agreement with this species is very close. This form may be distinguished as var. *latum*.

Figs. 9 to 12 TROCHONEMA BEACHI? Whitfield................................................ 1048

9 Gutta percha impression of a natural mold of the upper side, showing surface markings. On the vertical peripheral band the lines of growth lean backward about as in fig. 31 of this plate, not forward as in *T. umbilicatum*. Stones River group, Minneapolis, Minnesota.

10 Cast of the interior from the same horizon at Janesville, Wisconsin, agreeing very well with Whitfield's figure of his *T. beachi*.

11 Vertical section of the same species from Dixon, Illinois.

12 Section of last whorl of fig. 10.

Figs. 13 to 16 TROCHONEMA FRAGILE U. and S................................................ 1050

13 Lateral view of a cast of the interior. Clitambonites bed of the Trenton group, Cannon Falls, Minnesota.

14 to 16 Three views of another cast; from Carroll county, Illinois. Like the other, this specimen shows the remarkable sharpness, considering that it is a cast, of the angles, and the narrowness of the sutural groove when compared with *T. umbilicatum*.

Figs. 17 and 18 TROCHONEMA ECCENTRICUM Ulrich................................................ 1049

Apertural and basal views of the best of three specimens from the upper division ("Glade limestone") of the Stones River group near Lebanon, Tennessee. We would point out that the lines of growth lean forward on the peripheral band about as in *T. umbilicatum* and that the present species is distinguished from that by the eccentricity of the umbilical ridge chiefly.

Figs. 19 to 22 TROCHONEMA RUGOSUM U. and S................................................ 1049

19 Gutta percha impression showing part of the periphery and under side. Stones River group, Minneapolis, Minnesota.

20 and 21 Lateral and basal views of a cast of the interior from the same locality.

22 Upper side of a small specimen which, though somewhat abraded, still retains some of the strong lines of growth; also from the Vanuxemia bed at Minneapolis, Minnesota.

Figs. 23 to 25 TROCHONEMA MADISONENSE Ulrich................................................ 1051

Three views of the type of this species. The absence of a basal angulation distinguishes it from all of the preceding forms. Richmond group, Madison, Indiana.

PAGE.

Figs. 26 to 29 TROCHONEMA BELLULUM Ulrich ........ 1050

Four views of the largest and relatively lowest of six specimens, all from the Stones River group, near Murfreesboro, Tennessee. It is to be observed that this is not only a smaller type than *T. eccentricum* but that the lines of growth lean backward on the peripheral band instead of forward. The left side of the last whorl projects too far in fig. 26.

Figs. 30 to 34 TROCHONEMA SUBCRASSUM U. and S. ........ 1051

30 Rather small silicified shell showing the under side.

31 and 32 Two views of a gutta percha impression, showing surface markings.

33 A silicified specimen from which part of the shell has been removed. This specimen shows that the shell is comparatively thick, the angles being very obtuse on the interior cast.

34 Lateral view of the specimen of which fig. 30 represents the under side. Upper part of Trenton group, Mercer county, Kentucky.

Figs. 35 to 38 TROCHONEMA RETRORSUM U. and S. ........ 1051

35 to 37 Two lateral and a basal view of a testiferous example, showing the narrow and exceedingly abrupt umbilicus and the comparatively slight obliquity of the aperture. Black River group (Ctenodonta bed), Goodhue county, Minnesota.

38 A strip across the last whorl of same and the right side in outline, ×3. The lines of growth are very fine and regular. Their direction is peculiar; first because it is turned so strongly backward on the upper peripheral angle, and, second, because the backward sweep of the lines on the base is less than usual among Trochonemas of similar appearance.

Figs. 39 to 41 TROCHONEMA ALTUM U. and S. ........ 1052

Three views of a cast of the interior. Fusispira bed, Cannon Falls, Minnesota.

Figs. 42 and 43 TROCHONEMA (EUNEMA) SALTERI U. and S. ........ 1053

Opposite views of a cast of the exterior chiefly, showing general form of shell and lines of growth. Base of Fusispira bed, Cannon Falls, Minnesota.

Figs. 44 and 45 TROCHONEMA (EUNEMA) NITIDUM Ulrich ........ 1053

Opposite views of an average specimen. Utica group, Covington, Kentucky. The dark lines crossing the last whorl of fig. 44 indicate merely the direction of the lines of growth. The latter are equal and exceedingly fine on the specimen.

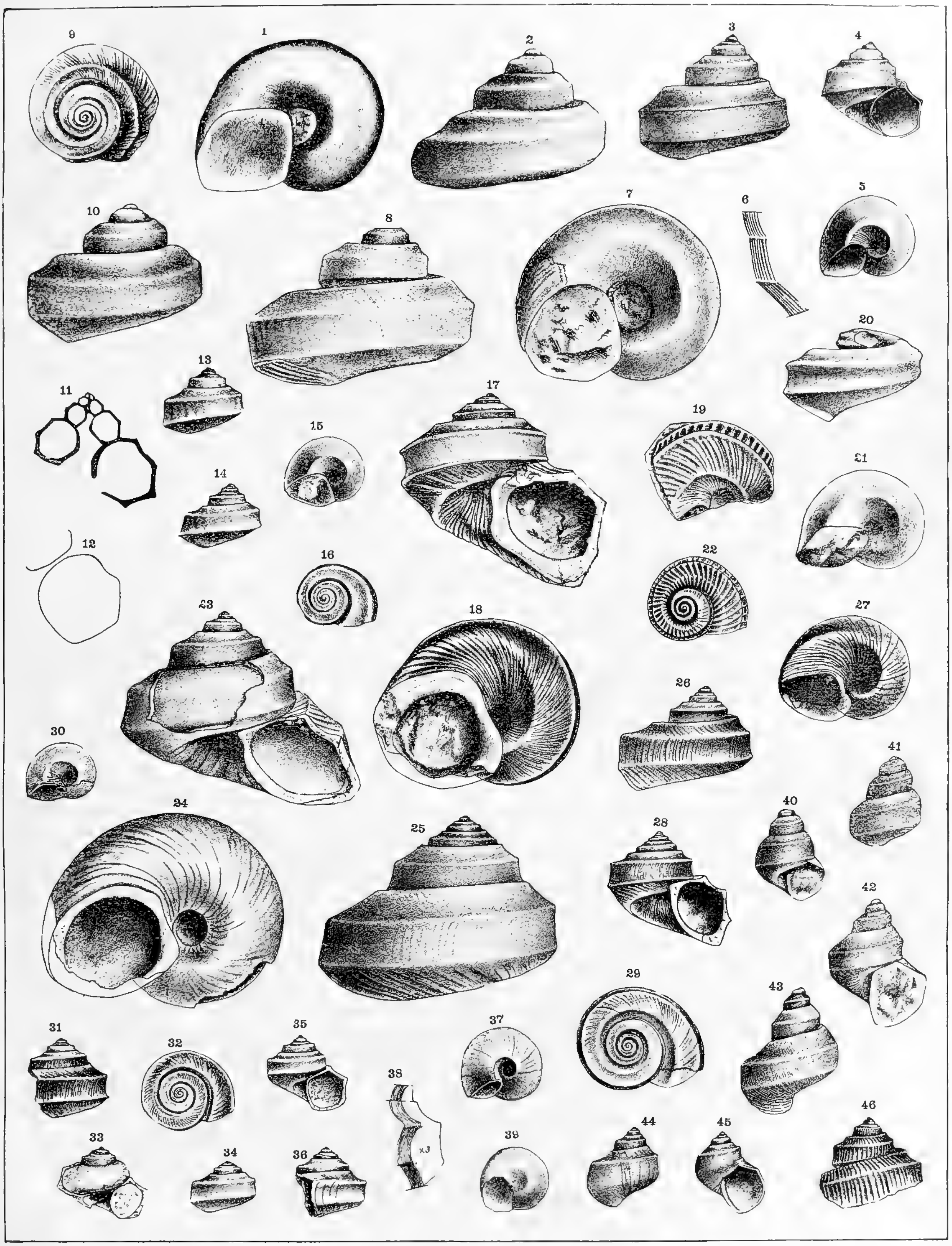
Fig. 46 TROCHONEMA VAGRANS U. and S. ........ 1049

