THE UNIVERSITY OF MINNESOTA.

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.

PUBLISHED BY AUTHORITY OF THE STATE.

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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.

SUBMITTED NOV. 30, 1891, AND PUBLISHED UNDER THE
DIRECTION OF HON. ALBERT BERG,
SECRETARY OF STATE.

ILLUSTRATED BY FORTY-EIGHT PLATES
AND ONE HUNDRED AND THIRTY-THREE FIGURES.

MINNEAPOLIS, MINN.
HARRISON & SMITH, STATE PRINTERS.
1897.

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

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INTRODUCTION TO VOL. III, PART II.

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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.

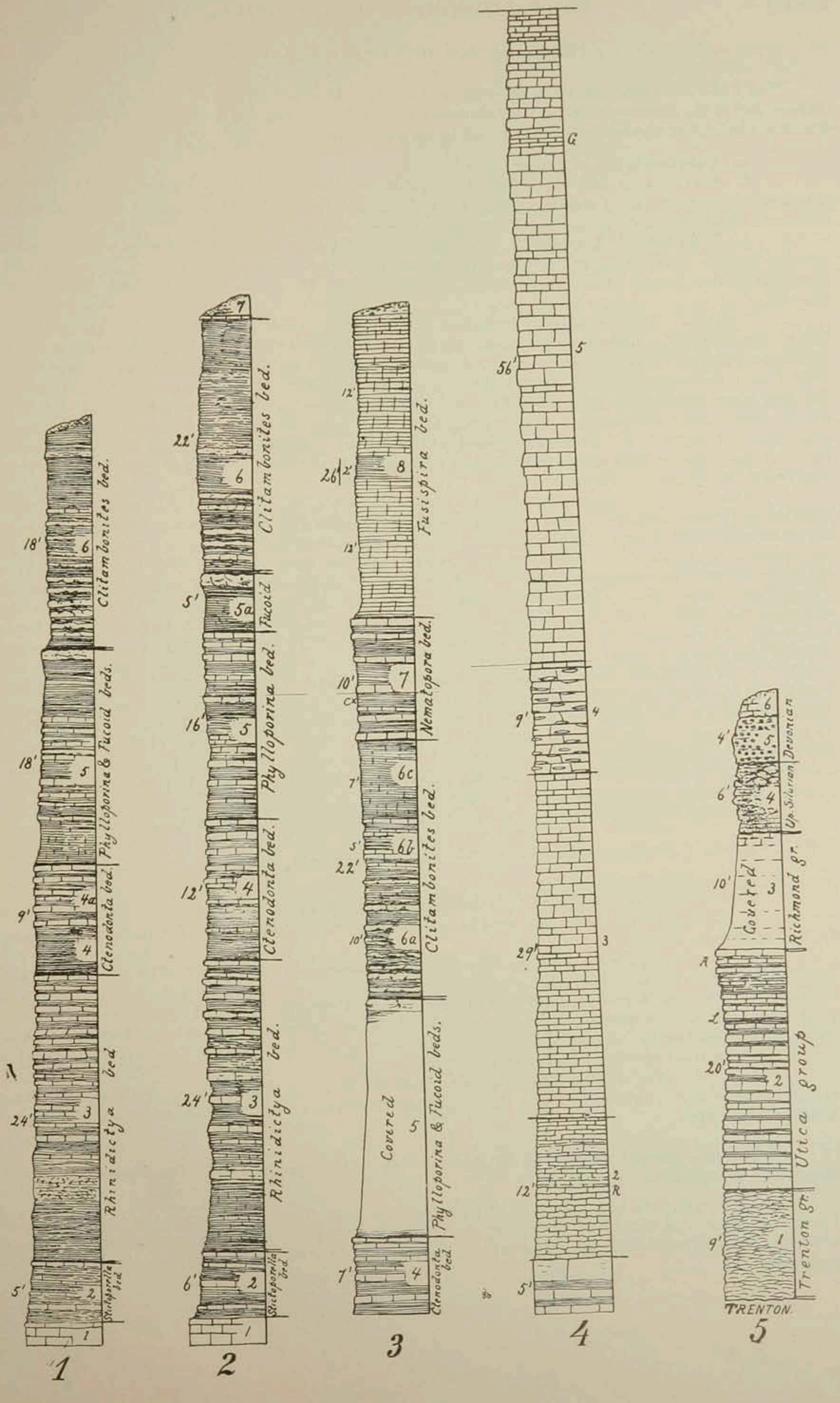
AVERAGE SECTION OF THE TRENTON PERIOD.

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

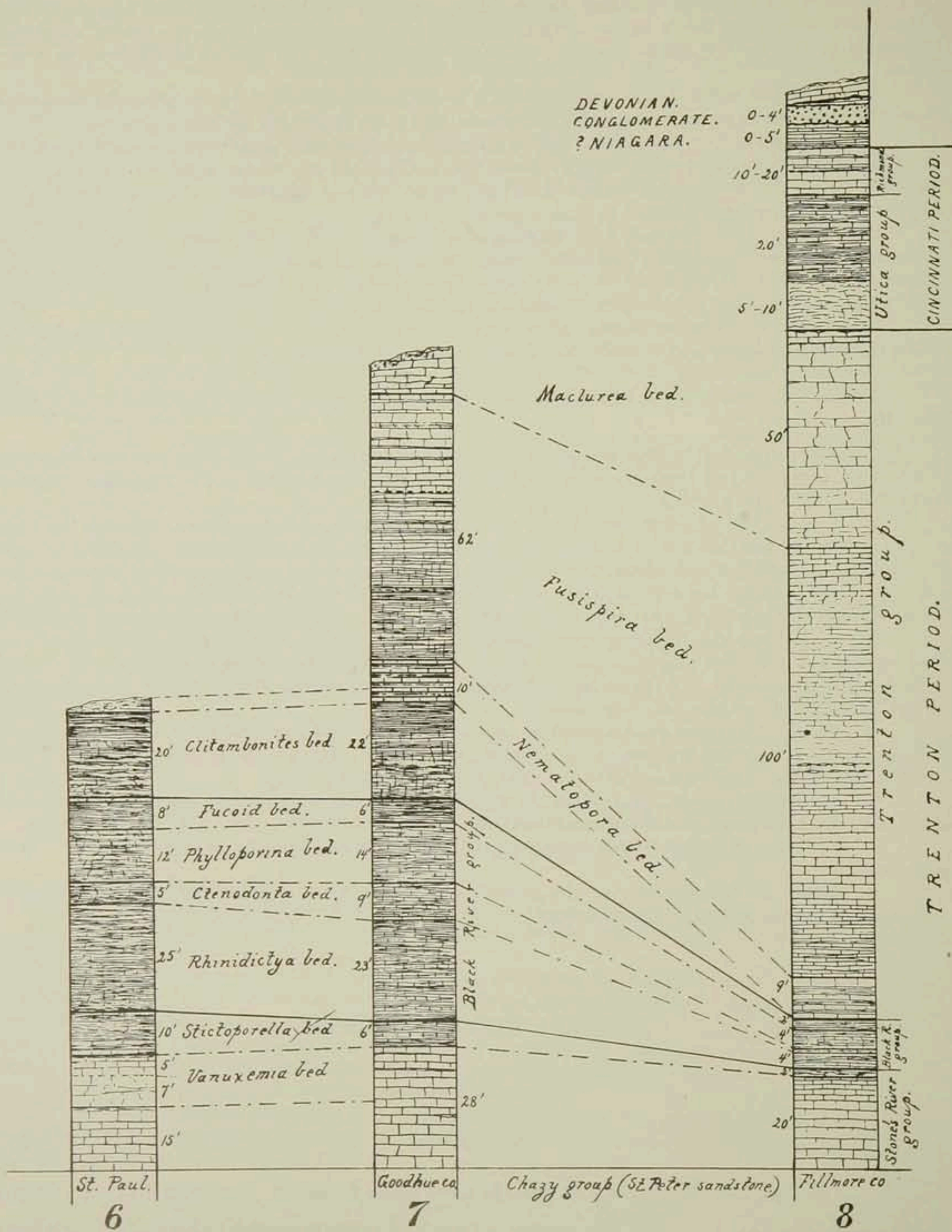
6. Above No. 5 the surface of the ground was strewn with irregular, porous lumps of yellow or buff, magnesian limestone of Devonian age.

CORRELATION OF STRATA.

TRENTON PERIOD.

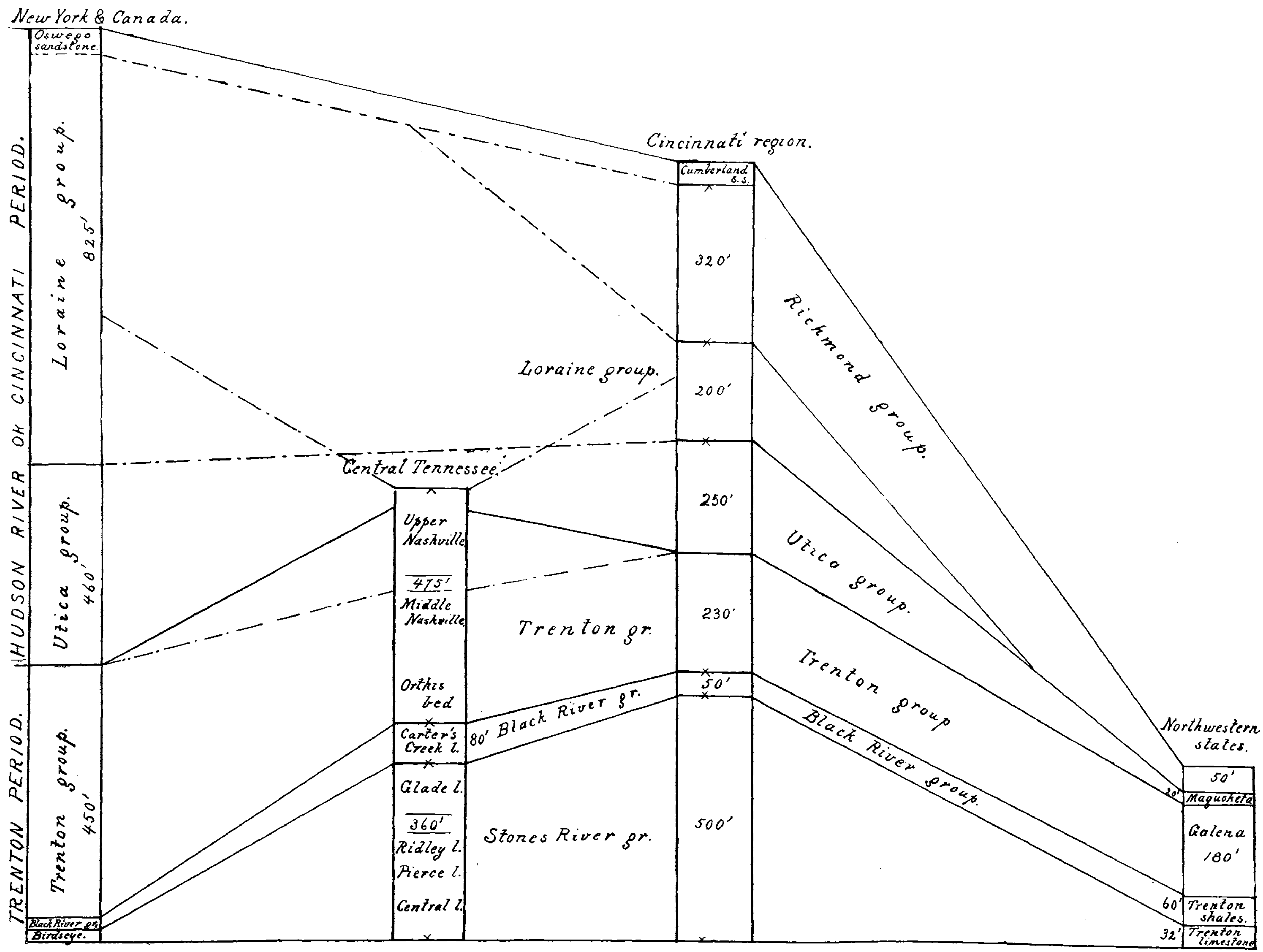
Chazy group.

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.



6 7 8

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 meedsi* 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 deltoidea, 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

* 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*, *Batostoma 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.		Trenton Period.									Hudson or Cincinnati Period.					
		Stones River Group.			Black River Group.			Trenton Group.								
	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.
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."	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.
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											

BRYOZOA AND BRACHIOPODA.	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.				
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				

BRACHIOPODA AND 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.				
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. 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.
Byssonychia tenuistriata, n. sp.	500											x	R			
Modiolpsis simili s 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. "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.
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."	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.
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		

GASTROPODA.	Page.	Trenton Period.									Hudson or Cincinnati Period.					
		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.	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		T U	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			S	S		Cal.
Solenospira prisca (?) Billings	1022		x													B
Solenospira pagoda Salter	1022						x							S		
Ophiletina sublaxa, n. sp	1030		x	?x												
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													

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.
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.									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.				
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											

OSTRACODA AND TRILOBITA.	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.				
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															
Isotelus gigas Dekay	701							x	x		x	x	T to R	T H	T U H	T U H
Isotelus maximus Locke	701								x		x		T to R	T H	T U H	Ch to H
Isotelus canalis Conrad	707	x	x					x	x		x	x	T to R	T H	T U H	T U H
														S	Ch to T	Cal Ch T

TRILOBITA, ECHINODERMATA, ETC.	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.				
Isotelus susæ Whitfield	708											x				
Ptychopyga ulrich, n. sp	709	x	x													
Nileus vigilans M. & W	712	x	x		x				x							
Ilænus 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.

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

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.	Stictoporella bed.	Rhinidictya bed.	Ctenodonta bed.	Phylloporina bed.	Clitambonit's bed.	Fusispira bed.	Maclurea 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	12	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

		Restricted species.	Occurring elsewhere.	Found elsewhere in				
				Stones River.	Black River.	Trenton.	Utica.	Richmond.
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.

ACKNOWLEDGMENTS.

The authors of the chapters in Part II desire to thank the following persons for assistance: Dr. C. E. Beecher, for the use of specimens belonging to the Peabody Museum, Yale University; Dr. C. H. Robbins, of Wykoff, and Mr. R. H. Hasse, of Granger, Minn.; Prof. Alpheus Hyatt, Boston, Mass.; Mr. J. F. Whiteaves, Ottawa, Canada, for the opportunity to examine type specimens belonging to the Geological Survey of Canada; Prof. J. M. Safford, Nashville, Tenn., for the use of many specimens from Tennessee, and Prof. R. P. Whitfield, of the American Museum of Natural History, New York, for similar favors.

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 *Tetradelia* insert *Ceratopsis* Ulrich.

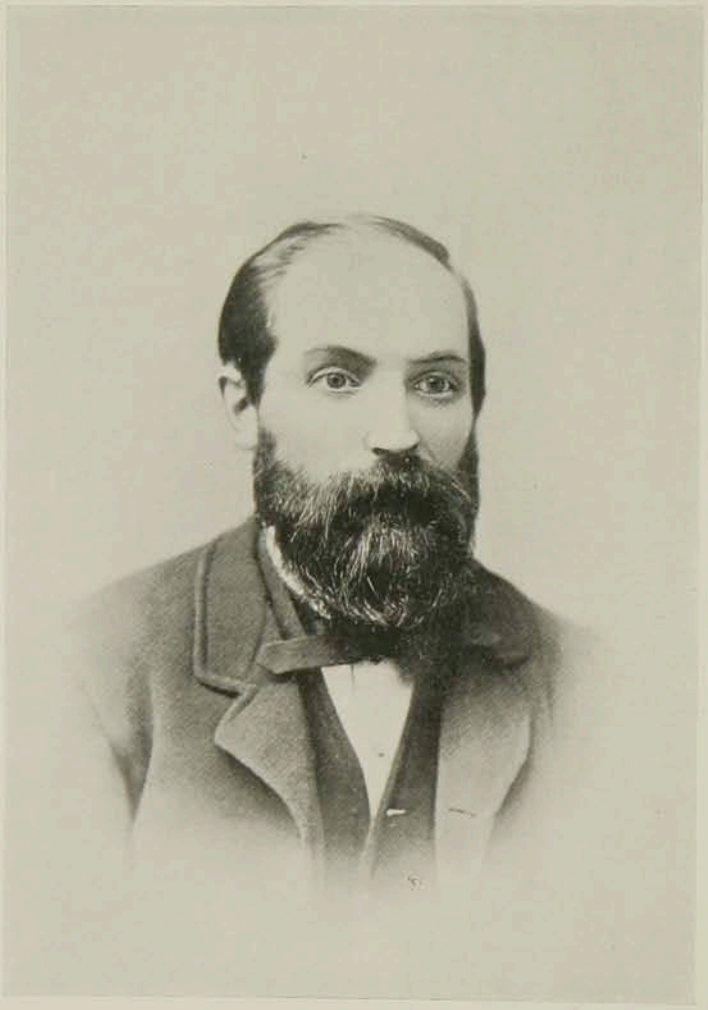
P. 657. Ninth line from bottom, for "*Ceratella*" read *Ceratopsis.*

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

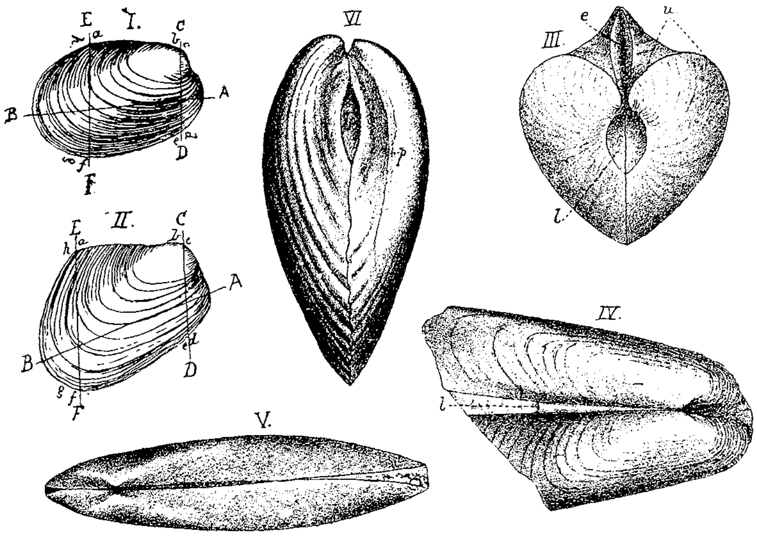


Fig. 35. I and II, right valves of ISCHYRODONTA (?) OVALIS *Ulrich and* MATHERIA RUGOSA *Ulrich*, lettered and divided by lines to illustrate the section on outline and dimensions. A–B, length; C–D, anterior hight; E–F, posterior hight; *a b*, dorsal or cardinal margin; *c d*, anterior end and margin; *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 *Chænodomus 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.