(See also plate LXXVIII, figs. 10–13.)

Gutta percha impression of a natural mould of the spire, showing external form and surface markings of shell. Vanuxemia bed, Minneapolis, Minnesota.

(Gastropoda.)

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# PLATE LXXVIII.

| | | Page. |
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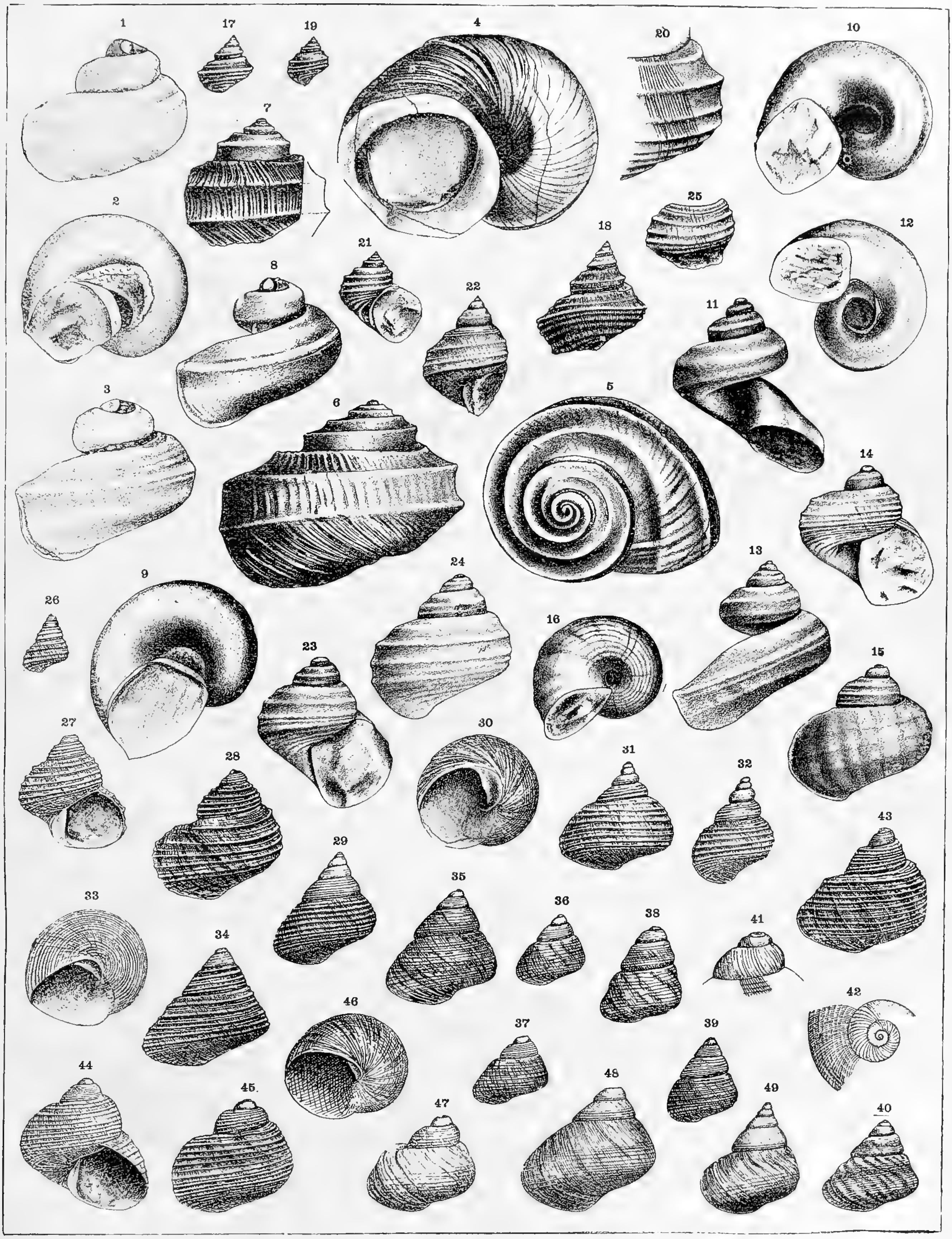
| Figs. 1 to 9 | Trochonema beloitense Whitfield | 1048 |
| 1 | Dorsal side of a cast of the interior, from Beloit, Wisconsin | |
| 2 and 3 | Umbilical and dorsal views of a well marked specimen of the form of the species prevailing at Dixon, Illinois. Excepting the umbilical region, which gives an idea of the thickness of the shell, the specimen is a cast of the interior. | |
| 4 to 6 | Three views of a large example, retaining most of the shell, from Mineral Point, Wisconsin. | |
| 7 | Gutta percha impression of a natural mould of the exterior, from Beloit, Wisconsin. | |
| 8 | Dorsal side of an interior cast of the Minnesota form of the species, having the last whorl partly free; Minneapolis. | |
| 9 | Under side of a similar specimen from the same locality. | |
| Figs. 10 to 13 | Trochonema vagrans U. and S. (See also plate LXXVII, fig. 46.) | 1049 |
| 10 and 11 | Basal and lateral views of a cast of the interior, from Minneapolis. | |
| 12 and 13 | Similar views of a nearly perfect cast from the same locality. Survey collection, Museum Register No. 6865 | |
| Figs. 14 to 16 | Gyronema liratum U. and S. | 1056 |
| | Three views of the specimen upon which this species is founded. While the greater part is preserved as a cast of the interior, a portion, as shown in fig. 14, is of the exterior. Beloit, Wisconsin. | |
| Figs. 17 and 18 | Gyronema semicarinatum Salter sp. | 1055 |
| | Dorsal views, natural size and ×2, of a specimen retaining the shell; near Cannon Falls, Minnesota. | |
| Figs. 19 to 21 | Gyronema pulchellum U. and S. | 1054 |
| 19 | Dorsal view of a small but nearly perfect example; Chatfield, Minnesota. | |
| 20 | Portion of same ×5 to show extremely fine lines of growth. | |
| 21 | Apertural view of a larger and excellently preserved specimen; Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 6854. | |
| Figs. 22 to 25 | Gyronema duplicatum U. and S. | 1055 |
| 22 | Side view of a specimen which retains some of the shell and has a higher spire than usual; Dixon, Illinois. | |
| 23 and 24 | Apertural and dorsal views of a large and almost entire cast of the interior belonging to the collection of the University of Wisconsin; Beloit, Wisconsin. | |
| 25 | The lower whorl of a cast of the exterior from the same collection and locality. | |
| Fig. 26 | Cyclonema (? Gyronema) præceptum, n. sp. (Ulrich.) | |
| | Dorsal view of an average example of this species; Stones River group, Murfreesboro, Tennessee. It was through a species like this that *Cyclonema* was evolved from *Gyronema*. The inner lip is relatively thicker, straighter, and more reflexed than in species of *Gyronema*, but not excavated as it should be in a true *Cyclonema*. A minute umbilicus is often present. This species is referred to but not named in the fifth paragraph on page 1046. | |
| Figs. 27 and 28 | Cyclonema varicosum Hall | 1060 |
| 27 | Apertural view of a specimen from the upper part of the Trenton group at Nashville, Tennessee. | |
| 28 | Dorsal view of a larger specimen, from Colby, Kentucky. The inner lip is nearly vertical and the carinæ very strong in this species. | |
| Figs. 29 and 30 | Cyclonema mediale Ulrich | 1059 |
| 29 | Dorsal view of an average example of the typical form of this species; Covington, Kentucky. In another common variety the revolving carinæ are less equal, being more as in fig. 34 of this plate. | |
| 30 | Under side of another specimen from Covington. | |
| Figs. 31 and 32 | Cyclonema inflatum Ulrich | 1060 |
| | Dorsal views of two specimens from Cincinnati, Ohio, showing rather extreme conditions in the manner of growth. The apex in the first is entire. | |
| Figs. 33 and 34 | Cyclonema pyramidatum James | 1061 |
| | Basal and dorsal views of a typical example of this species; from the vicinity of Morrow, Ohio. | |
| Figs. 35 to 39 | Cyclonema bilix Conrad sp. | 1058 |
| 35 | Dorsal view of a rather large example of this species, from Versailles, Indiana. | |
| 36 | A similar view of a smaller specimen, from Waynesville, Ohio. | |
| 37 | A dorsal view of a third specimen, from Clarksville, Ohio. These three specimens are regarded as agreeing in every respect strictly with the original type of the species. It is to be observed that the revolving carinæ are not as strong as in *C. mediale*, and the suture more abruptly impressed. | |
| 38 and 39 | Dorsal views of two specimens of the form which Miller proposed to distinguish as variety *conicum;* from Versailles, Indiana. | |
| Figs. 40 to 42 | Cyclonema bilix var. fluctuatum James | 1059 |
| 40 | Dorsal view of a perfect specimen of this variety, from Versailles, Indiana, showing the relatively fine revolving lines, oblique folds and concave slopes of the whorls which usually characterize this variety. | |
| 41 and 42 | Two views, ×5, of the apex of same. | |
| Figs. 43 to 46 | Cyclonema humerosum Ulrich | 1061 |
| 43 | A large and strongly marked specimen of the Richmond group variety of this species; Waynesville, Ohio. Possibly this is an extreme variety of *C. bilix*, with which it was found associated, rather than of the Lorraine group types of this species. | |
| 44 | Apertural view of a large example of an abundant variety in the Lorraine group at Cincinnati. The whorls are more rounded and the "shoulder" less distinct than in the typical form of the species. | |
| 45 and 46 | Dorsal and basal views of a typical example from Cincinnati. The shoulder at the top of the whorls is often more pronounced. | |
| Fig. 47 | Cyclonema simulans Ulrich | 1061 |
| | Dorsal view of an average example of this species, showing the rather delicate revolving lines growing more and more obsolete on the last volution; Cincinnati, Ohio. | |
| Figs. 48 and 49 | Cyclonema sublæve Ulrich | 1062 |
| 48 | Dorsal view of a representative example; Covington, Kentucky. | |
| 49 | Similar view of a relatively higher specimen, from the same locality. | |

(Gastropoda.)

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# PLATE LXXIX.