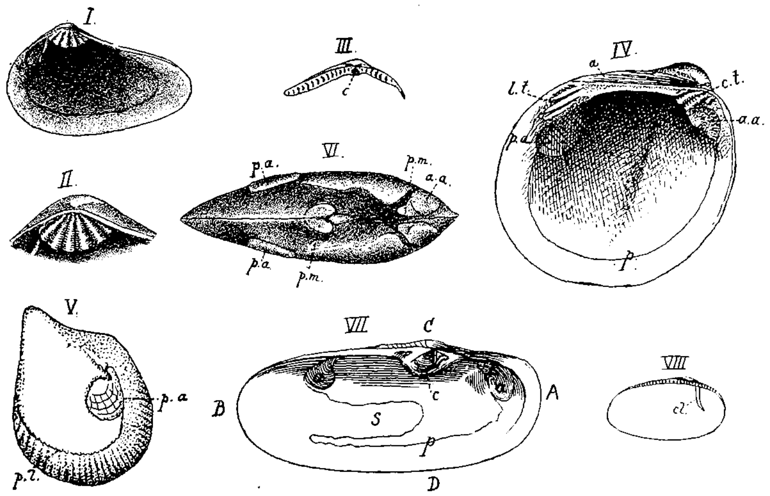


Fig. 36. Illustrating Hinge Types, Muscles and Pallial Impressions.

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.

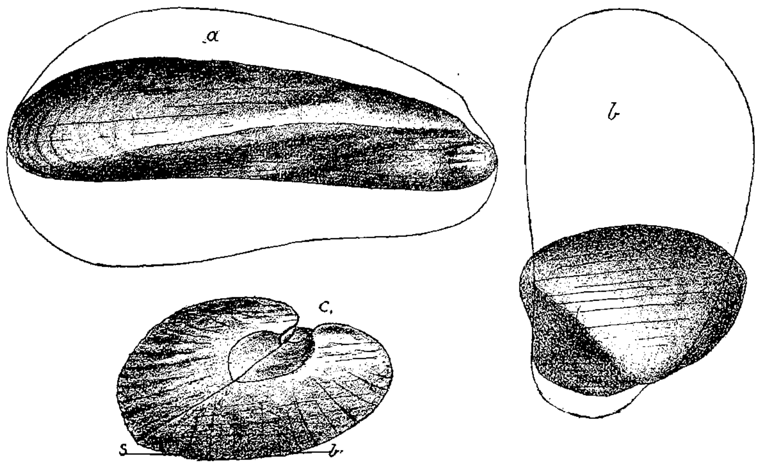


Fig. 37. Illustrating distortion of shells through pressure. *a*, right side of a specimen of *Modiolopsis modiolaris* Conrad, the hight of which has been reduced, as shown in outline, to less than half what it was originally. *b*, a shell of the same species greatly compressed lengthwise. *c*, the shell 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.

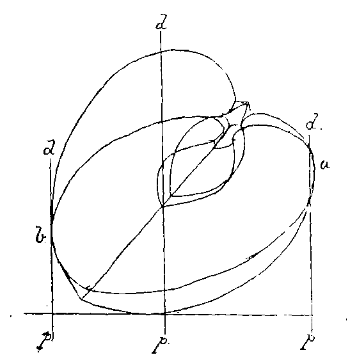


Fig. 38. Illustrating how to obtain a restoration of an obliquely compressed shell. The inner ontline represents the specimen as it is now (see fig. 36-c), the outer one a restoration of its original form. S-B. plane of sea bottom; *d.-p.*, direction of compressing force.

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; ? *Orthonota*, 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

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*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.*

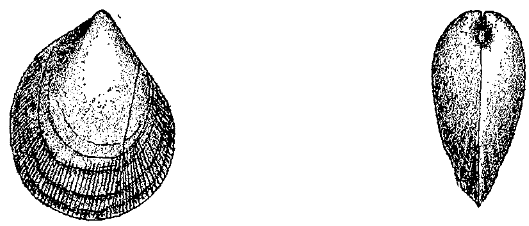

Fig. 39. *Byssonychia tenuistriata*, n. sp. Hudson River group, Granger, Minnesota. The right side and a front view of an imperfect cast of the the interior. *Mus. Reg.* No. 8371.

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 distinugished 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 *Modiolòpsis*, 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.

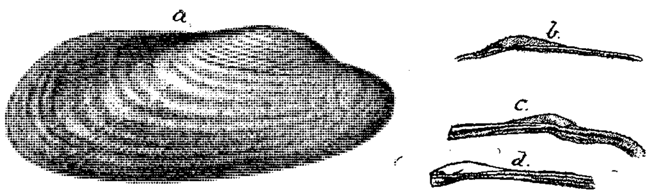

Fig. 39. *a*, a large right valve of *Actinomya cincinnatiensis*, mostly devoid of shell, showing the muscular scars and delicate internal radii on the cast; *b*, the hinge of another right valve of the same species; *c* and *d*, hinges of a left and a right valve of *Actinomya pholadiformis* Hall, sp. 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.*

*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.

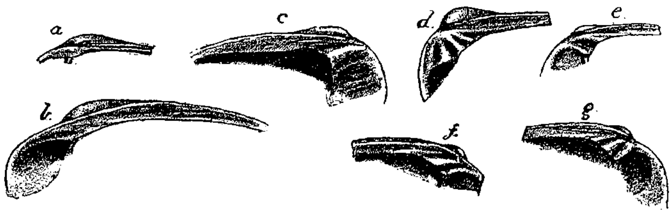

Fig. 40. Hinges of *Modiolopsis*, *Modiomorpha* and *Modiolodon*. *a*, anterior half of hinge of a right valve of *Modiolopsis versaillensis* Miller, from the upper part of the Cincinnati group at Versailles, Indiana. *b*, hinge of a right valve of *Modiolopsis valida*, a new species from the top of 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.

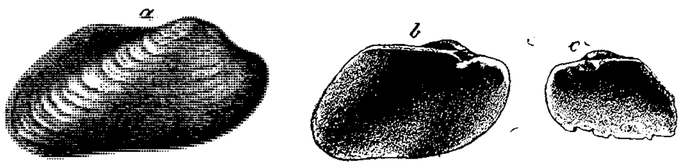

Fig. 41. *Colpomya constricta* Ulrich, top of Trenton group, Frankfort, Kentucky. *a*, right valve, showing the usual characters of the species; *b*, interior of a left valve; *c*, interior of an imperfect right valve.

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 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.

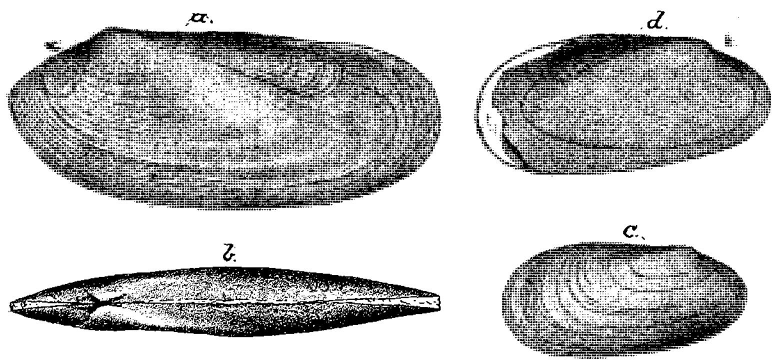

Fig. 42. *a.* and *b*, the left side and a dorsal view of an excellent cast of the interior of *Psiloconcha grandis*, n. sp , from the upper beds of the Cincinnati group, at Waynesville, Ohio. *c.* a right valve retaining the shell, and *d.* the right side of an internal cast of *Psiloconcha elliptica*,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

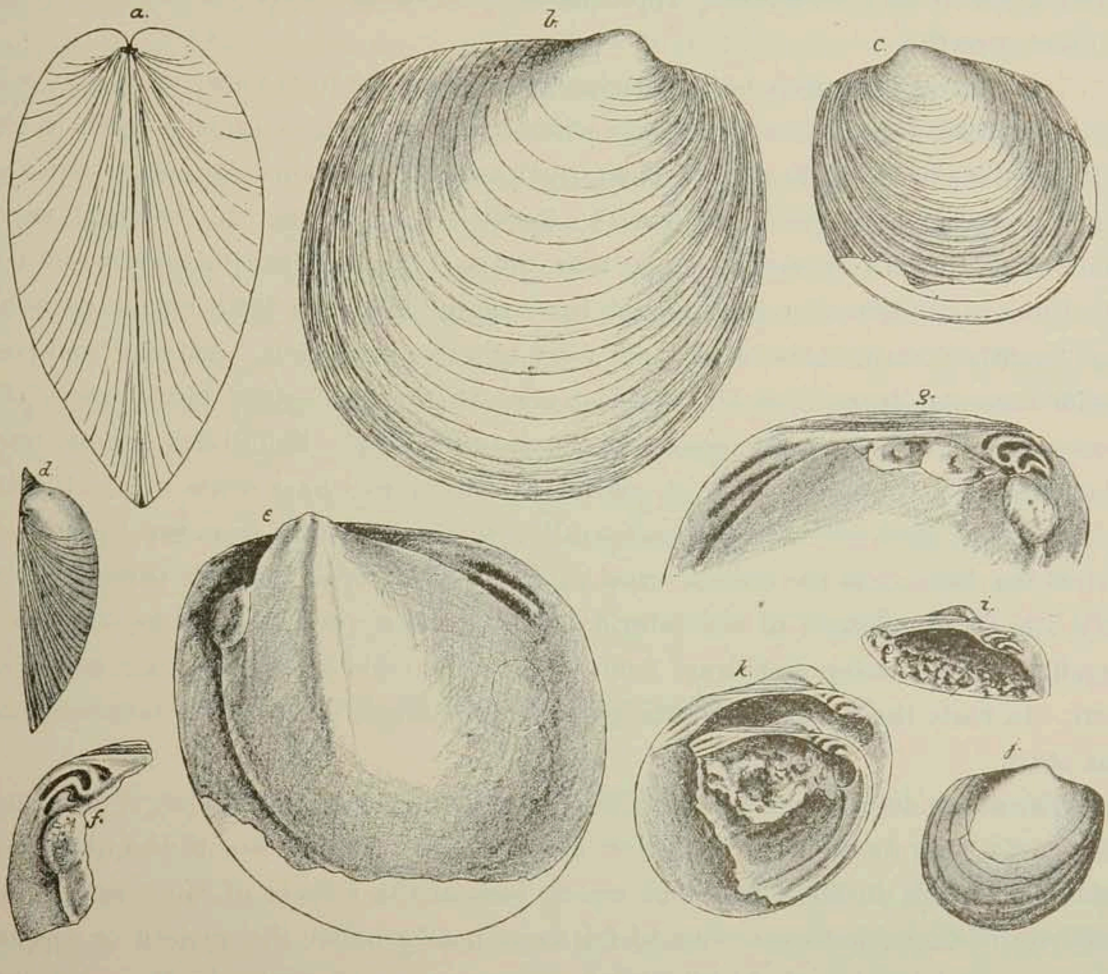

Fig. 43. *Cyrtodonta grandis*, and varieties. *a* and *b*, anterior and lateral views of a perfect specimen, upper Trenton, two miles south of Burgin, Kentucky. *c* and *d*, lateral and antero-cardinal views of a small left valve of same, with stronger surface markings than usual; from same formation 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 spocies 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 llmestone 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 con centric 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 difiers 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 umboual 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* (Modiolopsis 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 conspicuous 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 *Axinœa* and other *Arcidœ*. 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 *Axinœa* (*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 *Axinœa*. Other *Arcidœ* 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 scareely 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 uumber 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.*

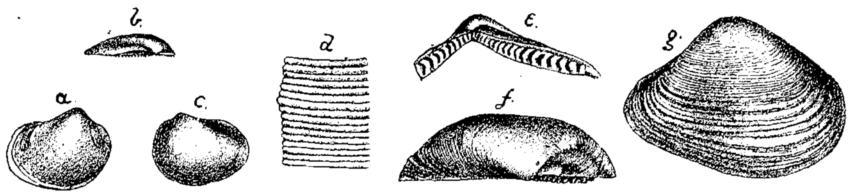

Fig. 44. *a*, right side of a cast of the interior of *Ctenodonta filistriata*, n. sp.; *b* and *c*, cardina and lateral views of left valve of same; *d*, small portion of surface of same, highly magnified; *e*, hinge of a right valve of same, × 2; specimens from lower beds of the Cincinnati group at 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.

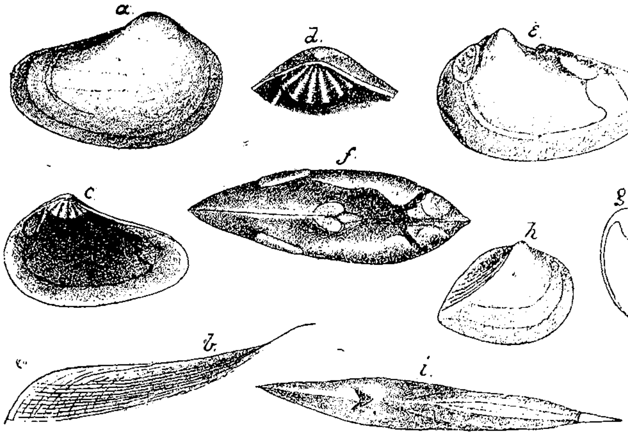

Fig. 45. *a*, right valve of *Lyrodesma major* Ulrich; *b*, cardinal slope of same, × 2, showing the fine radiating striæ; *c*, interior of a right valve; *d*, hinge of same, × 2; *e*, left side of a cast of the interior of same, showing the muscular scars and pallial line with unusual distinctness; *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 *Chœnodomus* 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*.

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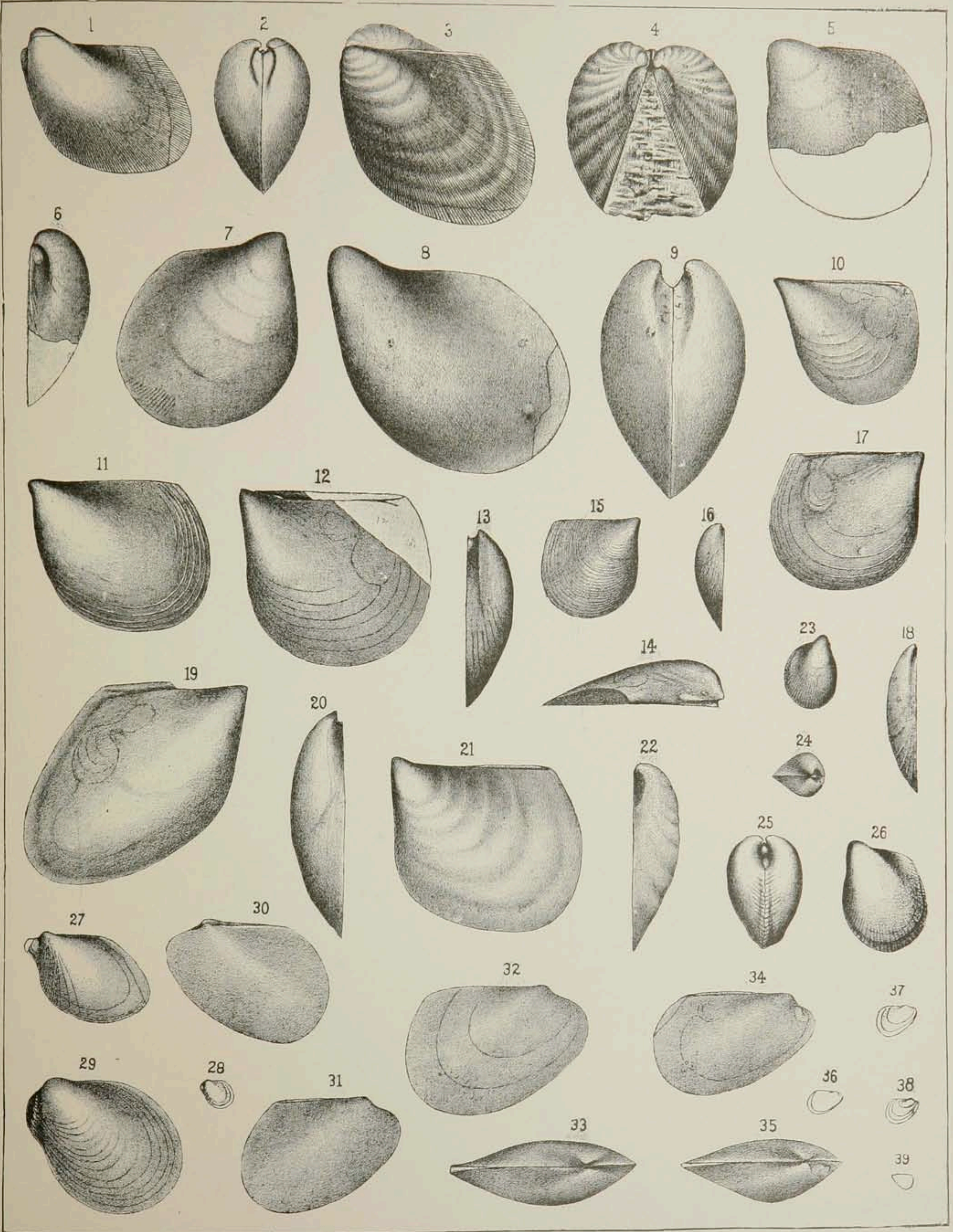
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PLATE XXXVI.

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Figs. 40 and 41. CUNEAMYA OBLONGA, n. sp.......... 623

Lateral and dorsal views of the specimen described. The imperfect posterior end is restored in the figure. Upper Galena, Dixon, Illinois.