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| Figs. 1 to 5 | Holopea insignis U. and S. | 1065 |
| 1 and 2 | Opposite views of the interior cast of a young shell. The hight is relatively greater than in fully grown individuals. Stones River group, Minneapolis, Minnesota. | |
| 3 to 5 | Three views of a large cast. This specimen is so sharp and clean that it may be a cast of the exterior rather than of the interior. Stones River group, Cannon Falls, Minnesota. | |
| Fig. 6 | Holopea concinnula U. and S. | 1066 |
| | A cast of the interior, the last whorl with obscure lines of growth. Stones River group, Beloit, Wisconsin. | |
| Figs. 7 to 10 | Holopea appressa U. and S. | 1065 |
| 7 to 9 | Three views of a small but entire cast of the interior, giving a good idea of the peculiarities of the species. Clitambonites bed, Goodhue county, Minnesota. | |
| 10 | Under side of a larger cast. Geological and Natural History Survey of Minnesota, Museum Register No. 6765. | |
| Figs. 11 and 12 | Holopea excelsa U. and S. | 1067 |
| 11 | Apertural view of an incomplete cast of the interior. Fusispira bed, Wykoff, Minnesota. | |
| 12 | Dorsal view of a nearly complete cast from the same locality. | |
| Figs. 13 to 18 | Holopea pyrene Billings. | 1067 |
| 13 and 14 | Two views of a cast of the interior, the inner whorls restored. Trenton group, near Cannon Falls, Minnesota. | |
| 15 to 18 | Four views of a cast of the interior of a young specimen. Fusispira bed, near Cannon Falls, Minnesota. | |
| Fig. 19 | Holopea var. parvula Ulrich. | |
| | Dorsal view of the largest of three specimens. Upper Trenton, near Burgin, Kentucky. | |
| Figs. 20 and 21 | Holopea rotunda U. and S. | 1066 |
| 20 | Perfect silicified shell, showing the aperture, minute umbilicus, and general form of the shell. Trenton group, Hartsville, Tennessee. | |
| 21 | A much larger specimen, presumably of this species, from the Stones River group at Dixon, Illinois. | |
| Figs. 22 to 25 | Holopea ampla U. and S. | 1065 |
| 22 | An average example of this species. The specimen is a cast of the interior and shows broad varices of growth and rather obscure traces of revolving lines. Stones River group, Cannon Falls, Minnesota. | |
| 23 to 25 | Body whorl of a large specimen, strongly marked with wrinkles and lines of growth. The specimen appears to be a cast of the exterior and is from Cannon Falls, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 5836. | |
| Fig. 26 | Holopea similis U. and S. | 1066 |
| | Dorsal view of an average example of the form which we have separated provisionally from *H. ampla* and *H. obliqua* under this name. Shales of the Black River group, Fillmore county, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 7381. | |
| Figs. 27 and 28 | Holopea supraplana U. and S. | 1068 |
| 27 | Dorsal view of a cast of the interior. Lower part of Fusispira bed, Kenyon, Minnesota. | |
| 28 | Apertural view of the largest specimen seen. Though a cast of the interior, it gives a good idea of the strongly inrolled thin inner lip. Kenyon, Minnesota. | |

(Gastropoda.)

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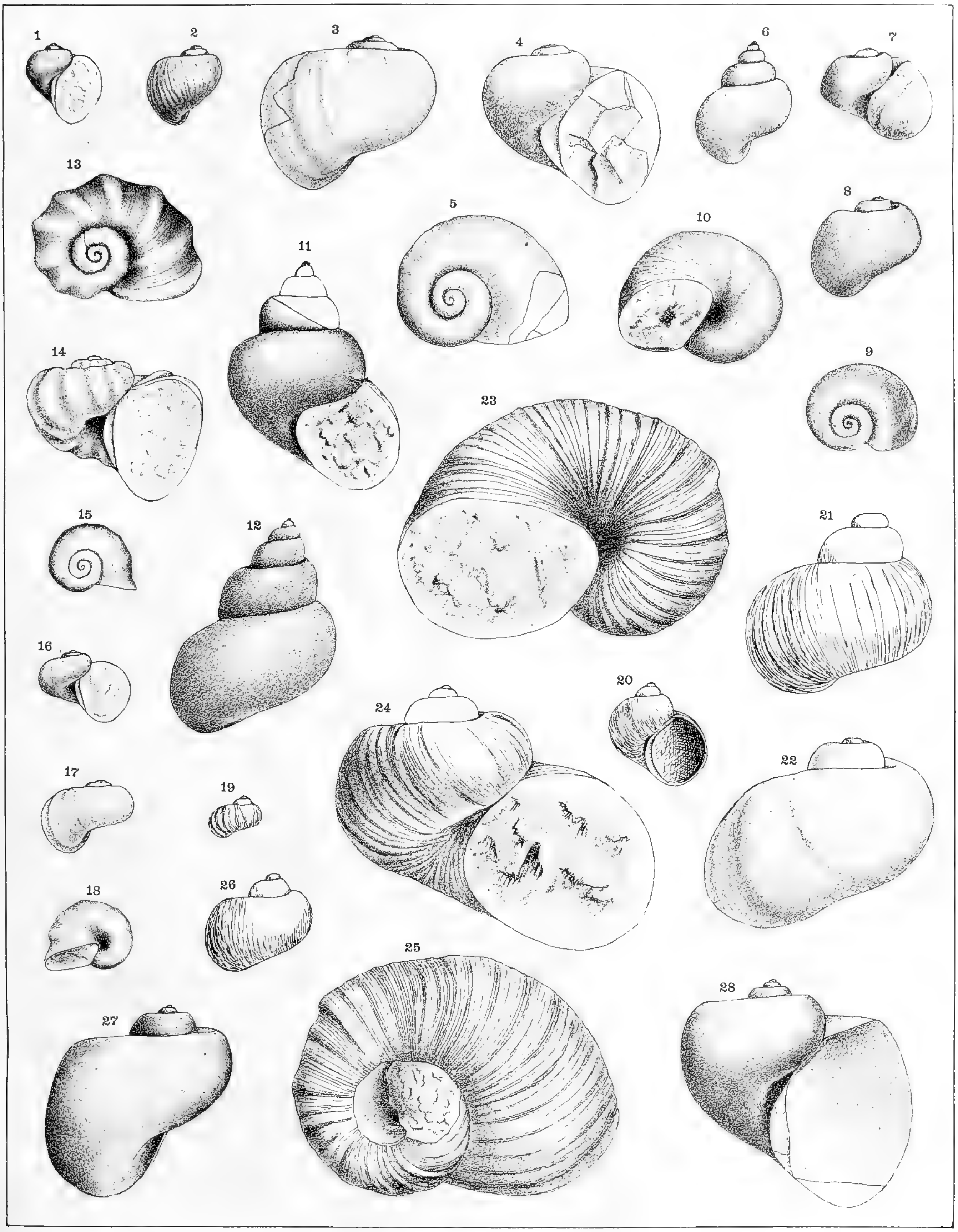


# PLATE LXXX.

PAGE.

Fig. 1 FUSISPIRA SCHUCHERTI U. and S. .......... 1076

View of the type and only known specimen of this species. Part of the shell is preserved. Its great thickness is the most important of the peculiarities of the species. Black River group, Beloit, Wisconsin. Geological and Natural History Survey of Minnesota, Museum Register No. 7322.

Figs. 2 to 4 FUSISPIRA NOBILIS U. and S. .......... 1078

2 and 3 Opposite views of a sharply defined but incomplete and small cast of the interior, showing, besides the usual characters of the species, seven obscure revolving lines on two of the whorls. Trenton group, Fusispira bed, Wykoff, Minnesota.