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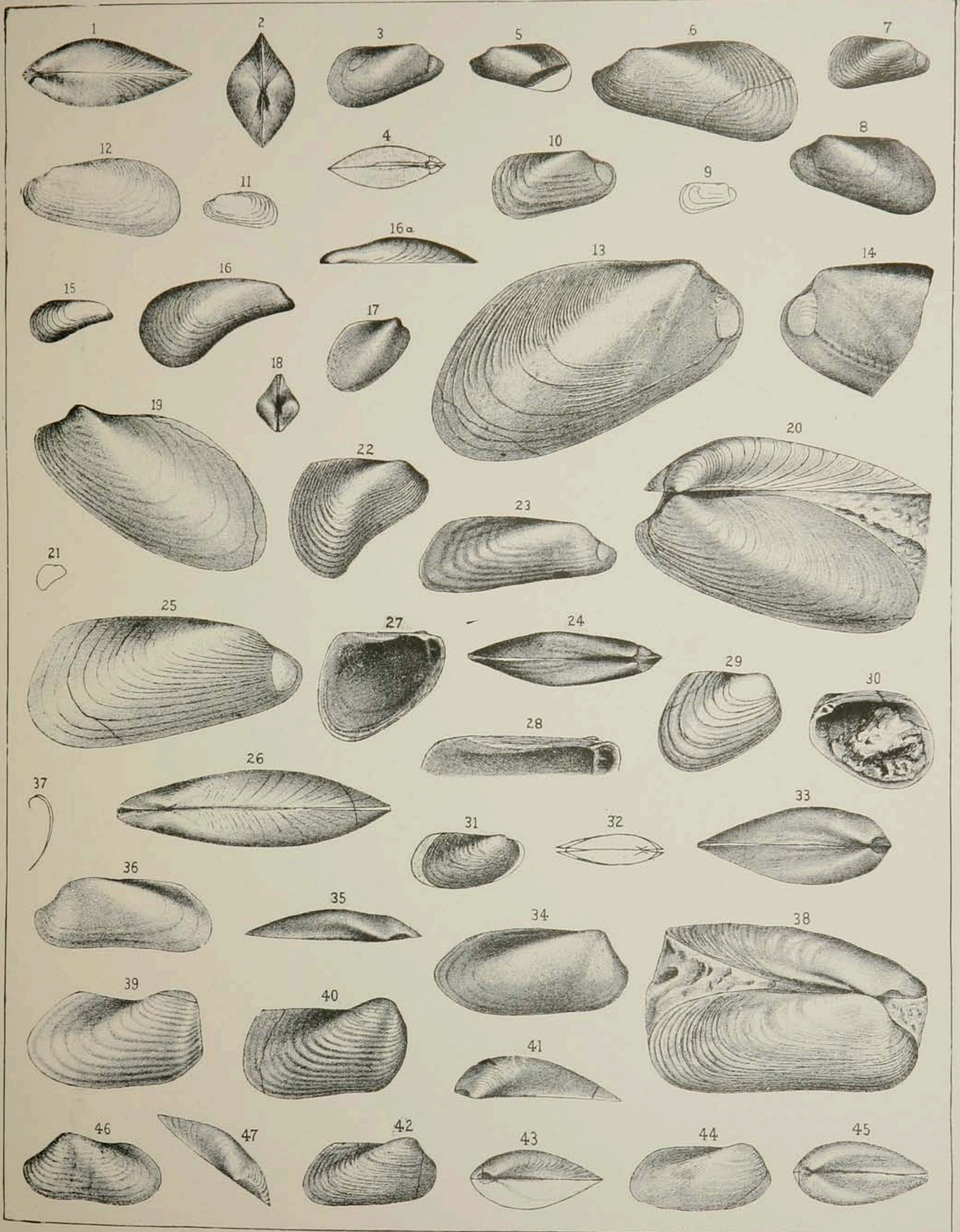

PLATE XXXVII.

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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.

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Lateral, anterior and cardinal views of the best cast seen. Trenton limestone, Minneapolis, Minnesota.

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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.

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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.

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Figs. 32 and 33. CLIDOPHORUS ?CONSUETUS Ulrich 606
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Fig. 34. TECHNOPHORUS EXTENUATUS Ulrich 614
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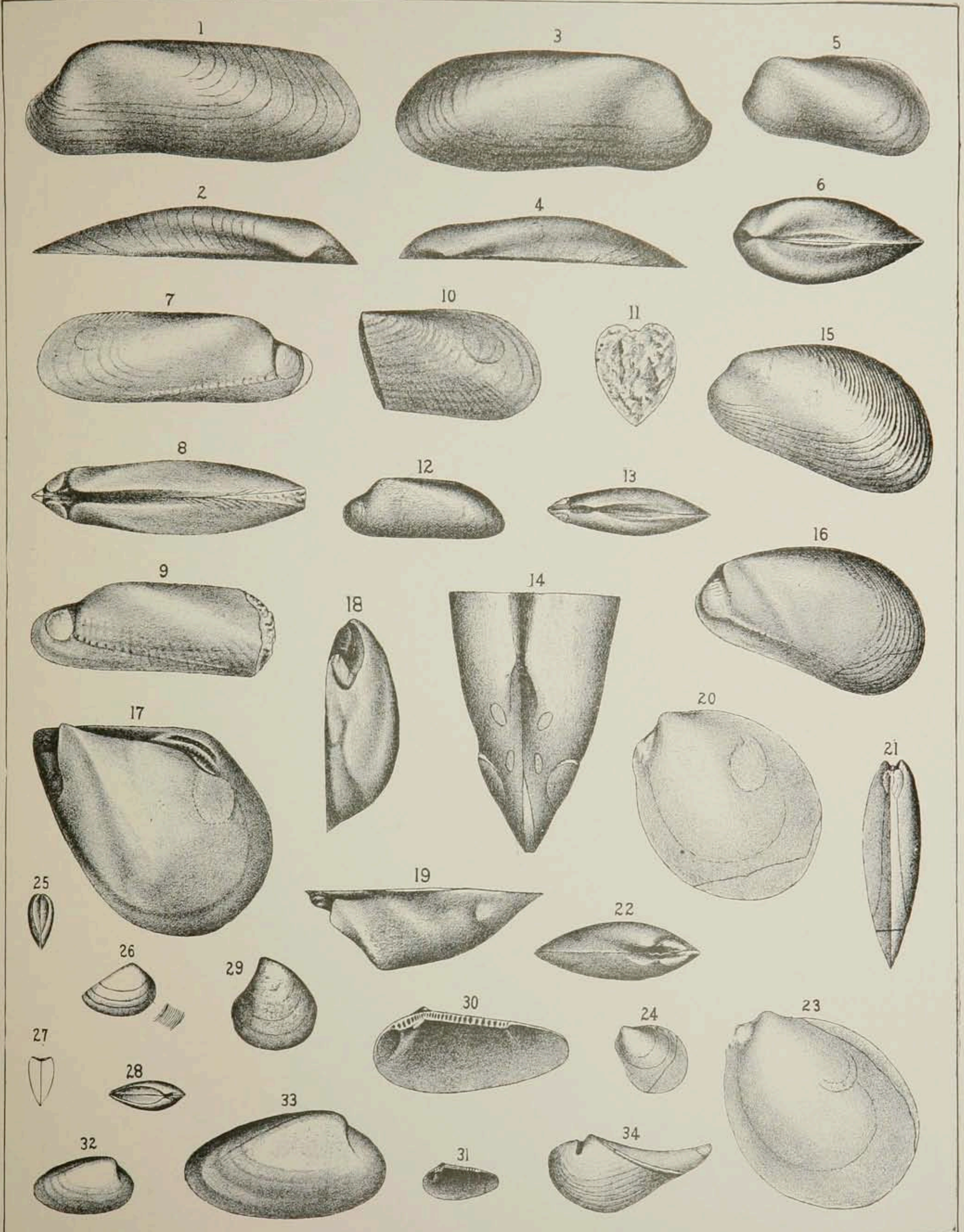
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PLATE XXXVIII.

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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.

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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.

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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.

24 to 26. Lateral, anterior and cardinal views of a specimen in which the right side is preserved as an internal cast, while the other retains some of the shell. Trenton limestone, Cannon Falls, Minnesota.

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Figs. 28 to 31. VANUXEMIA UMBONATA, n. sp 556

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

(See also plate XL, and page 479, fig. 36, IV.)

A cast of the interior of a small right valve. Galena shales, Kenyon, Minnesota.

Figs. 33 and 34. VANUXEMIA TERMINALIS Ulrich 556

33. Anterior views of the two valves shown in fig. 34.

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.

37. External view of a left valve, imperfect in the postero-dorsal region.

38. Outline cardinal view of the original of fig. 36. Upper part of middle third of the Trenton shales near Cannon Falls, Minnesota.

Figs. 39 to 44. VANUXEMIA ABRUPTA, n. sp 560

39 to 41. Anterior, lateral and dorsal views of a nearly perfect cast of a right valve. This specimen is of the average size and proportions.

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.

43 and 44. Side and dorsal views of a smaller cast of a right valve in which the anterior end is very obtuse. Middle Galena, Fillmore county, Minnesota.

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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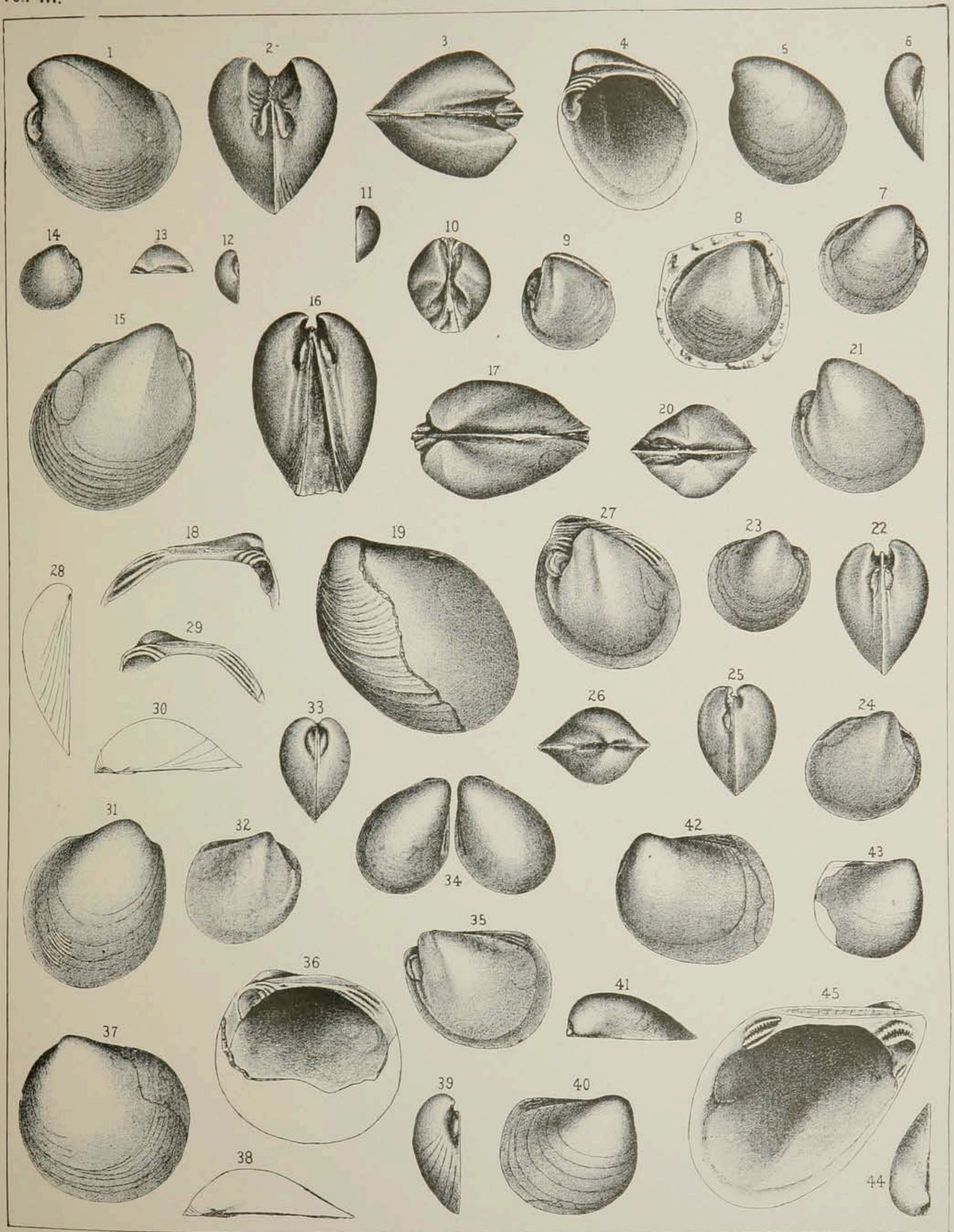

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1 to 3. Lateral, dorsal and anterior views of the largest cast of the interior seen.

4 and 5. Side and dorsal views of a smaller cast of a right valve. Geol. Sur. Mus., Reg. No. 8626.

Figs. 6 and 7. VANUXEMIA WORTHENI Ulrich.......... 561

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16 and 17. Side and profile views of a large internal cast, from the middle third of the Trenton shales near Fountain, Minnesota. Geol. Sur. Mus. Reg. No. 8336.

18 and 19. Two views of the testiferous type of the species. Black River limestone, Mercer county, Kentucky.

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23. A cast of the interior of the var. *fillmorensis*. Middle Galena, Fillmore county, Minnesota.

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Figs. 26 and 27. CYRTODONTA JANESVILLENSIS, n. sp.......... 537

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30. Right side of a cast of the interior from the middle third of the Trenton shales, St. Paul, Minnesota.

33. The hinge of a right valve from High Bridge, Kentucky.

45. A cast of the interior of a right valve which is doubtfully referred to this species. The hight of the specimen has evidently been reduced by pressure. Trenton limestone, Cannon Falls, Minnesota.

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An imperfect cast of the interior of a large left valve. Trenton limestone, Cannon Falls, Minnesota.

Figs. 35 and 36. CYRTODONTA OBLIQUA Meek and Worthen.......... 540

The left side and a front view of the original type of this species. Illinois State Museum. Galena limestone, Scales Mound, Illinois.

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(See also plate XL, fig. 1.)

Mold of the interior of a left valve, with a portion of the shell remaining. "Lower Blue" beds of the Trenton formation, Janesville, Wisconsin.

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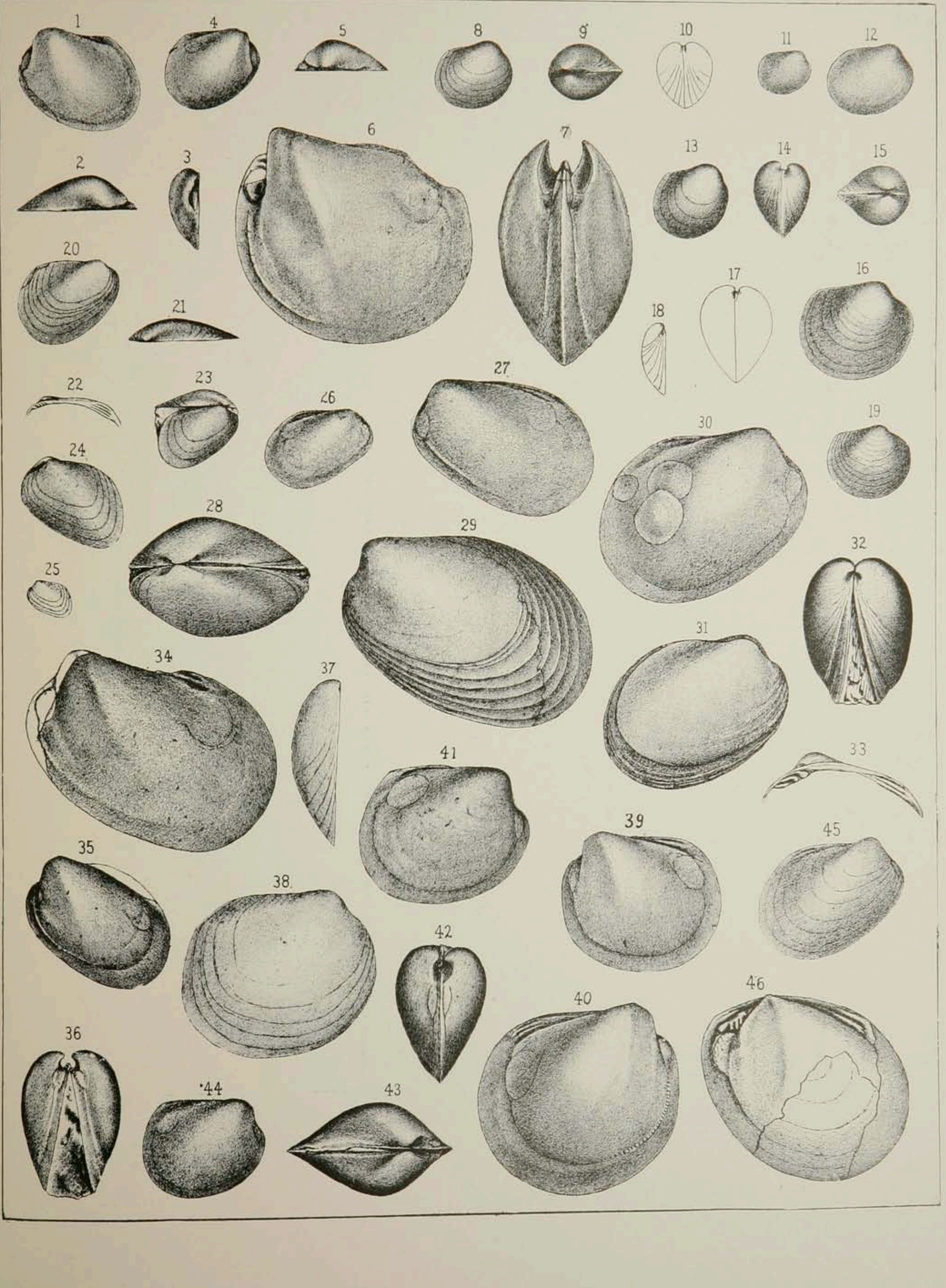

PLATE XL.