4 A larger specimen from the same locality. This slightly exceeds in size the average for the species. The whole surface is covered with a thin layer of crystalline calcite and exhibits not a trace of revolving bands.

Figs. 5 to 7 FUSISPIRA SULCATA Ulrich .......... 1077

5 Dorsal view of a specimen that, excepting the patch of shell shown, is a sharply defined cast of the interior. The shell is rather thick, and, as shown in the figure, the external suture line is situated considerably higher than it is in the cast. The latter shows, especially on the upper whorls, rather distinct revolving sulci. Base of Utica or top of Trenton, Scott county, Kentucky.

6 Apertural view of same.

7 Small portion of the surface of the shell ×10, showing punctæ of two sizes arranged in series parallel with the suture line.

Figs. 8 to 10 FUSISPIRA CONVEXA U. and S. .......... 1077

8 Dorsal view of an incomplete but clean cast of the interior, from the Trenton limestone at Trenton Falls, New York. Has obscure revolving bands like the preceding species but differs in its more convex and more depressed whorls.

9 The last two whorls of a larger cast, apparently of this species. Clitambonites bed of the Trenton group, Goodhue county, Minnesota.

10 Outline of the lower and outer parts of the lip of same as seen from beneath.

Figs. 11 to 16 FUSISPIRA SUBBREVIS U. and S. .......... 1076

11 and 12 Opposite views of a small cast of the interior, Fusispira bed, Goodhue county, Minnesota.

13 Apertural view of a much larger cast. This specimen has the mouth entire but has suffered some from pressure and may not really belong to this species. Maclurea bed of the Trenton group, Stewartsville, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 8728.

14 Dorsal view of lower two whorls of same.

15 Dorsal view of a specimen from the Fusispira bed at Decorah, Iowa. This agrees, so far as we can see, exactly with the original of fig. 11. Geological and Natural History Survey of Minnesota, Museum Register No. 7362.

16 Outline, as seen from below, of lower and outer portions of the lip of the specimen represented by figs. 13 and 14.

Figs 17 and 18 FUSISPIRA INFLATA Meek and Worthen .......... 1075

17 Apertural view of a cast of the interior of a young specimen. Lower part of Fusispira bed, Kenyon, Minnesota.

18 Apertural view of a large and nearly perfect cast of the interior, showing the adult appearance of the species. Fusispira bed, Goodhue county, (Hader P. O.), Minnesota. In the variety which occurs in the Maclurea bed the under side of the whorls is more ventricose, causing the bend in the inner outline of the aperture to be more abrupt.

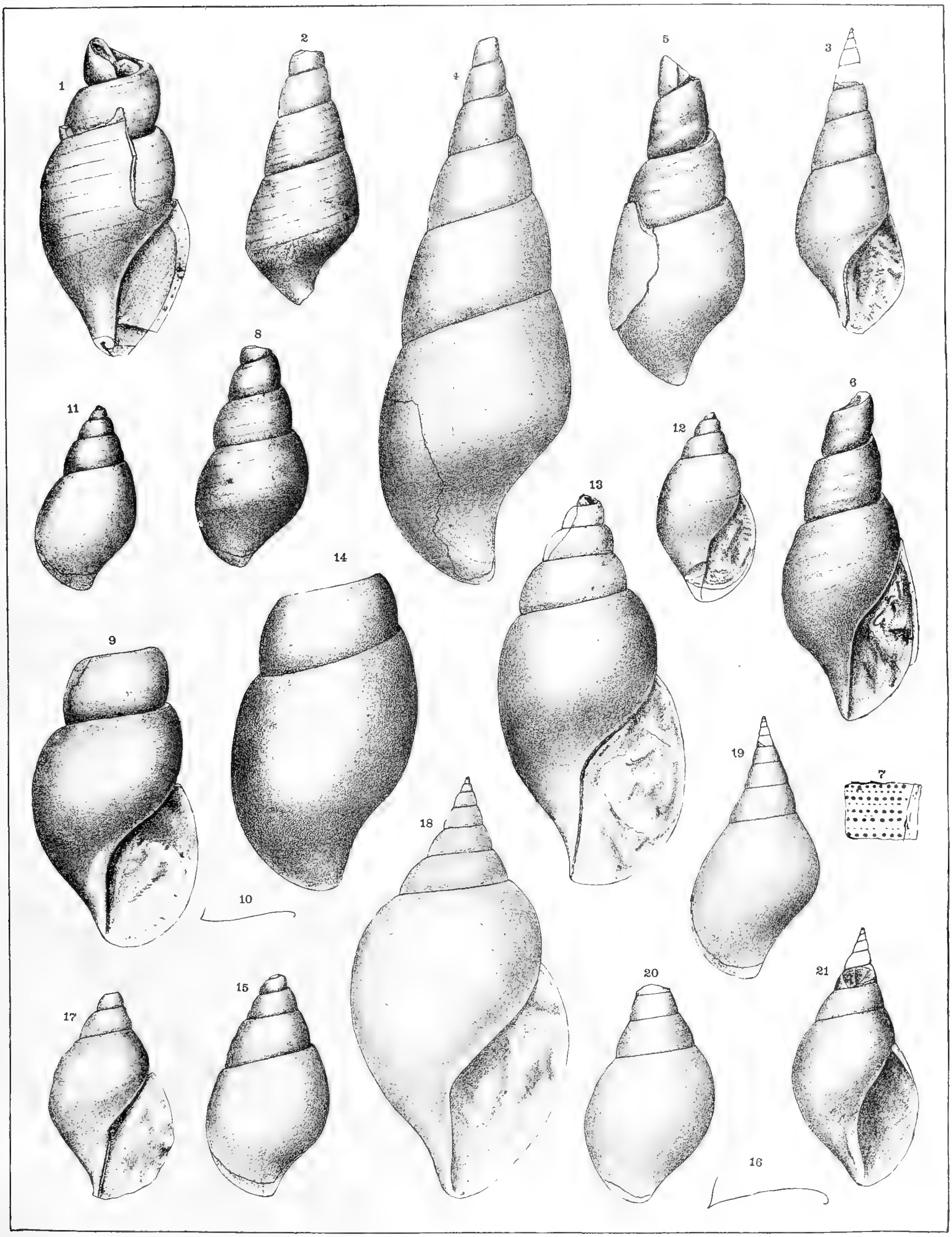
Figs. 19 to 21 FUSISPIRA INTERMEDIA U. and S. .......... 1076

19 Dorsal view of a specimen showing the slender spire and relatively rapid expansion of the last whorl. Maclurea bed, Stewartsville, Minnesota. Geological and Natural History Survey of Minnesota, Museum No. 7451.

20 and 21 Opposite views of another specimen from this locality, showing, as far as it goes, the same features.

(Gastropoda.)





# PLATE LXXXI.

PAGE.

Figs. 1 and 2 SUBULITES sp. undet. (? ELONGATUS Conrad)......................................
Lateral view of a cast of the interior and top of same, showing the peculiar termination of interior casts of species of *Subulites*. Trenton group, Ottawa, Canada.

Fig. 3 SUBULITES CANADENSIS Ulrich...................................................... 1071
Figure of a cast of the interior, restored at both extremities from other specimens. Black River group, Ottawa, Canada.

Figs. 4 and 5 SUBULITES CONRADI U. and S.................................................... 1071
4 Cast of the interior; from the Stones River group, Cannon Falls, Minnesota. The relative narrowness of the shell, especially of the basal part, is the most important of the distinctive features of this species.
5 Basal outline of lips.

Figs. 6 to 8 SUBULITES DIXONENSIS U. and S.................................................. 1071
6 Lateral view of a partial cast of the interior, showing the anterior outline of the outer lip.
7 Another view of same showing the form of the aperture, which is relatively wider below than in the other species, and the comparatively abrupt basal taper of the volutions. Stones River group, Dixon, Illinois.
8 Outline of lower and outer lips as seen from below.

Figs. 9 to 11 SUBULITES BELOITENSIS U. and S................................................ 1072
9 Entire cast of the interior.* The mouth is very similar to that of *S. canadensis* (see fig. 3), but the shell as a whole is more slender, while the sides of the whorls are practically flat instead of gently convex.
10 Lower part of same specimen in another view, for comparison with fig. 6. Stones River group, Beloit, Wisconsin.
11 Outline of lower and outer lips as seen from below.

Figs. 12 to 15 SUBULITES PERGRACILIS U. and S.............................................. 1072
12 Apertural view of a fragment, with the lower extremity and the spire restored in outline.
13 and 14 Two views of another fragment, the first showing the peculiar band along the suture, the second the aperture.
15 Three lines, the lower representing the basal outline of fig. 12, the middle one the basal outline of fig. 14, the upper one part of the greatest circumference of the body whorl. Trenton group, Fusispira bed, Wykoff, Minnesota.

Figs. 16 and 17 SUBULITES PARVUS Ulrich....................................................... 1072
Opposite views of a cast of the interior. Stones River group, High Bridge, Kentucky.

Figs. 18 and 19 SUBULITES NANUS Ulrich......................................................... 1072
Opposite views of the larger of two specimens of this small species. Stones River group ("Glade limestone"), Lebanon, Tennessee.

Fig. 20 SUBULITES sp. undet...........................................................
Fragmentary example of a curved species; from the Fusispira bed at Wykoff, Minnesota.

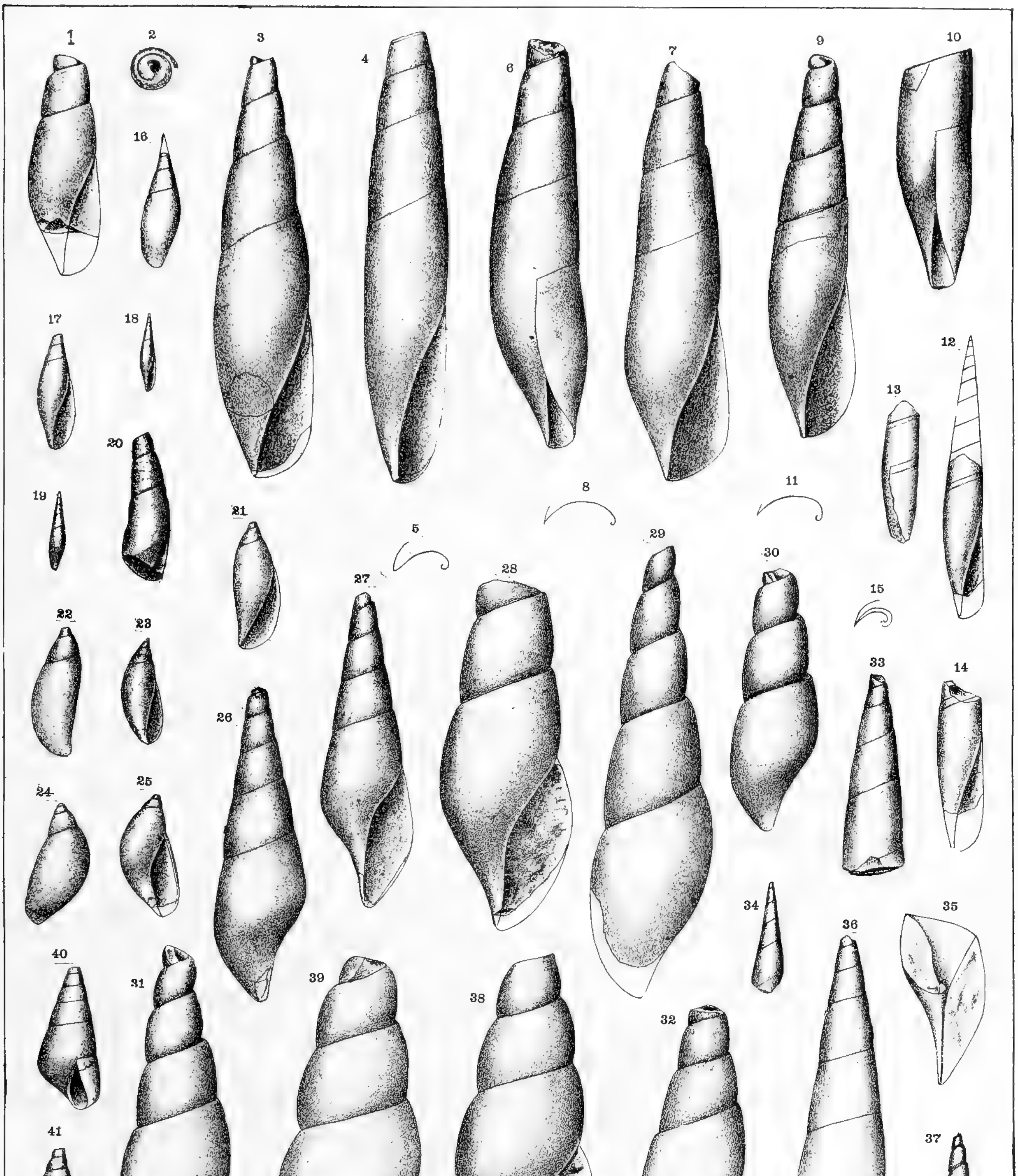
Figs. 21 and 22 CYRTOSPIRA BICURVATA Ulrich.................................................. 1074
Opposite views of the unique specimen upon which the species is founded. Stones River group, High Bridge, Kentucky.