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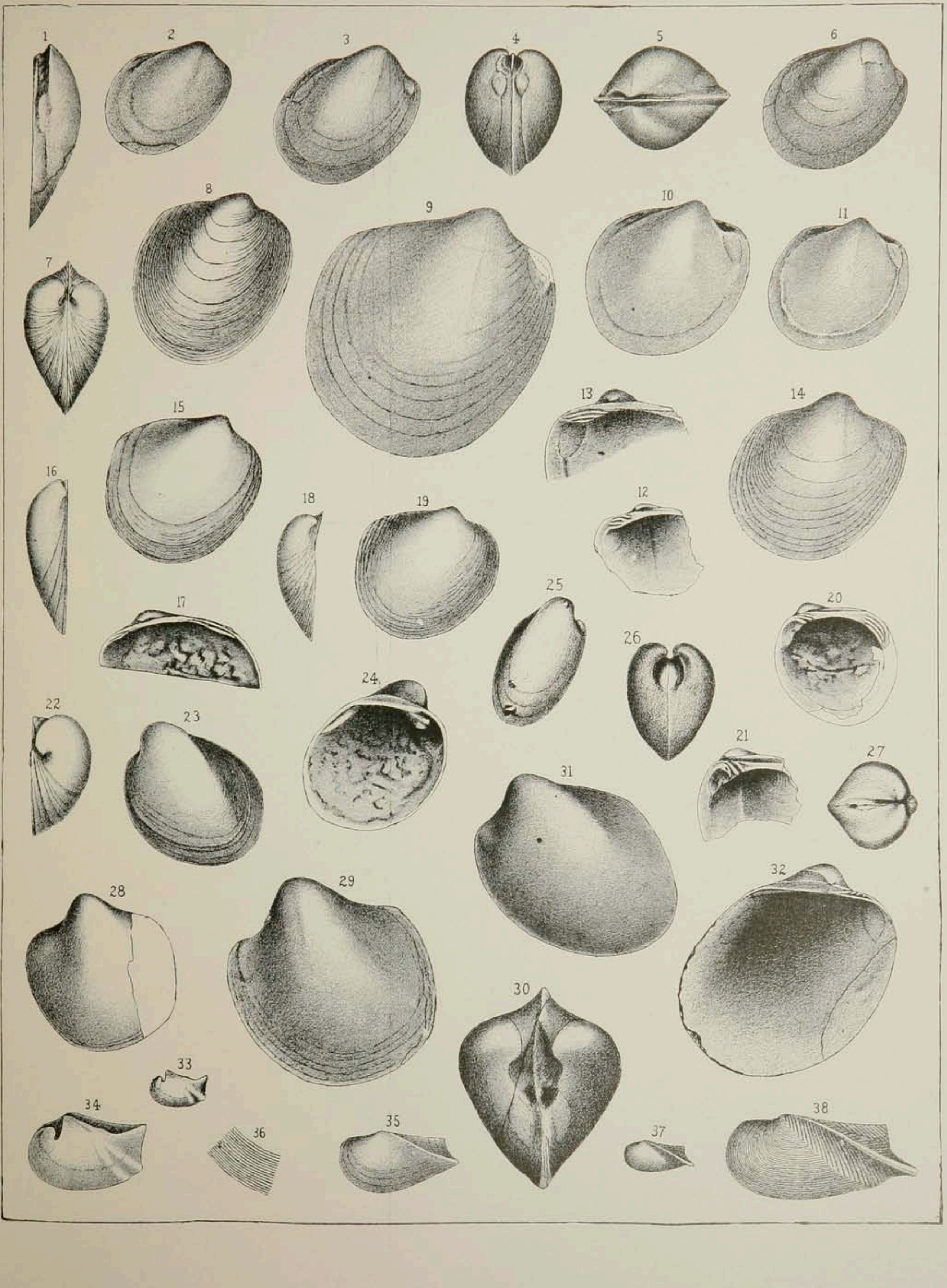

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	18.	Hinge of same. The cardinal teeth are abnormally developed.	
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	41.	Hinge of the left valve. Upper beds of the Hudson River group, near Spring Valley, Minnesota.	

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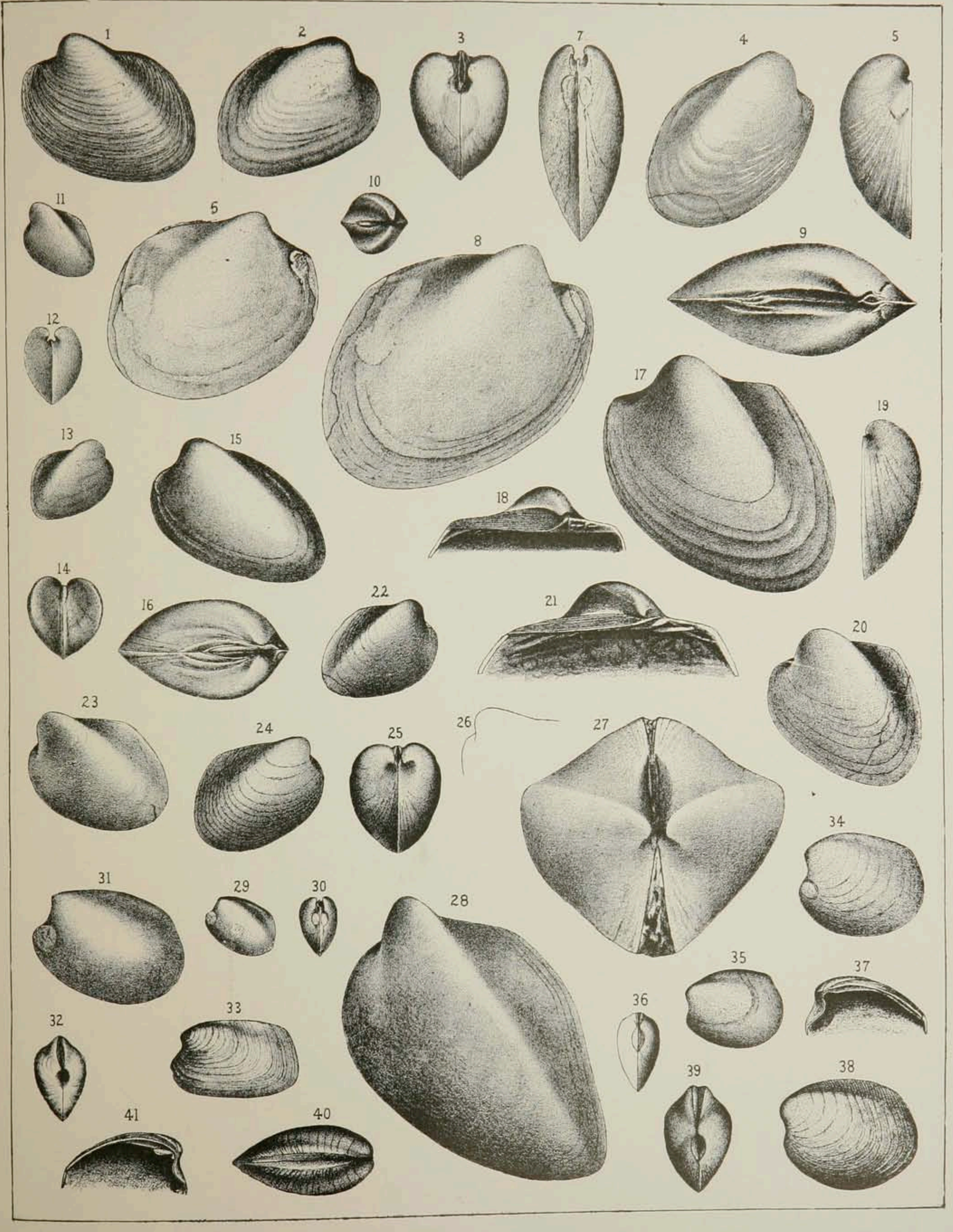

PLATE XLII.

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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*
5. The hinge of a right valve of the typical form, × 3, showing the retral sweep of the teeth.

Figs. 6 to 8. LYRODESMA CANNONENSE, n. sp 910
6. Somewhat weathered cast of the Interior.
7 and 8. Lateral and cardinal views of a cast preserving the muscular scars.

Figs. 9 to 14. ALLODESMA SUBELLIPTICUM Ulrich 617
9 and 10. Cardinal and lateral views of the cast of the interior upon which the species was founded.
11 and 12. Lateral and cardinal views of a better preserved cast, × 2. showing the muscular scars, pallial line and impressions of the hinge teeth.
13 and 14. Restoration of the hinge.

Figs. 15 and 16. MODIOLOPSIS OWENI, n. sp 506
Lateral and cardinal views of a partial cast of the interior.

Figs. 17 and 18. MODIOLOPSIS CONSIMILIS, n. sp 505
Lateral and cardinal views of an entire silicified example of this species.

Fig. 19. MODIOLOPSIS SIMILIS Ulrich 504
(See also plate XXXVI, figs. 1 and 2.)
View of the right side of the type of this species. The specimen is preserved chiefly as a cast of the interior and shows an impression of the shallow anterior muscular scar.

Figs. 20 to 25. OLIDOPHORUS NEGLECTUS Hall 607
20 to 23. Four views of a rather large specimen from the left side of which the shell has been removed, so as to show the muscular scars and the strong vertical furrow left by the clavicle. The posterior extremity in this specimen is narrower than usual.
24. An oblique cardinal view of a cast of the interior, × 6, showing an impression of the denticulated hinge.
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
26 and 27. Cast of the interior of a right valve. Minn. Geol. Sur. Mus. Reg. No. 8316.
28. Gutta-percha impression of same, showing the hinge.

Fig. 29. CTENODONTA OVIFORMIS, n. sp 586
Left side of a cast of the interior, showing the strong muscular scars and other characters of the species.

Fig. 30. CTENODONTA NASUTA Hall 584
A small testiferous left valve of this species from the middle third of the Trenton shales, near Cannon Falls, Minnesota.

Figs. 31 to 33. CTENODONTA CUNEIFORMIS, n. sp 587
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33. Hinge of a right valve, × 2.

Figs. 34 to 36. CTENODONTA SUBNASUTA, n. sp 585
Three views of a cast of the interior.

Fig. 37. CTENDONTA GIBBERULA Salter 587
(See also text p. 599, fig. 44, f and g)
An excellent mold of the interior of a left valve.

Figs. 38 to 40. CTENODONTA PLANODORSATA Ulrich 589
(See also plate XXXVII, figs. 25–28)
38. View of the inner side of a left valve, × 3.
39. Hinge of same, more highly magnified.
40. Artificial cast of the interior of a right valve.

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41 and 42. A right and left valve, both imperfect and varying sligtly in outline.
43. Dorsal view of the left valve,

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44. The right side of a small testiferous specimen.
45 to 47. Lateral, cardinal and posterior views of same, × 2.
48. The right side of a well preserved cast of the interior of a large example.
49. Cardinal view of same, × 2, showing scars of the adductor and pedal muscles.

Figs. 50 to 52. CTENODONTA MEDIALIS, n. sp 593
50. Silicified right valve of the species from the middle third of the Trenton shales.
51. Hinge of same, × 2.
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.
57. Hinge of a right valve, × 2.
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
59. Outline views of three specimens of different sizes and showing slight variations in form.
60. Hinge of two right valves, × 3, showing slight differences in the anterior parts.

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.
62. Another cast of a left valve. Minn. Geol. Sur. Mus. Reg. No. 8628.
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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67 and 68. The right side and an anterior view of a cast of the interior. In many specimens the posterior margin is more rounded
69. A small part of the external surface magnified to show the fine concentric and radiating lines.
70 to 72. Cardinal and anterior views and the right side of a specimen preserving the shell.
73. The wavy hinge line as shown on a cast of the interior, × 5.

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79. A smaller specimen of the usual form.
80. Hinge of a large and smaller right valve, showing the subrostral pit and the geniculated teeth.
81 and 82. Cardinal and lateral views of a cast of the interior which retains a part of the hinge.

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90. The greater part of the hinge of another left valve, × 5, showing the various parts in a beautiful state of preservation.

Figs 91 and 92. CTENODONTA HAMBURGENSIS Walcott 605
A right(?) valve of the natural size and × 5.

Figs. 93 and 94. CTENODONTA ALTA Hall 602
Lateral and posterior views of a cast of the interior.

Figs. 95 to 97. CTENODONTA INTERMEDIA Ulrich 601
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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.
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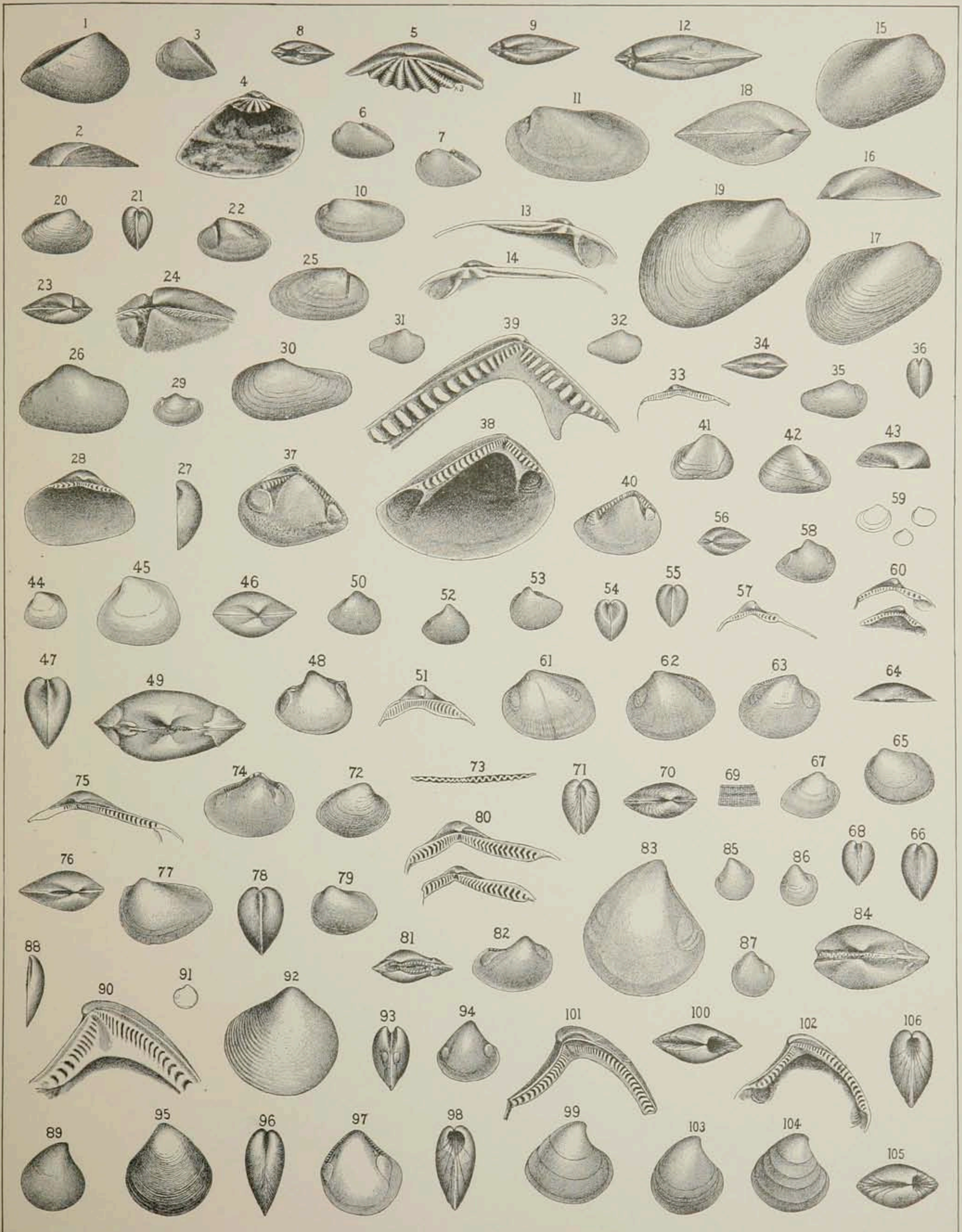
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PLATE XLIII.

Unless otherwise stated all the figures are magnified about twenty diameters.

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Two views of a right valve. Upper third of the Trenton shales, St. Paul, Minn.

Figs. 75 to 77. PRIMITIELLA UNICORNIS Ulrich 649

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Dorsal, lateral and ventral views of a right valve. Lower third of the Trenton shales, Minneapolis, Minn.

Figs. 82 and 83. BEYRICHIA INITIALIS, n. sp. 658

Lateral and ventral views of a left valve. Middle third of the Trenton shales, Minneapolis.

Figs. 84 to 88. MOOREA PUNCTATA, n. sp. 682

84. A right valve.

85 to 87. Three views of a left valve.

88. Another left valve in which the marginal ridge is twice interrupted along the ventral border. Upper third of the Trenton shales, St. Paul, Minnesota.

Fig. 89. MOOREA ANGULARIS, n. sp. 682

(See also plate XLVI, figs. 15 and 16.)

Side and ventral views of a right valve. Middle third of the Trenton shales, Minneapolis, Minn.

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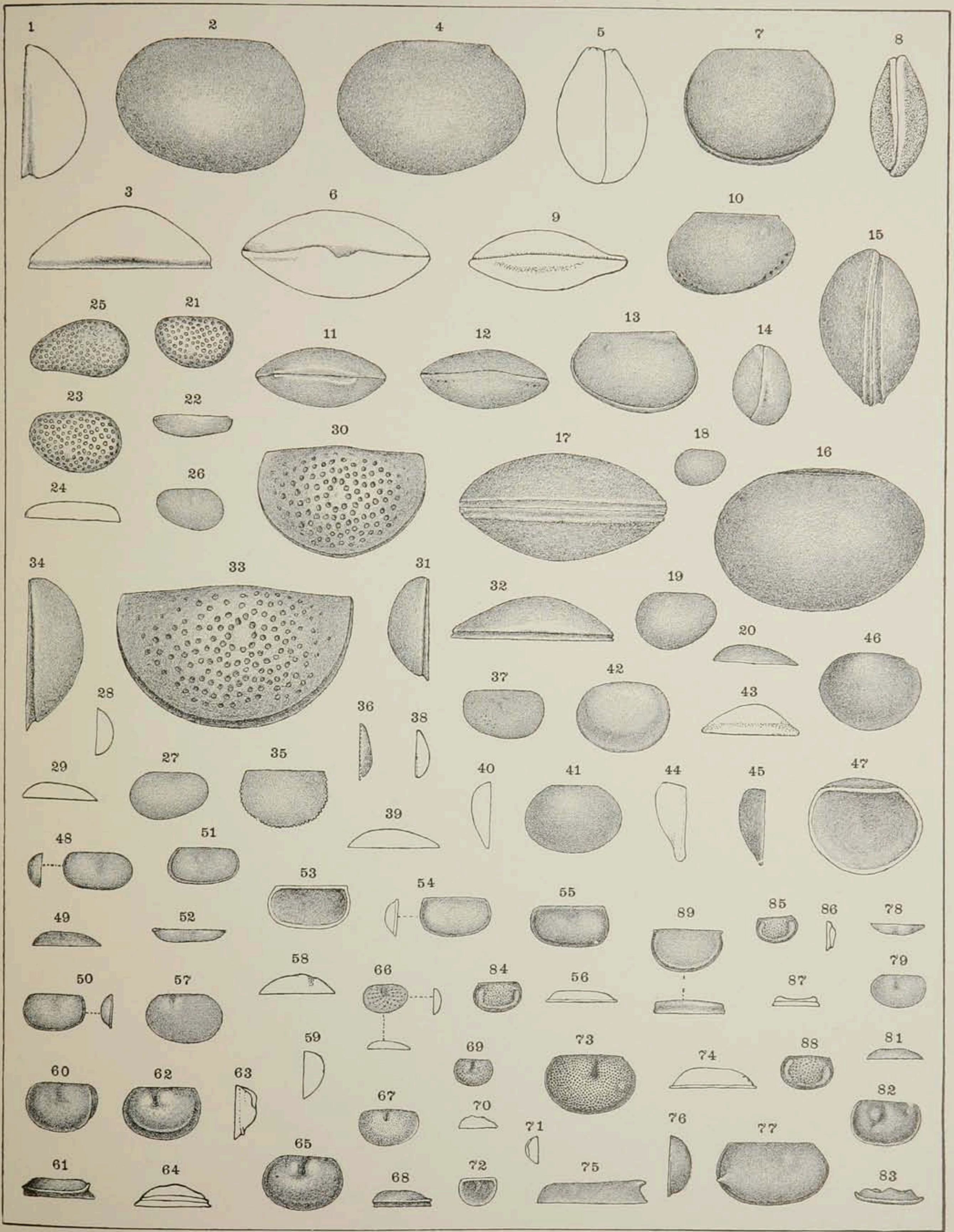
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PLATE XLIV.

All the figures on this plate are magnified about twenty diameters.

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	33.	Ventral view of a complete carapace; also from Cincinnati, Ohio.	
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53.	View of the interior of a left valve. Also a vertical section through center of same. High Bridge, Kentucky.	

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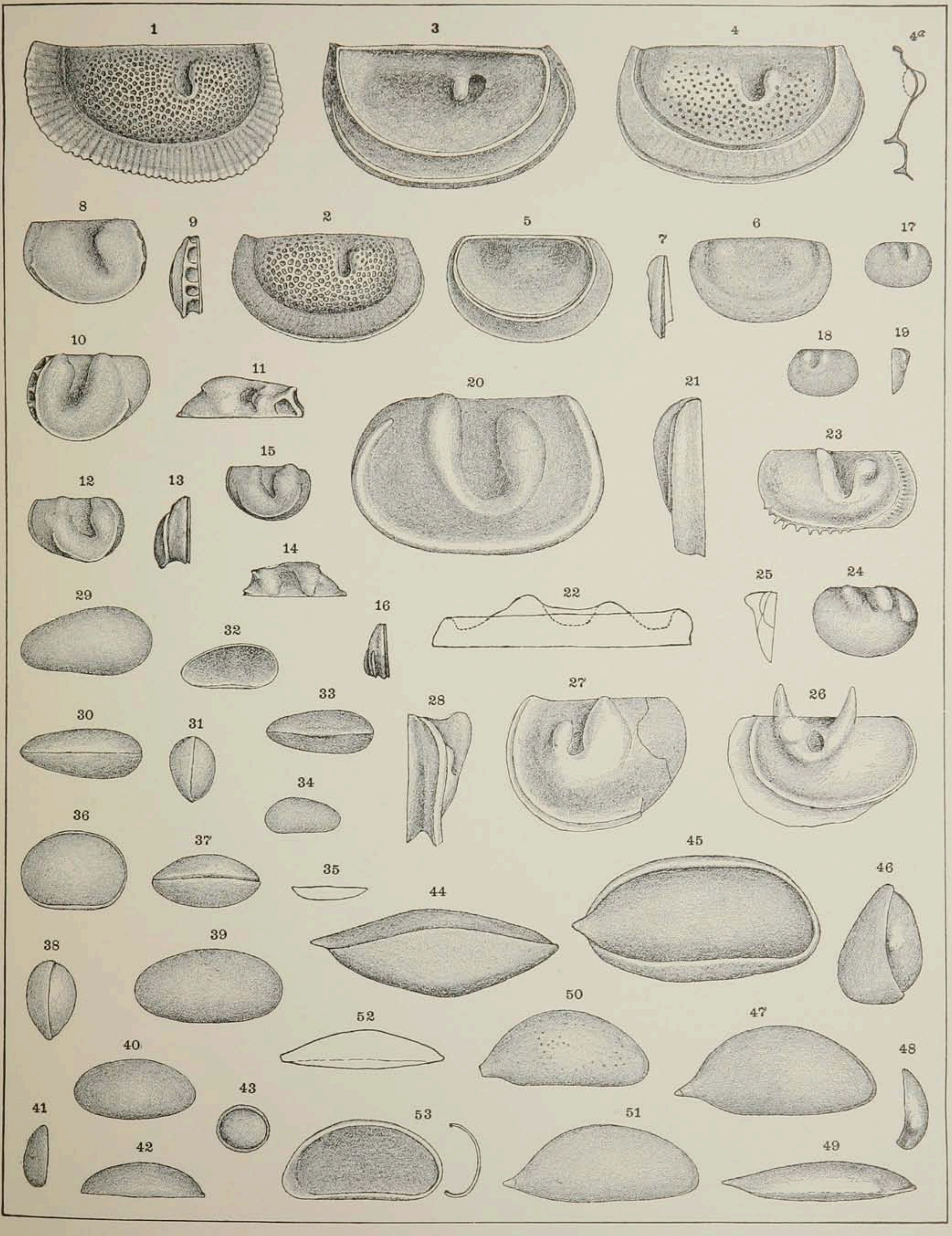
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PLATE XLV.

Unless otherwise is stated, all the figures on this plate are magnified about twenty diameters.

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Figs. 1 to 3. EURYCHILINA VENTROSA, n sp. or var. 662

1. Left valve, imperfect at the extremities, yet preserving the essential characters of the species. Galena shales, Cannon Falls, Minnesota.

2 and 3. Lateral and posterior views of a perfect right valve, from the same locality.

Figs. 4 to 6. EURYCHILINA (?) SYMMETRICA, n. sp. 663

(See also plate XLIV, figs. 5—7.)

4 and 5. Side and end views of a valve. × 28, differing somewhat from the specimens figured on plate XLIV. Upper third of the Trenton shales, St. Paul, Minn.

6. Longitudinal section of same.

Figs. 7 to 9. EURYCHILINA (?) SUBÆQUATA, n. sp. 663

Side view of a left valve, with vertical and longitudinal sections of same. Upper third of the Trenton shales, St. Paul, Minnesota.

Figs. 10 to 12. APARCHITES FIMBRIATUS Ulrich 645

Side, ventral and posterior views of a right valve. Hudson River group, Spring Valley, Minnesota.

Figs. 13 to 15. LEPERDITELLA TUMIDA Ulrich 637

Side, dorsal, and posterior views of a typical right valve of this species, × 15, from the Birdseye limestone at High Bridge, Kentucky. Introduced for comparison with *L. canalis* and *L. persimilis*, figured on plate XLIII.

Figs. 16 to 18. APARCHITES MILLEPUNCTATUS Ulrich 645

Ventral, anterior, and side views of a right valve. Surface punctation omitted except on the antero-dorsal fourth of fig. 18. Trenton shales, Fountain, Minn.

Figs. 19 and 20. LEPERDITELLA DORSICORNIS Ulrich 639

19. A left valve, × 15. Hudson River group, Savannah, Illinois.

20 and 20*a*. Outlines of same in dorsal and anterior views.

Figs. 21 to 23. APARCHITES GRANILABIATA Ulrich 644

Posterior, side, and ventral views of a left valve. The minute surface granules are omitted except on a small space of fig. 22. Upper third of the Trenton shales, St. Paul, Minnesota.

Figs. 24 to 26. LEPERDITELLA GERMANA Ulrich 638

Outlines of a left valve in anterior, side, and ventral views, × 15. Lower Trenton limestone, Mineral Point, Wisconsin.

Figs. 28 to 30. PRIMITIELLA FILLMORENSIS, n. sp. 649

Three views of a right valve of this small species. Trenton shales, Fountain, Minnesota.

Fig. 31. PRIMITIA MINUTISSIMA, n. sp. 651

A left valve. Trenton shales, Fountain, Minnesota.

Figs. 27, 32—33. SCHMIDTELLA INCOMPTA, n. sp. 642

(See also plate XLIII, figs. 39—41.)

27. Interior of a left valve. Trenton shales, Fountain, Minnesota.

32 and 33. Side and anterior views of a right valve; from the same locality.

Figs. 34 and 35. SCHMIDTELLA BREVIS, n. sp. 642

Side and anterior views of a left valve. Trenton shales, Fountain, Minnesota.

Figs. 36 to 38. SCHMIDTELLA UMBONATA, n. sp. 641

36 and 37. Anterior and side views of a left valve (opposite valve restored). Upper third of Trenton shales, St. Paul, Minnesota.

38. View of the interior of a right valve, from the same locality.

Figs. 39 to 42. SCHMIDTELLA SUBROTUNDA, n. sp. 643

Side and end views of a right and left valve. In both cases the opposite valve has been restored. Lower third of the Trenton shales, Minneapolis, Minn.

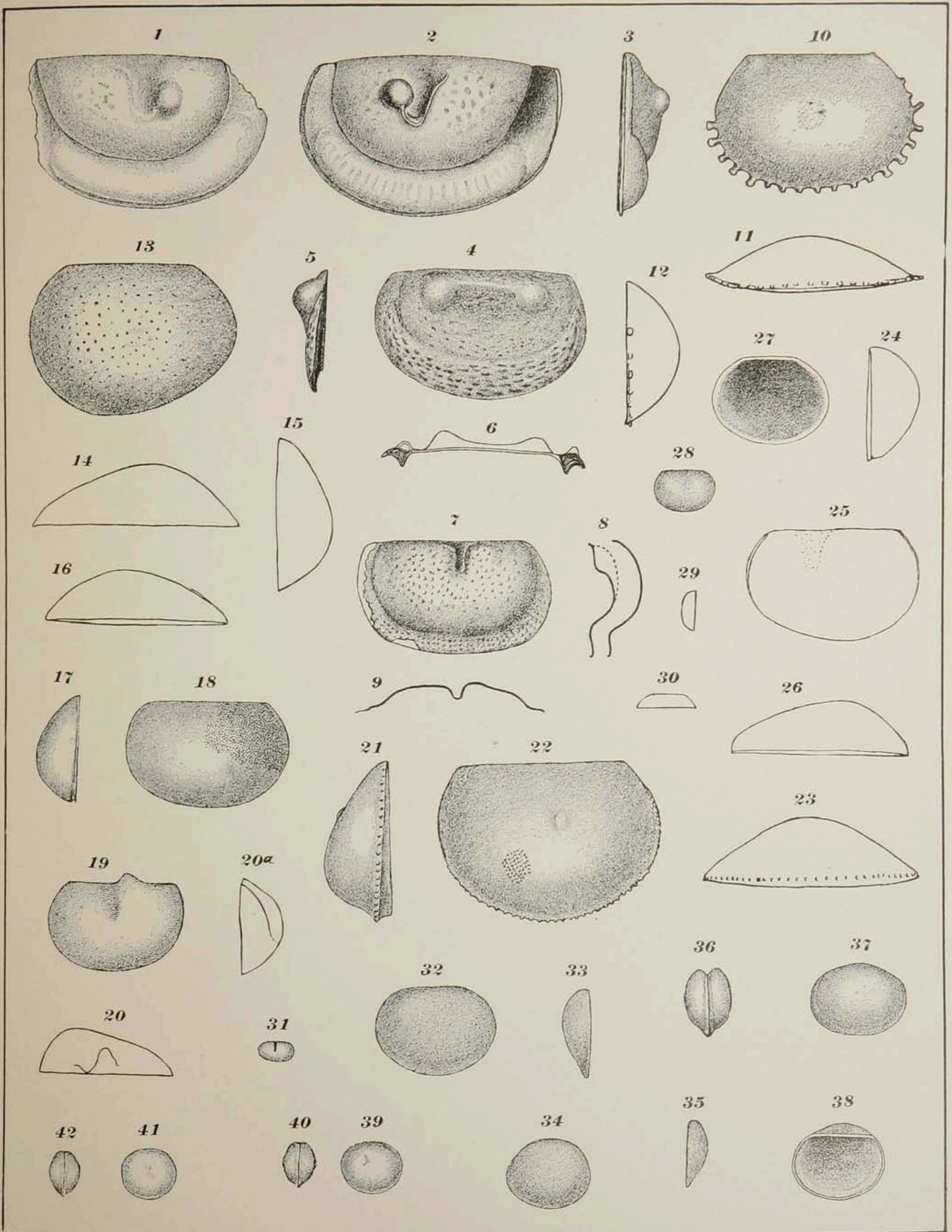
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PLATE XLVI.

All the figures on this plate are magnified about twenty diameters.

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Figs. 1 to 11. TETRADELLA QUADRILIRATA Hall and Whitfield, sp. 679

1 to 3. Posterior, side, and dorsal views of a right valve. Middle third of the Trenton shales, Minneapolis, Minn.

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.

9 to 11. Three views of a variety, agreeing with var. *simplex* in wanting the posterior marginal loculi. Trenton shales, Fountain, Minnesota.

Figs. 12 to 14. TETRADELLA LUNATIFERA Ulrich 680

Three views of a left valve of a variety of this species. In other specimens that were found with this one the antero-median ridge is more distinctly double. (See cut, p. 680.) Galena shales, Cannon Falls, Minnesota.

Figs. 15 and 16. MOOREA ANGULARIS, n. sp. 682

(See also plate XLIII, fig. 89)

Two views of a weather-worn valve, apparently of this species. Trenton shales, Fountain, Minnesota.

Figs. 17 and 18. MOOREA (?) PERPLEXA, n. sp. 683

Side and sectional views of the remarkable valve upon which this species is founded. Trenton shales, Fountain, Minnesota.

Figs. 19 to 22. CERATOPSIS CHAMBERSI Miller, sp. 676

19 and 20. Side and ventral views of a left valve of the usual form. Upper third of the Trenton shales, St. Paul, Minnesota.

21. Inner side of a more elongate right valve, from the same locality.

22. Another right valve from the same locality, peculiar in having the small post-median ridge divided.

Figs. 23 to 25. BOLLIA UNGULOIDEA, n. sp. 669

Three views of a left (?) valve. Galena shales, Cannon Falls, Minnesota.

Figs. 26 to 29. BOLLIA SUBÆQUATA, n. sp. 669

26 and 27. End and side views of a valve of this species. Trenton shales, Fountain, Minn.

28. A small valve from the same locality.

29. Large and relatively high valve from the same position at Cannon Falls, Minn.

Figs. 30 to 34. DILOBELLA TYPA, n. gen. et sp. 673

Figures of three valves showing slight variations. Upper third of the Trenton shales, St. Paul, Minnesota.

Figs. 35 to 38. DREPANELLA BILATERALIS, n. sp. 671

35. A right (?) valve of the usual size and appearance.

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.

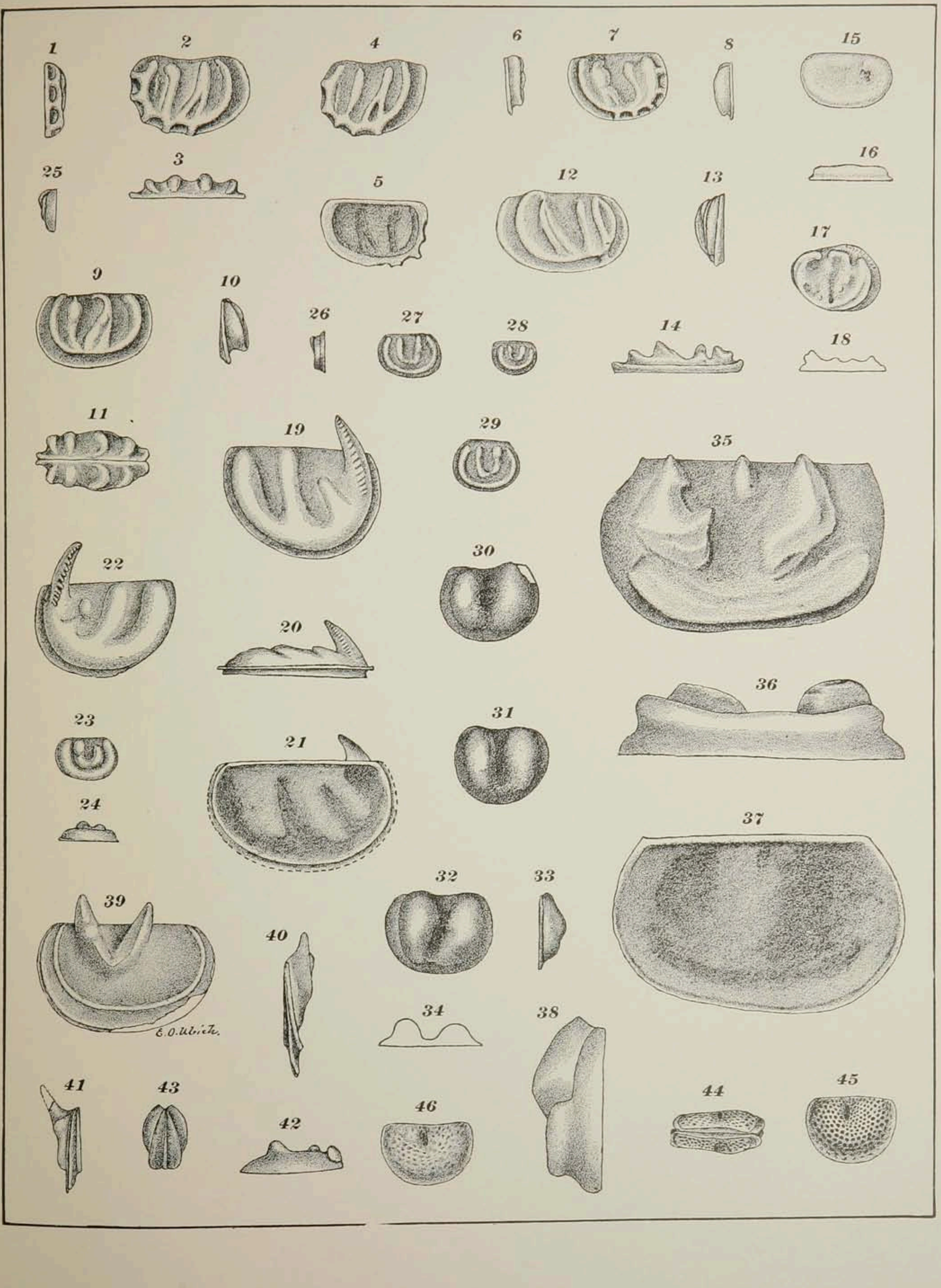
Fig. 42. DICRANELLA (?) SIMPLEX, n. sp. 666

Ventral view of the valve figured on plate XLIV, figs. 24 and 25.

Figs. 43 to 46. HALLIELLA LABIOSA, n. sp. 656

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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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 subcentral 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*, Ronault; *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.).

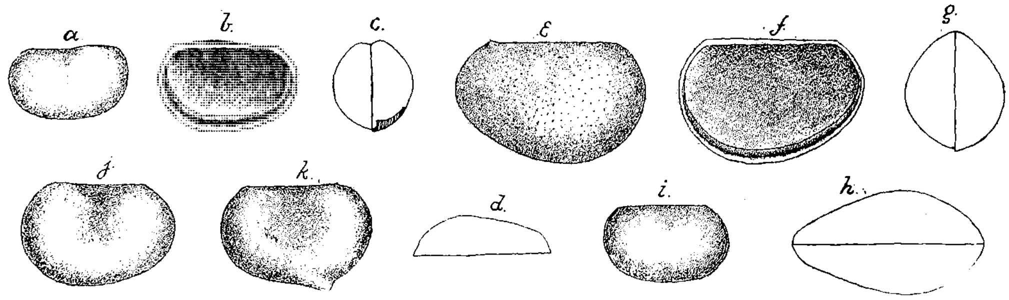


Fig. 46. *a*, small left valve of *Leperditella inflata* Ulrich; *b*, inner side of a larger valve of same, showing the marginal groove; *c*, vertical section in outline of entire carapace of same; *d*, dorsal outline of left valve of same; *e* and *f*, external and internal views of a left valve of *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. 5*a* and 15*a*; 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.