Fig. 23 CYRTOSPIRA WYKOFFENSIS U. and S.................................................... 1074
Apertural view of the type specimen, the apex restored in the figure. Fusispira bed, Wykoff, Minnesota.

* We believe this specimen is composed of parts of two individuals. However that may be, it gives a correct idea of the species and therefore may justly stand as the type.

(Gastropoda.)

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## PLATE LXXXII.

PAGE.

Figs. 1 and 2 TRYBLIDIUM MODESTUM U. and S. .... 826
Two views, dorsal and profile, of the specimen described.

Figs. 3 and 4 ARCHINACELLA PEROVALIS Whitfield sp. .... 830
Dorsal and profile views of a cast of the interior from Minneapolis. (After Sardeson, who called it *Metoptoma explanata.*)

Figs. 5 and 6 ARCHINACELLA RUGATINA Ulrich .... 835
Two views of a cast, apparently of the exterior, from Middletown, Ohio.

Figs. 7 to 9 SCENELLA MAGNIFICA U. and S. .... 839
Three views, in outline and restored at the apex, of the specimen described.

Fig. 10 SCENELLA OBTUSA Sardeson sp. .... 841
Dorsal view of a cast of the interior, from Minneapolis. (After Sardeson, who called it *Conchopeltis obtusa.*)

Figs. 11 to 15 STENOTHECA EXSERTA Sardeson sp. .... 842
11 and 12 Two views of a small specimen presumably of this species; Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 715.
13 Outline view of a large specimen from Beloit, Wisconsin, belonging to the collection of the University of Wisconsin.
14 and 15 Copies of Sardeson's original figures of his *Tryblidium exsertum*, founded upon a specimen from the "Blue limestone" at Minneapolis.

Figs. 16 to 20 SALPINGOSTOMA SCULPTILIS U. and S. .... 902
16 Lateral view of a partial cast of the interior from which the greater part of the apertural expansion has been broken away; Goodhue county, Minnesota.
17 and 18 Lateral and dorsal views of a more complete cast of the exterior, showing the greater part of the expanded aperture, the dorsal slit and surface sculpture; from Goodhue county. Geological and Natural History Survey of Minnesota, Museum Register No. 7462.
19 Portion of same, ×5, showing slit-band and sculpture.
20 Transverse section of inner half of last whorl of a cast of the interior from Fillmore county, Minnesota.

Figs. 21 and 22 SALPINGOSTOMA IMBRICATA U. and S. .... 902
Two views of the specimen described.

Figs. 23 to 25 OXYDISCUS SUBACUTUS, n. sp. (Ulrich.) .... 913
(See also plate LXII, Figs. 62—65.)
23 Lateral view in outline, each volution embracing about one-half of the preceding one.
24 Ventral view of same, ×2, to correct fig. 62 on pl. LXII.
25 Side view of a similar specimen, ×2, showing the slender inner whorls. Both specimens are from Danville, Kentucky.

Figs. 26 to 28 OXYDISCUS CRISTATUS Safford sp. .... 914
26 Lateral view of the smallest of four specimens; Jackson county, Tennessee. Collection of Prof. J. M. Safford.
27 Similar view of the largest specimen; Lindsley's Hill, Tennessee. In this example the outer part of the last whorl is free from the dorsal keel of the preceding whorl.
28 Portion of the dorsal keel of a large specimen, broken like fig. 27, showing the posterior extremity of the long slit; Nashville, Tennessee.

Figs. 29 to 31 CŒLOCAULUS NEGLECTUS U. and S. .... 1020
29 and 30 Lateral and basal views of the specimen described; near Cannon Falls, Minnesota.
31 Upper two whorls of same, ×2.5, to show the rounded terminus more clearly.

Figs. 32 to 34 HELICOTOMA GRANOSA Ulrich .... 1035
32 The upper side of a small specimen, ×3, from High Bridge, Kentucky.
33 Profile view of same, ×3, showing the surface granulation more clearly than in fig. 32.
34 Upper side of same, natural size.

Figs. 35 to 38 LIOSPIRA ABRUPTA U. and S. .... 995
35 Under side of an average example. Murfreesboro, Tennessee.
36 Upper side of another specimen.
37 Profile views, ×2, the lower line giving the form for the original of fig. 35, the line above it for that of fig. 36. The spire is sometimes more depressed. The line on the right of the figure is intended to show the contour of the "band" and peripherial portion of the whorls.
38 Oblique view of the umbilicus, ×2, showing the crescent-shaped reflexion of the inner lip.

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Figs. 39 to 41 LIOSPIRA DECIPIENS Ulrich........ 998

39 Upper side, showing slender volutions and distinct peripheral band; Murfreesboro, Tennessee.

40 Lower side of same, with the apertural portions restored. The umbilicus is filled with shell-matter as in *L. micula*, *L. progne* and other species of the genus. (See plates LXVIII and LXIX.)

41 Profile of same, natural size; also outline of upper surface and periphery of last whorl, intended especially to show the band in transverse section.

Figs. 42 to 44 LIOSPIRA MODESTA Ulrich........ 995

Three views, ×2, of a specimen from the Ctenodonta bed at Chatfield, Minnesota. Since page 995, on which this shell is referred to as possibly belonging to *L. abrupta*, was printed, we have decided that it is sufficiently distinct to bear a name of its own. We propose, therefore, to call it *L. modesta.*

Fig. 45 MACLURINA MANITOBENSIS Whiteaves sp........ 1041

Inner whorls on the flat side of a specimen from Olmsted county, Minnesota, ×2.

Fig. 46 MACLURINA CUNEATA Whitfield sp........ 1042

Vertical section of a very young example, magnified nearly two diameters, showing that the inner whorls are widely umbilicated. The specimen is imbedded in the rock filling the outer whorl of the specimen of *M. manitobensis* showing the inner whorls as represented in fig. 45.

Figs. 47 and 48 SUBULITES REGULARIS U. and S........ 1072

(See also plate LXXXI, fig. 35.)

47 Ventral view of a young specimen; High Bridge, Kentucky.

48 Side view of a large specimen, from the same locality.

Figs. 49 to 54 STROPHOSTYLUS TEXTILIS U. and S........ 1064

49 Cast of the interior from St. Paul, Minnesota, showing the usual form and several of the strong obliquely transverse furrows which occur so frequently, especially on interior casts, in this species.