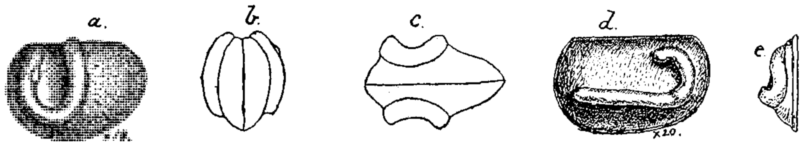


Fig. 47.—*a*, *b*, c, lateral, posterior, and ventral views of an entire carapace of *Jonesella crepidiformis* Ulrich; *d*, left valve of *J. pedigera* Ulrich; all about × 20. Both species are from the lower beds of the Cincinnati group at Covington, Kentucky.

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,

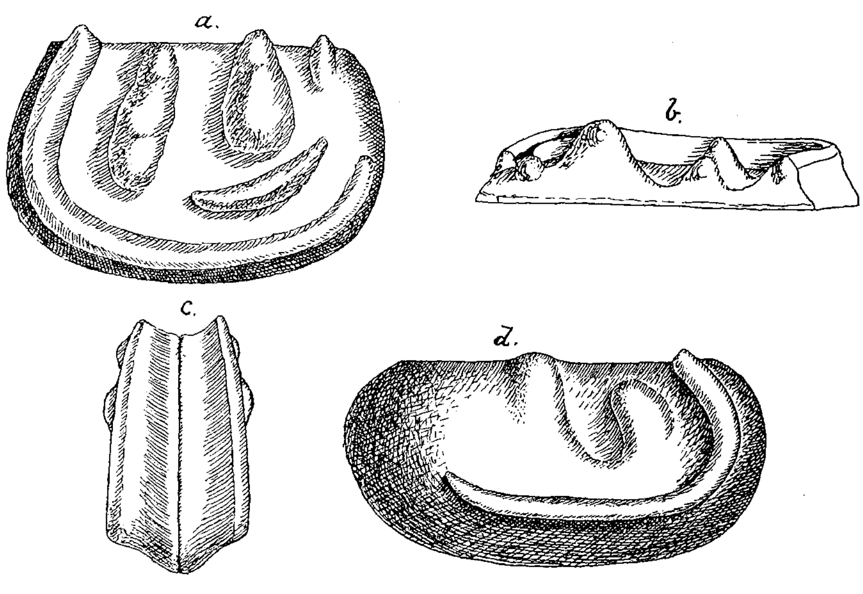


Fig. 48.—*a*, *b*, lateral and dorsal views of a right valve of *Drepanella crassinoda* Ulrich, from the Birdseye limestone at High Bridge, Kentucky; *c*, a left valve of *D. ampla*, var. *elongata* Ulrich, from the same formation and locality, introduced for comparison with *D. bigeneris*; *d*, right 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.

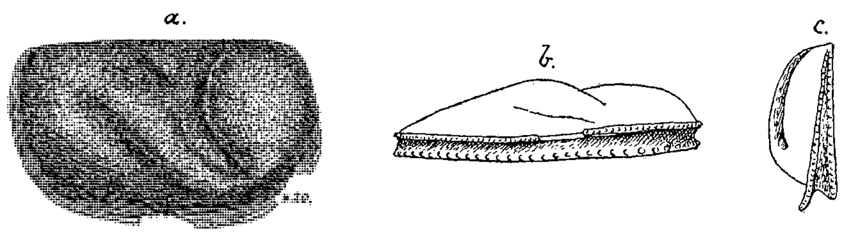


Fig. 49.—*a*, *b*, *c*, lateral, posterior, and ventral views of a left valve of *Ctenobolbina ciliata* var. *emaciata* Ulrich, × 20; shales of the Hudson River group, Savannah, Illinois. This species probably occurs also in the equivalent shales near Spring Valley, Minnesota.

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 edge 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 semicircular 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.

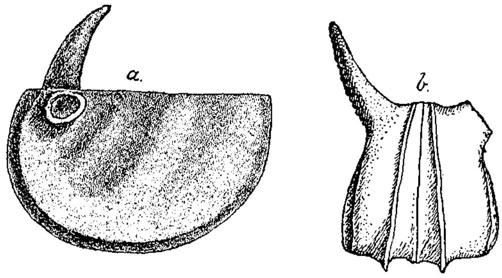


Fig. 50.—Lateral and posterior views of an entire carapace of this variety from the shales of the Hudson River group, near Spring Valley, Minnesota.

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 Paleozoic 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 *Krausella 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.*

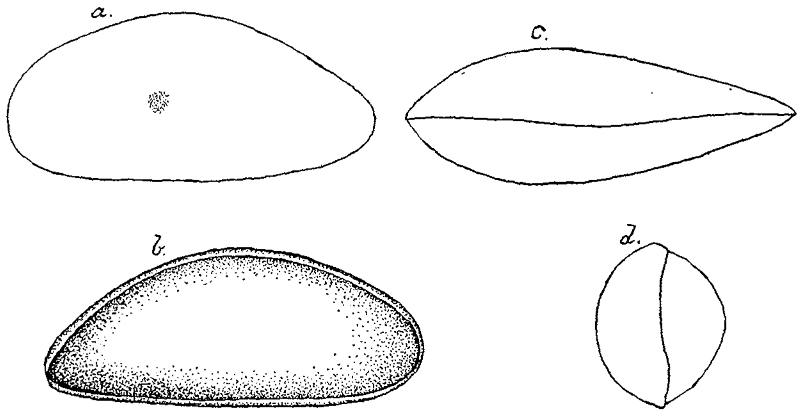


Fig. 52.—*a*, a left valve, with somewhat blunter ends than usual, showing position of subcentral spot; *b*, right side of entire carapace; c and *d*, ventral and posterior outline views of same; lower Trenton ("Lower Blue limestone"), Dixon, Illinois.

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.

*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 lin being straighter and the dorsal margin more arcuate than in *K. inæqualis.* Th posterior spine also is more slender and situated lower, the point in some instance being almost on a line with the ventral edge of the right valve. Finally, the lef valve is more uniformly convex, the upper half of the surface being fuller, while tl 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

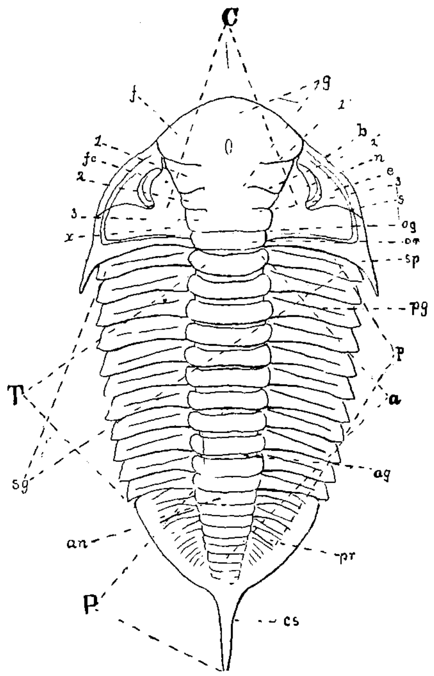


Fig. 1—*Diagrammatic figure of a trilobite.*

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.

a. axis.
p. pleuræ.

P. Pygidium.
an. annulation.
pr. pleural rib.
cs. caudal spine

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

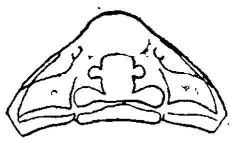


Fig. 2.—Outline of cephalon of *Calymmene callicephala* Green. From the cast of the original.

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

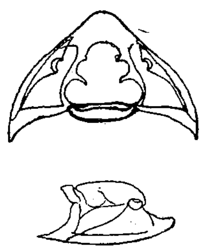


Fig. 3.—Outlines of cephalon of *Calymmene senaria* Conrad, Trenton Falls, N. Y.

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.

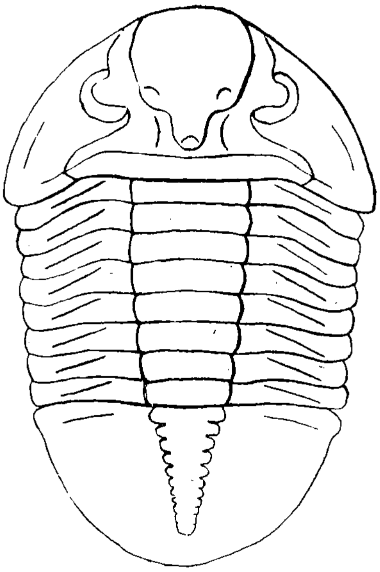


Fig. 4. Outline of *Asaphus expansus* Wahlenberg (after Dalman).

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.

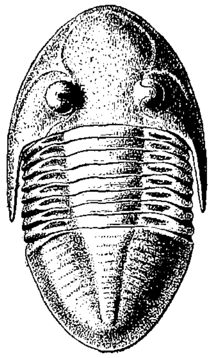


Fig. 5.—*Isotelus maximus* Locke. Hudson River group, Granger.

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

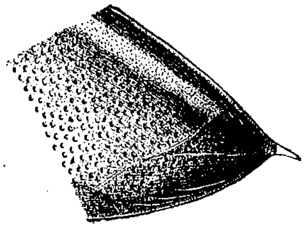


Fig. 6. Genal extremity of *Isotelus gigas maximus*, with minute spinule, × 3.

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.

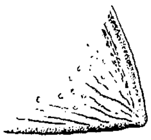


Fig. 7.—Genal extremity of *Isotelus gigas-maximus*, with puckered, but aspinous apex. Trenton limestone, N. Y.

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.

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.†

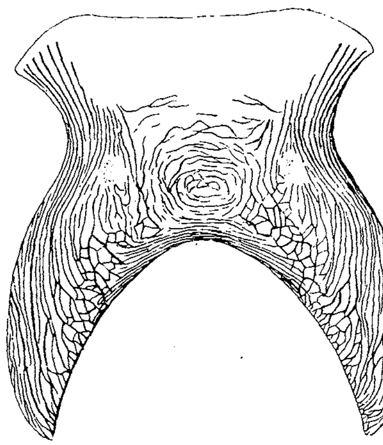


Fig. 8.—*Isotelus gigas* DeKay. Hypostoma of a large individual. Hudson River sandy shales (erratic), central New York.

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.

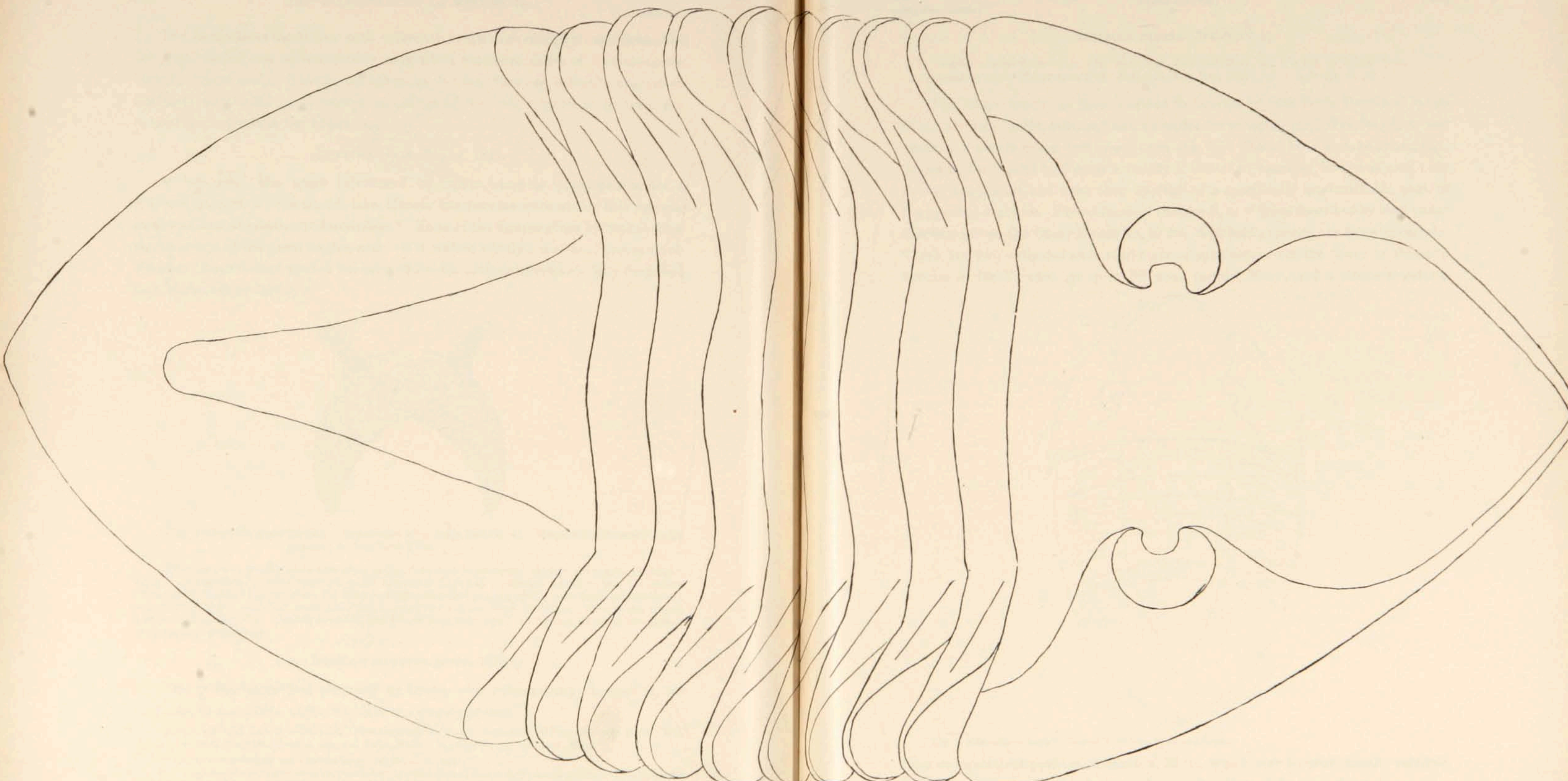
ISOTELUS MAXIMUS *Locke*, 1838.

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 cephal 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 ar clearly defined, and the segmentation of both axis and pleuræ are discernible even to the extremity of the shield, especiall on the internal casts. The fossil is not especially common, though I have seen several characteristic examples. The specie may be distinguished by the term, *Isotelus jacobus*, being dedicated to Prof. James Hall.



Outline of Isotelus gigas *DeKay*.
(Natural 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

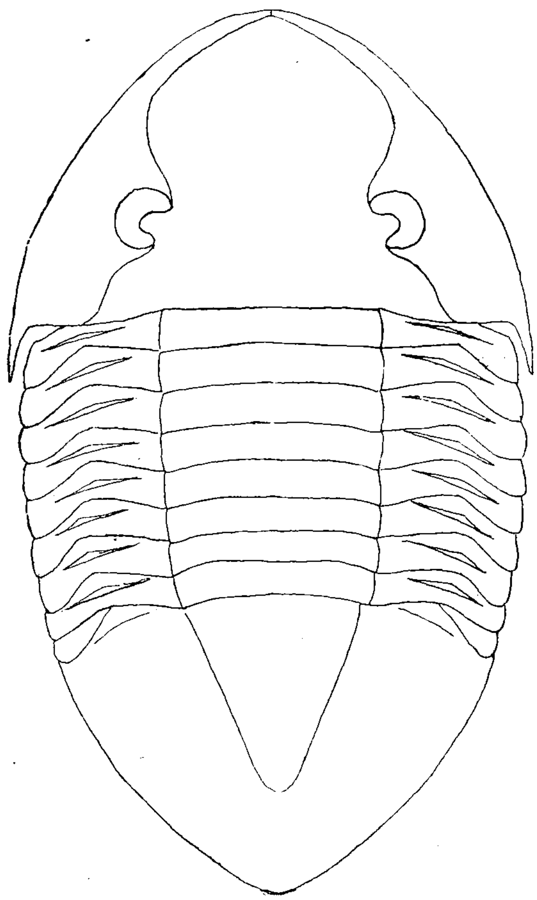


Fig. 9.—*Isotelus canalis?* Lower Trenton, Fillmore county.

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, 1861.

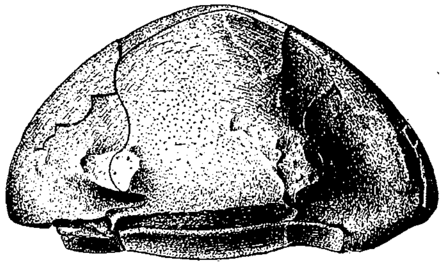
are not impressive. The smaller individual has a more decidedly flattened cephalic border than the larger, but this difference is probably due to circumstantial causes; its cheek spines are much the longer, extending to the sixth segment, while on the larger example they reach only to the second.

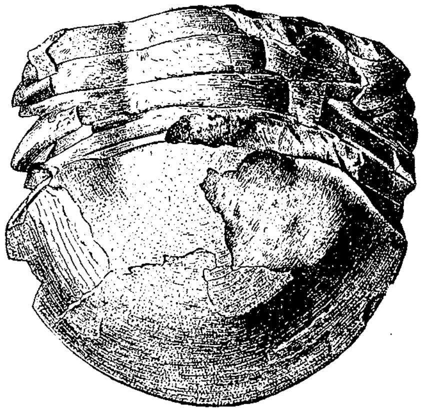
Formation and locality.—Lower Trenton; Fillmore county, and Stanton, Goodhue county.

ISOTELUS SUSÆ *Whitfield*, 1882.

Asaphus susæ (CALVIN 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 susæ* 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.

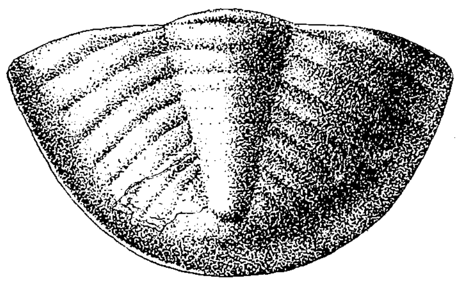


Fig. 12.—An entire pygidium of *Ptychopyge ulrichi*, Cannon Falls.

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.

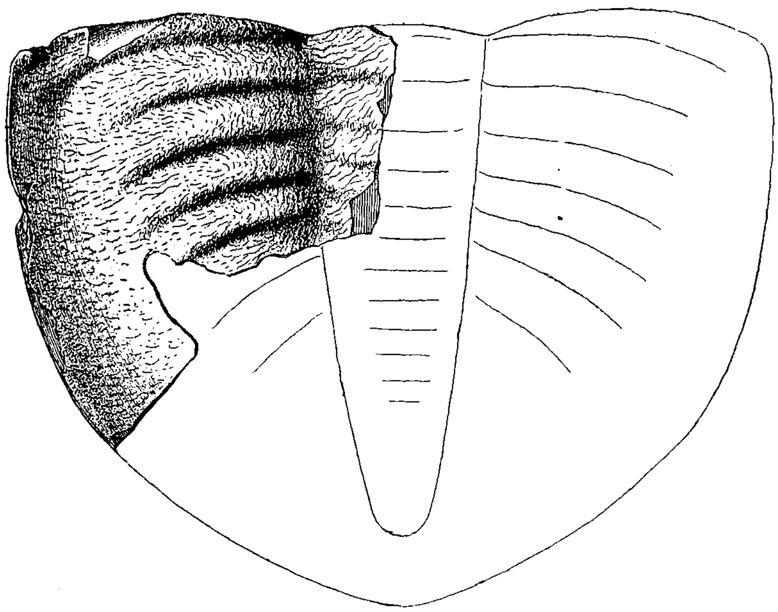


Fig. 13.—Fragment of a large pygidium of *Ptychopyge ulrichi*, with restoration of outline. Cannon Falls.

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.

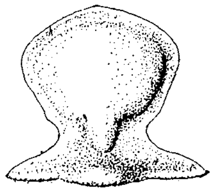


Fig. 14.—Cranidium of *Gerasaphes ulrichana*, × 4.

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 paracmic 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.

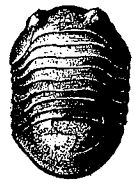


Fig. 19.—*Nileus vigilans* Meek and Worthen. An entire individual, with cephalon inclined.

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.

Illænus americanus BILLINGS, 1859. Canad. Nat. and Geol., vol. iv, p. 371.
Illænus taurus HALL, 1861. Geol. Surv. Wisconsin; Rept. Progress, p. 49.
Illænus americanus BILLINGS, 1865. Palæozoic Fossils, vol. i, p. 329, figs. 316*a–d*.
Illænus taurus MEEK and WORTHEN, 1868. Geol. Surv. Illinois, p. 320, pl. 3, fig. 2.
cf. *Illænus 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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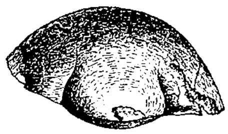

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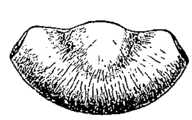

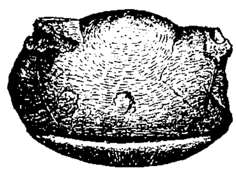

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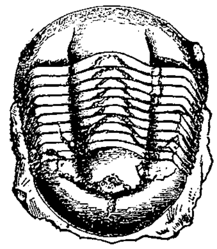

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Figs. 20—23.—*Illænus americanus* (after Billings). Fig. 20.—Upper side of head. Fig. 21.—Front view of the same individual. Fig. 22.—Pygidium of the same. Fig. 23.—A nearly entire individual.

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.

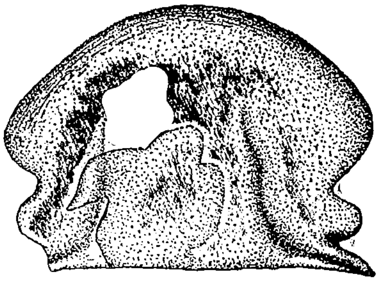


Fig. 24.—Cranidium of *Illænus; cf. I. indeterminatus* Walcott.

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.

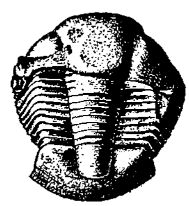


Fig. 25.—Internal cast of *Thaleops ovata* Conrad.

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

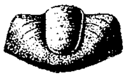


Fig. 26.—Pygidium of *Thaleops ovata* Conrad.

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.

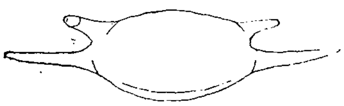


Fig. 28.—*Thaleops ovata* Conrad. Outline of head viewed from the front; showing the terete genal extremities. From an impression of the external mould of the specimen shown in figure 25.

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 re-appeared 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*.

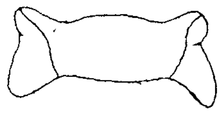
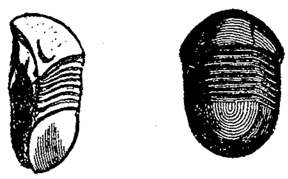


Fig. 29.—Outline of head of *Illænus crassicauda* Wahlenberg, viewed from in front.

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

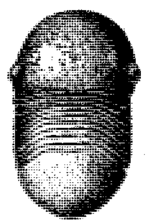


Fig. 32.—*Bumastus trentonensis* Emmons (sp.). An entire individual with ten segments. Trenton Falls, New York.

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

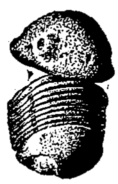


Fig. 33.—*Bumastus trentonensis* Emmons (sp.). An entire but disjointed individual, with nine segments.

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 *Illœnus milleri* the detailed structure of this species has been clearly given by Billings.

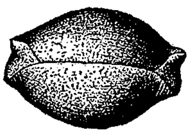


Fig. 34.—Front view of an enrolled individual of *Bumastus trentonensis* Emmons (sp.). ×2.

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.

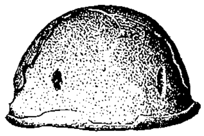


Fig. 36.—*Bumastus orbicaudatus* Billings. Galena shales, Kenyon.

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.

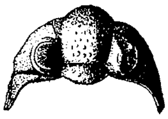


Fig. 37.—Portion of head of *Bathyurus extans* Hall, Cannon Falls.

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.

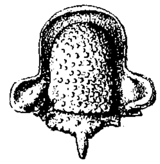


Fig. 38.—Cranidium of *Bathyurus spiniger* Hall.

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.

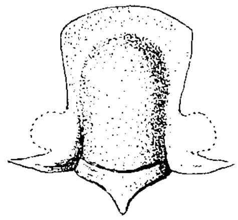


Fig. 41.—Cranidium of *Bathyurus schucherti.*

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.

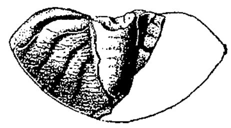


Fig. 42.—Pygidium of *Bathyurus schucherti*, partially restored. × 2.

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'

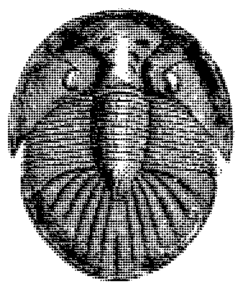


Fig. 43.—*Bronteus lunatus*, after Billings.

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.

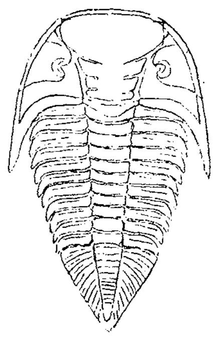


Fig. 44.—Outline of *Dalmanites achates* Billings. Trenton Falls, N. Y.

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.

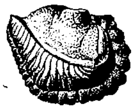


Fig. 46.—Profile of the same.

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

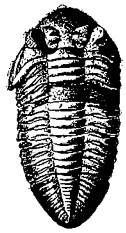


Fig. 48.—*Pterygometopus eboraceus.*

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,*

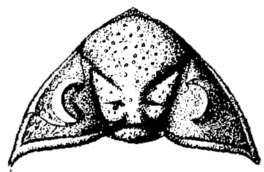


Fig. 49.—Cephalon of *Pterygometopus eboraceus,* from the same specimen; somewhat restored. × 2.

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

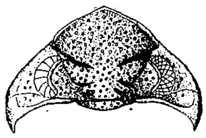


Fig. 50.—Cephalon of *Pterygometopus schmidti.*

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

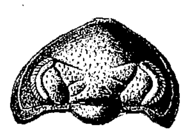


Fig. 51.—Cephalon of *Pterygometopus callicephalus* Hall.

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

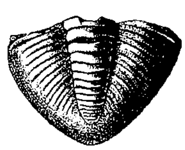


Fig. 52.—Pygidium of *Pterygometopus callicephalus* Hall. × 2.

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.*

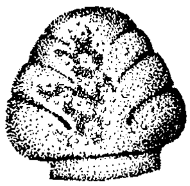
The remains of this fossil are quite imperfect, but the occurrence of this type of structure in the Trenton fauna of New York is worthy of notice.

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 $6\frac{1}{2}$ 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.

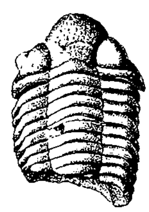


Fig. 56.—*Encrinurus vannulus.* × 2.

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

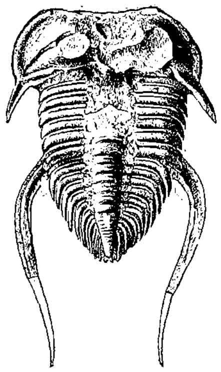


Fig. 59.—*Cybele winchelli.*

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

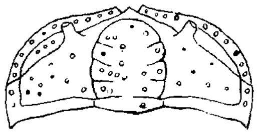


Fig. 60.—Cephalon of *Cybele bellatula* (after Schmidt).

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 *Cybel·* 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. 3); 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.

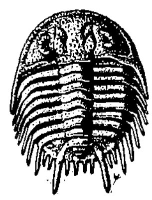


Fig. 61.—*Odontopleura parvula* Walcott. × 3. Trenton Falls, N. Y.

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. 6a–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. propos.* 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

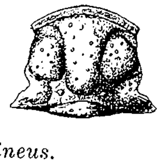


Fig. 65.—Cranidium of *Arges consanguineus*.

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).

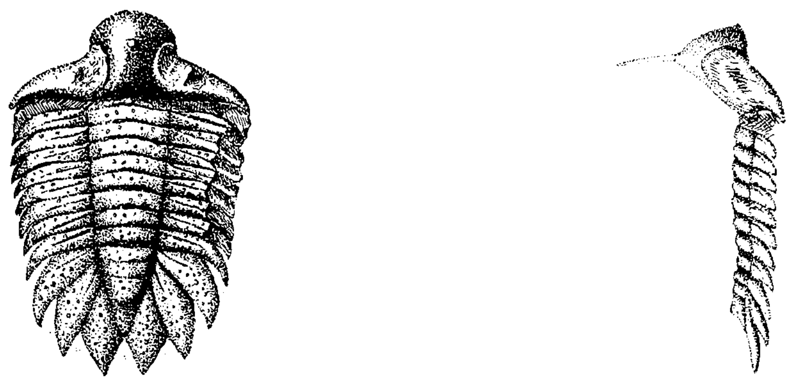
* See Dames, Zeitschr. d. deutsch. geolog. Gesellsch., vol. xxix., p. 794, pl. 12-14, 1877.

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 8½ 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

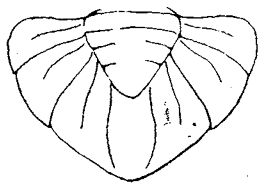


Fig. 74.—Outline of pygidium of *Lichas laciniatus* Wahlenberg (after Dalman).

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. 1*e*.

‡ 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,)

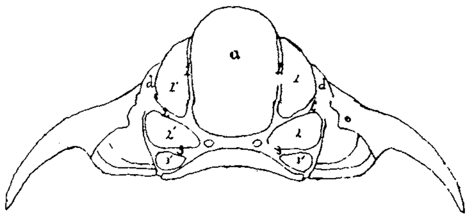


Fig. 75.—Glabella of *Lichas palmata* Beyrich. (After Barrande.)
d. dorsal furrows.
a. median or frontal lobe.
1′, 2′, 3′. anterior median and posterior lateral lobes.
1, 2, 3. anterior median and posterior lateral furrows.

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) hylœus* 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.

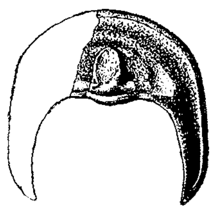


Fig. 76.—Cephalon of *Harpina minnesotensis.*

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

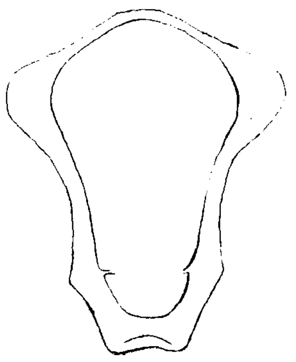


Fig. 77.—Hypostoma of *Harpes venulosus* Corda, enlarged. (Étage F_2). After Novak.

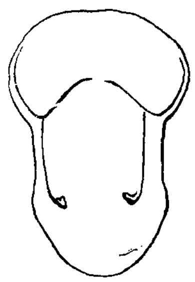


Fig. 78.—Hypostoma of *Harpina prima*, enlarged (Étage D_2). After Novak.

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

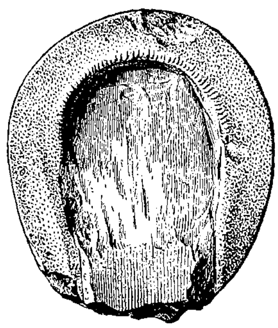


Fig. 79.—*Harpina*, cf. *H. ottawensis* Billings.

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. i, 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.

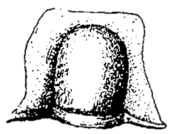


Fig. 82.—Cranidium of *Cyphaspis? galenensis.* (× 5).

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

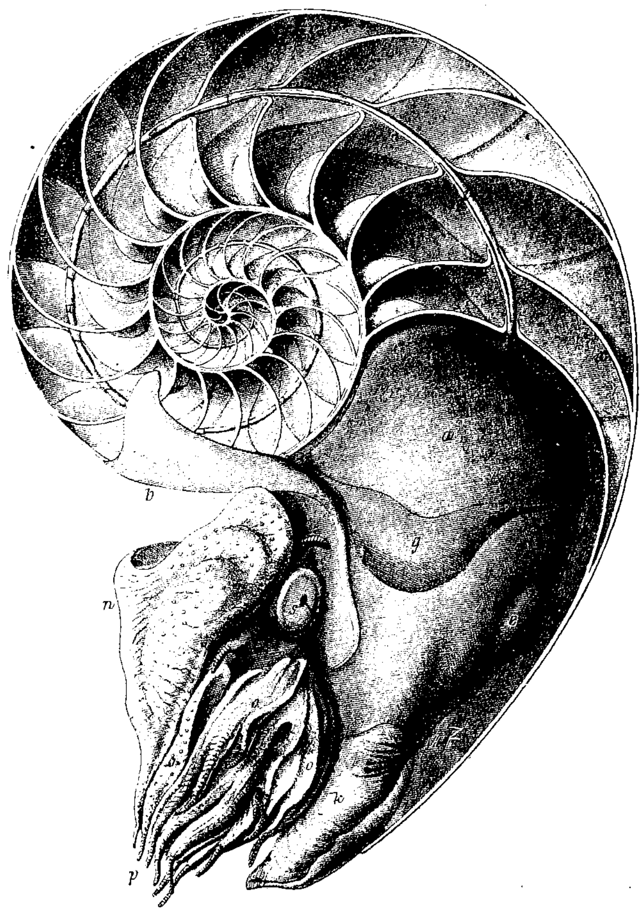


Fig. 1.—*Nautilus pompilius*.

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

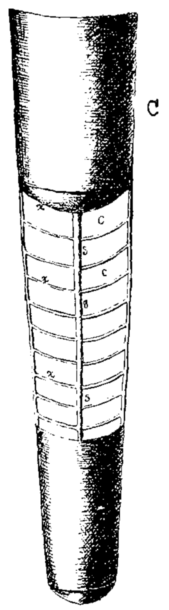


Fig. 2.—An *Orthoceras* represented as vertically sectioned for a portion of its length.
C. body-chamber; *c*. air-chambers; *x*. septa; *s*. sipho.

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

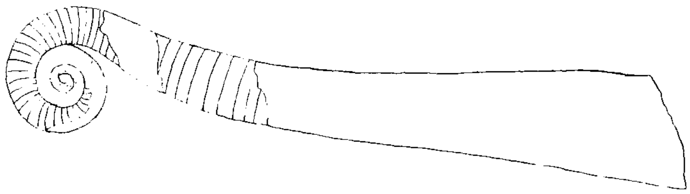


Fig. 3.—*Lituites lituus.* (After Rœmer).

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.

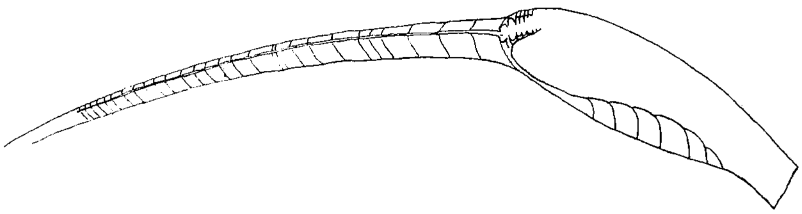


Fig. 4.—*Ascoceras manubrium.* (After Lindström).

*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

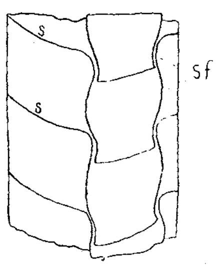


Fig. 5.—*Cameroceras burchardi*, showing overlapping siphonal funnels. (After Dewitz).
s. septa; *sf.* siphonal funnels.

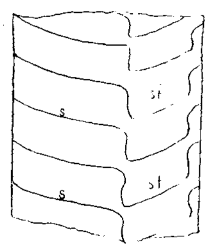


Fig. 6.—*Cameroceras proteiforme;* showing the the short siphonal funnels.

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.

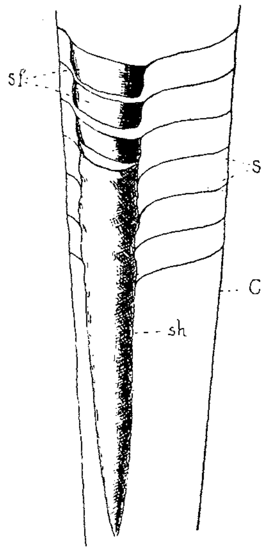


Fig. 7.—*Cameroceras proteiforme*.
C. outer shell or conch; *s.* septa; *sf.* siphonal funnels; *sh.* solid apical portion or guard of sipho.

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

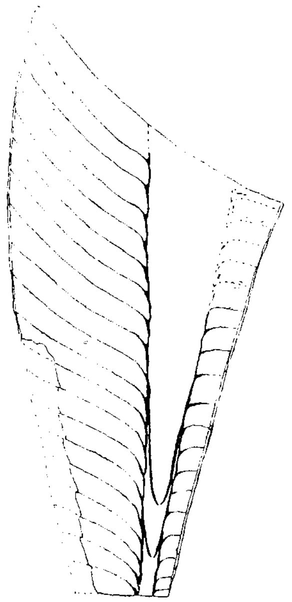


Fig. 8.—Median vertical section of one of the specimens described. × 2

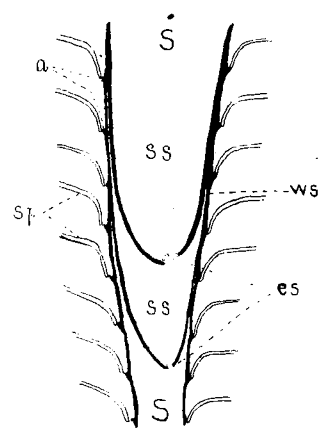


Fig. 9.—Enlargement of a portion of the same. *s.* sipho; *ss.* siphonal sheaths; *ws.* wall of sipho; *es.* endosiphon; *sp.* septa; *a.* annulus formed at junction of septum with sipho.