50 A more depressed cast from Fillmore county, retaining traces of external markings.

51 Ventral view of a testiferous example from the vicinity of Cannon Falls, Minnesota.

52 Dorsal view of an incomplete shell from the same locality. The surface markings are beautifully preserved on this specimen.

53 View of a specimen from Chatfield, Minnesota, from which a part of the last whorl was removed so as to show the spirally twisted folds of the columella.

54 Surface of last whorl of original of fig. 52, ×5.

Figs. 55 to 61 CYCLONEMA GRACILE Ulrich, and varieties........ 1062

55 to 57 Three specimens of the typical form of this species, showing considerable difference in their respective apical angles, Newport, Kentucky.

58 Ventral view of a specimen, from the same locality, referred to this species with some doubt. It may be an extreme form of *C. sublæve* (plate LXXVIII, figs. 48 and 49), but the upper whorls are more convex than in any of the numerous specimens of that species before us.

59 Dorsal view of a rather small but perfect specimen of a form that, on account of the constant presence of delicate revolving lines, may be distinguished as var. *striatellum.* It occurs with the other varieties at Cincinnati.

60 and 61 Two views of the apical whorls of same, ×5.

Figs. 62 to 64 CYCLONEMA (?HOLOPEA) LIMATUM Ulrich........ 1063

62 and 63 Opposite views of an excellently preserved example of this *Holopea*-like shell. The surface on portions of the specimen is polished, and here exhibits traces of revolving lines as shown in the figures.

64 Ventral view of a more ventricose individual. Both specimens were found in the vicinity of Cincinnati, Ohio.

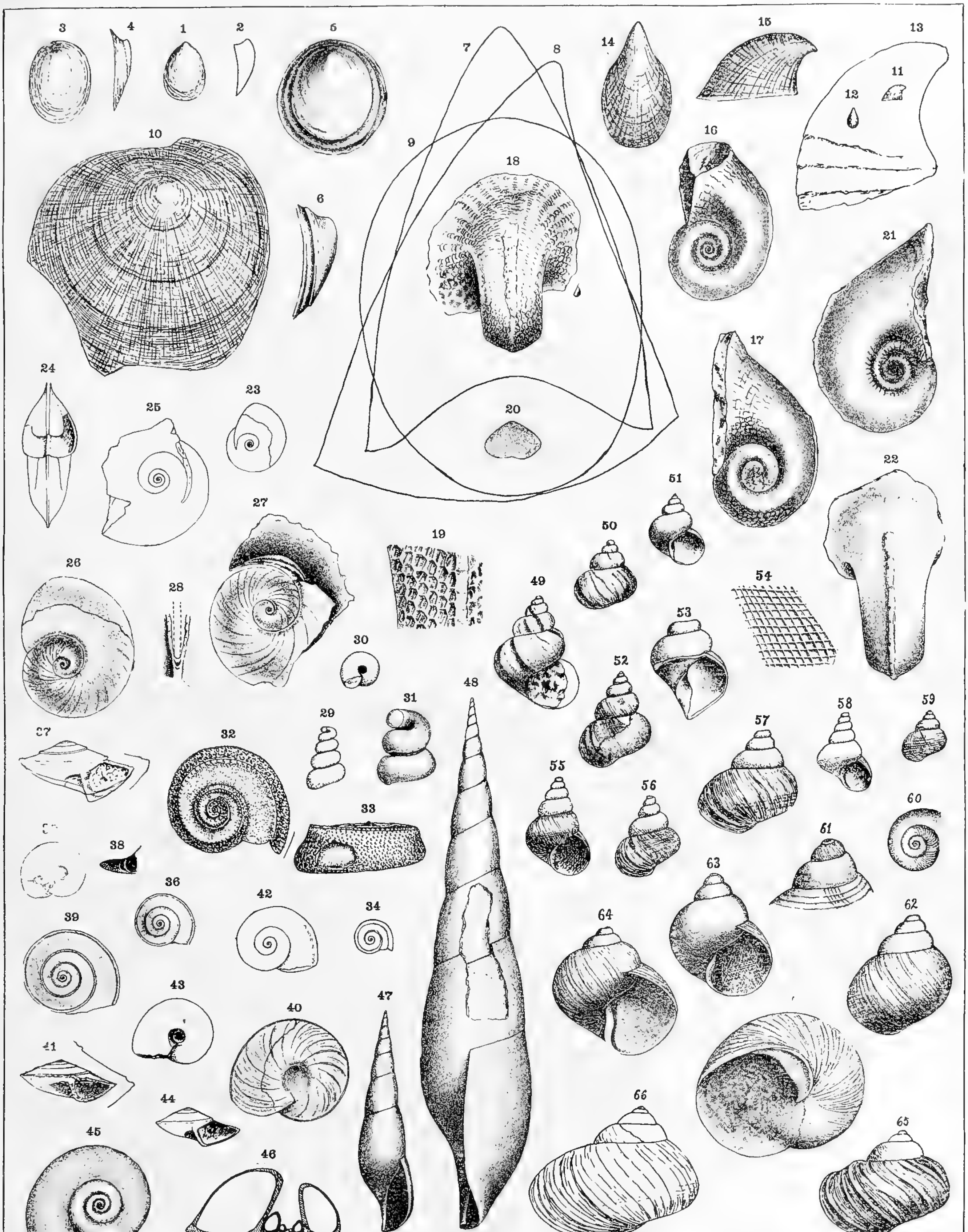
Figs. 65 to 67 CYCLONEMA TRANSVERSUM Ulrich........ 1062

65 Dorsal view of the strongly marked specimen regarded as the type of this species; Covington, Kentucky. The two upper whorls are restored in the figure.

66 and 67 Dorsal and basal views of a larger specimen which, while agreeing in probably all essential respects with the preceding, has a smoother surface with faint indications of revolving lines on the periphery.

(Gastropoda.)

VOL. III. PLATE LXXXII.



# GEOGRAPHICAL AND PERSONAL INDEX.

PART II. PAGES 475 TO 1081.

# SCIENTIFIC INDEX.

## PART II. PAGES 475 TO 1081.

The most important reference is given first; others follow in numerical order. Each scientific name is indexed for every page on which it occurs. Synonyms, and also the figures referring to the pages on which they are mentioned, are in italics. An asterisk after a page reference signifies that an illustration of the form in question is given on that page. A page reference in bold face type signifies that on this page the form is described.