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 *Echinosphærites*-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 $1\frac{1}{2}$ 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. 1-1*c*; pl. XVI, figs. 1-1*e*; pl. XVII, figs. 1*a*, *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 characterizəd 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. 1*a*–*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.

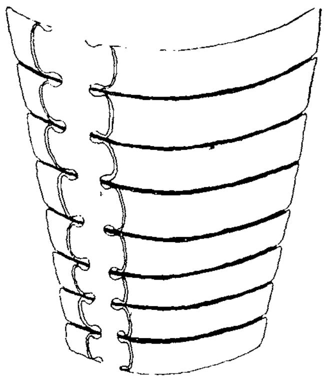


Fig. 10.—Vertical median section of *O. minnesotense* showing the form of the siphonal beads. × 1.5.

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 acu te, 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.

Piloceras newton-winchelli, sp. nov.
Nanno aulema, Clarke.
Cyrtocerina (?) *schoolcrafti*, sp. nov.
Cameroceras proteiforme, Hall.
Cameroceras hennepini, sp. nov.
Cameroceras, sp.
Cameroceras, sp. nov.
Actinoceras bigsbyi, Stokes.
Actinoceras beloitense, Whitfield.
Actinoceras remotiseptum, Hall.
Orthoceras nicoleti, sp. nov.
Orthoceras anellus, Conrad.
Orthoceras perroti, sp. nov.
Orthoceras lesueuri, sp. nov.
Orthoceras bilineatum, Hall.
Orthoceras olorus, Hall.
Orthoceras tenuistriatum, Hall.
Orthoceras sociale, Hall.
Orthoceras beltrami, sp. nov.
Orthoceras multicameratum, Emmons.
Orthoceras junceum, Hall.
Orthoceras cf. *amplicameratum*, Hall.
Triptoceras planoconvexum, Hall.
Triptoceras planodorsatum, Whitfield.
Triptoceras oweni, sp. nov.
Triptoceras lambi, Whiteaves.
Triptoceras, sp. ?
Gonioceras anceps, Hall.
Gonioceras occidentale, Hall.
Poterioceras apertum, Whiteaves.
Clinoceras mumiæforme, Whitfield.
Oncoceras exiguum, Billings.
Oncoceras minnesotense, sp. nov.
Oncoceras lycum, Hall.
Oncoceras carveri, sp. nov.
Oncoceras douglassi, sp. nov.
Oncoceras pandion, Hall.
Cyrtoceras neleus, Hall.
Cyrtoceras camurum, Whitfield.
Cyrtoceras hallianum, D'Orbigny.
Cyrtoceras billingsi, Salter.
Cyrtoceras houghtoni, sp. nov.
Cyrtoceras featherstonhaughi, sp. nov.
Cyrtoceras minneapolis, sp. nov.
Cyrtoceras corniculum, Hall.
Cyrtoceras norwoodi, sp. nov.
Cyrtoceras shumardi, sp. nov.
Cyrtoceras scofieldi, sp. nov.
Gyroceras duplicicostatum, Whitfield.
Eurystomites undatus var. *occidentalis*, Hall.

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.	

(Cephalopoda.)

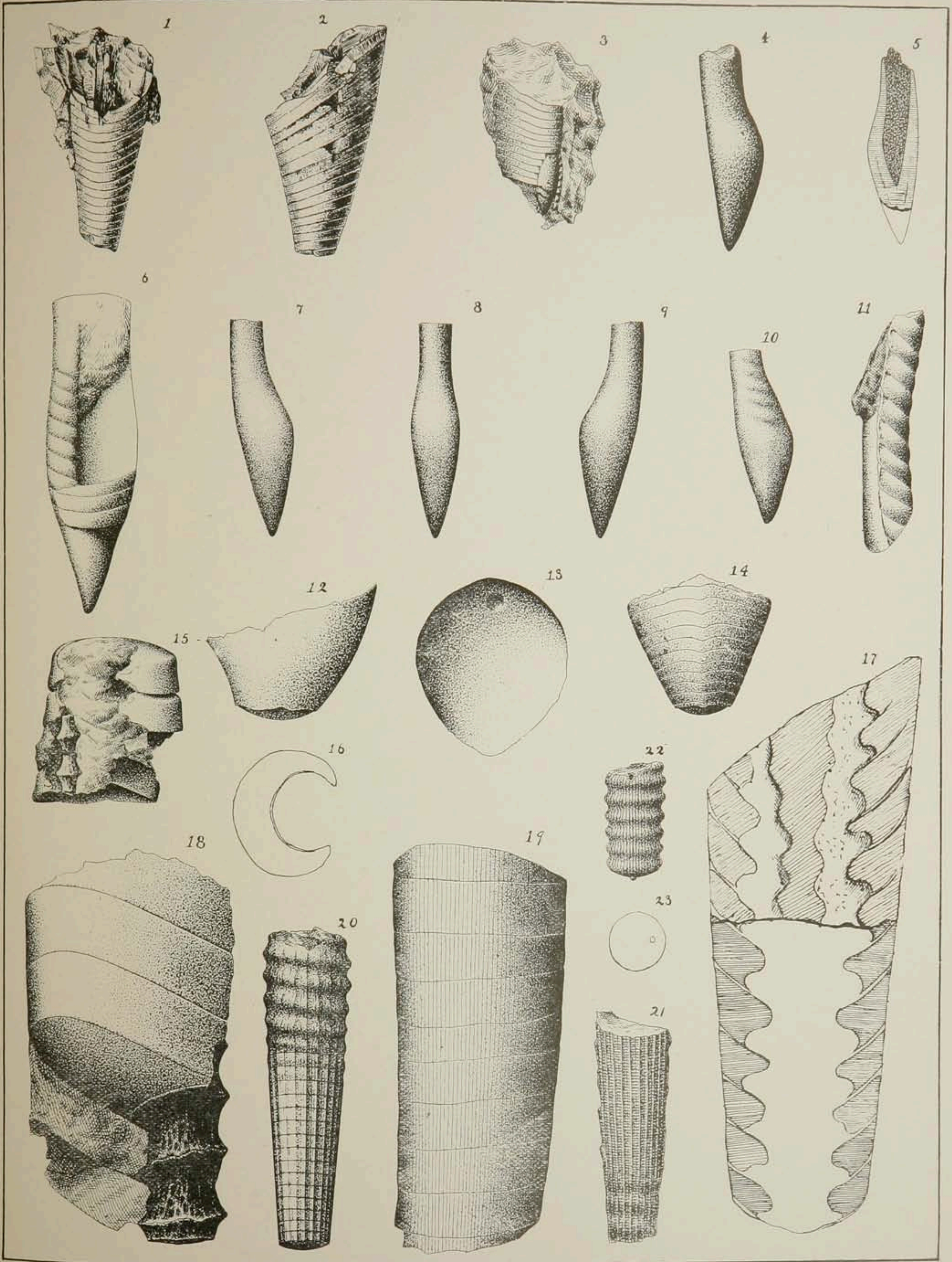


PLATE XLVIII.

		Page.
Fig. 1	Cameroceras proteiforme Hall	777

(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.

(Cephalopoda.)

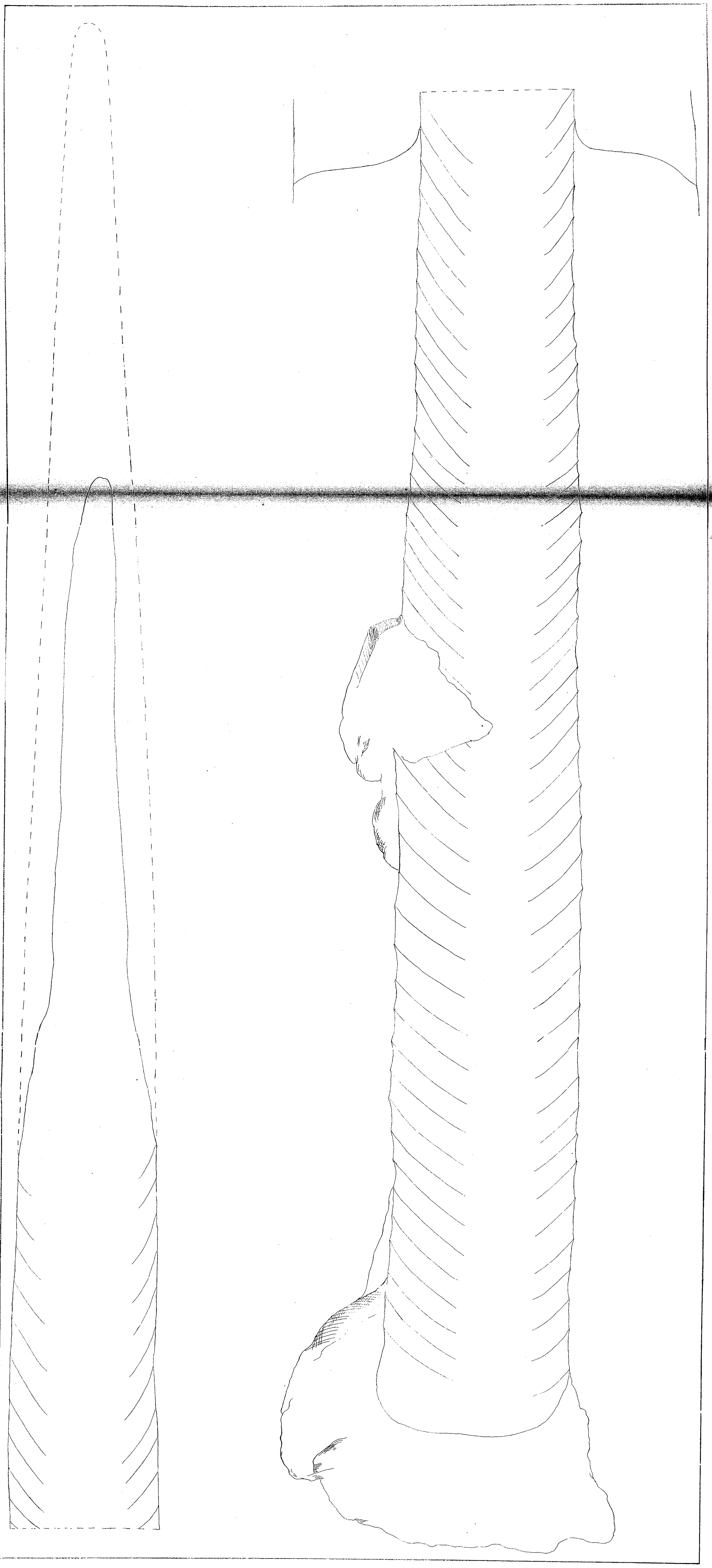


PLATE XLIX.

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.

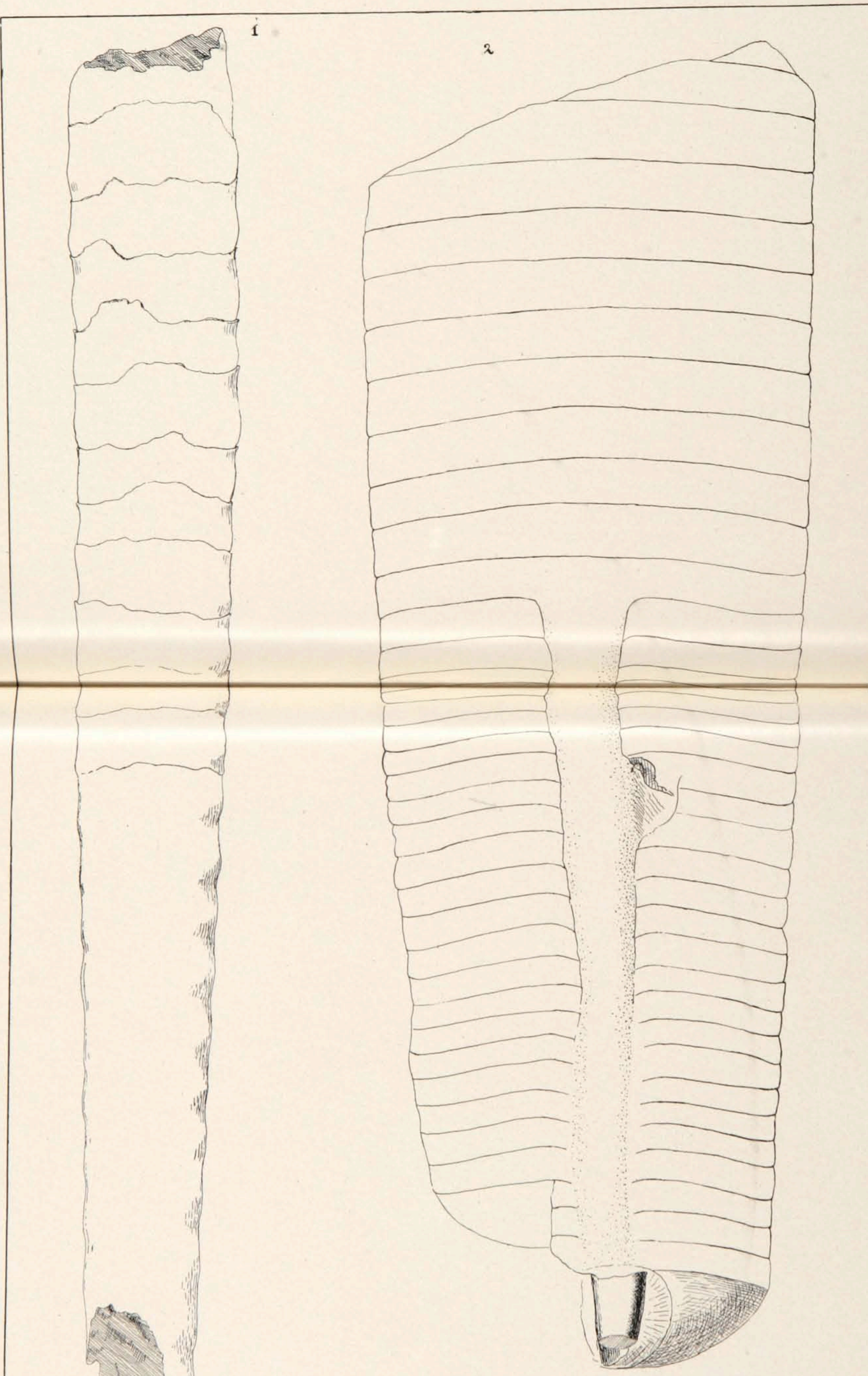

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PLATE L.

			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.	
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.	

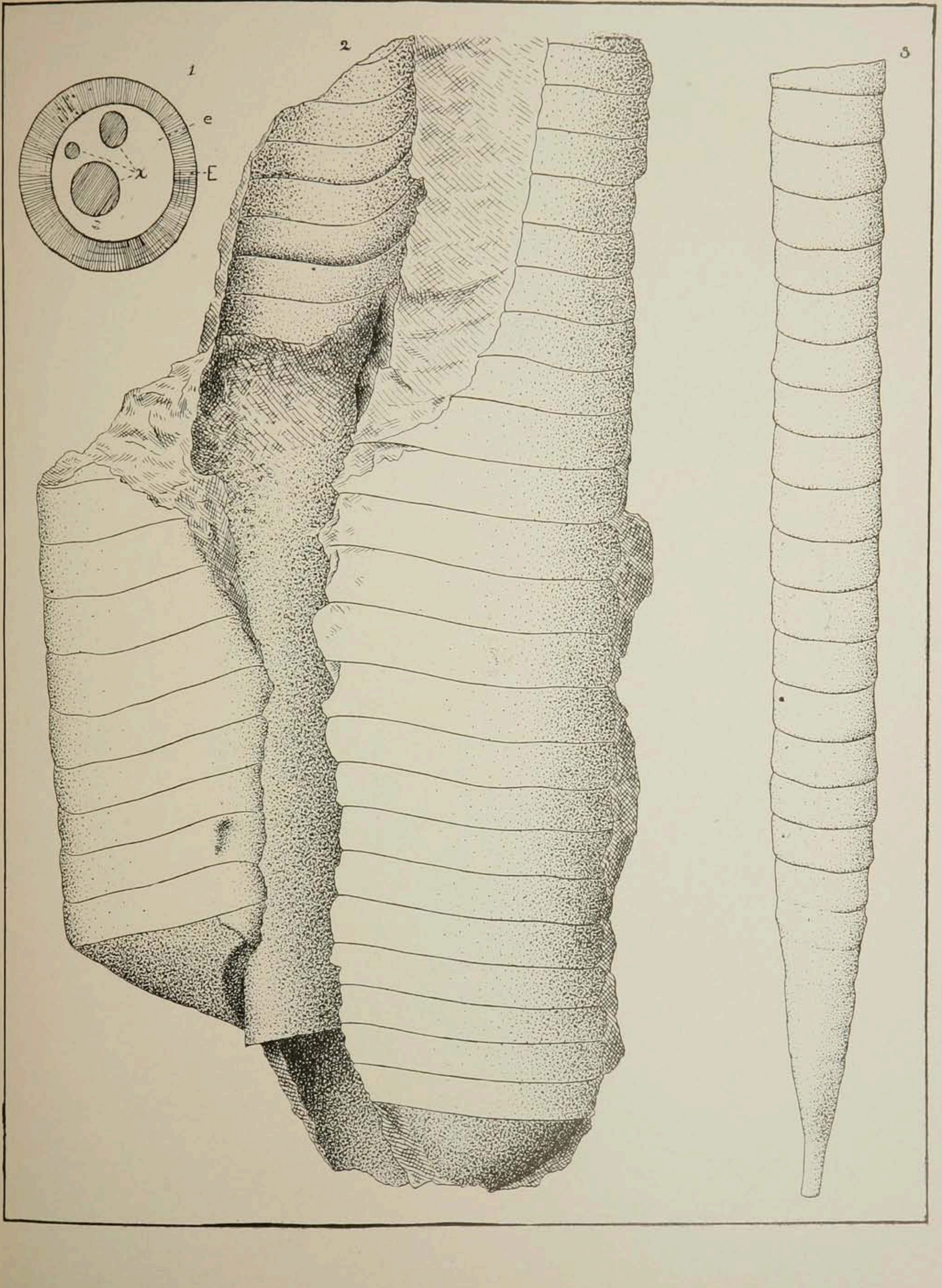
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PLATE LI.

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Figs.	1 to 3	CAMEROCERAS PROTEIFORME Hall (See also plates LVIII, LIX, LX, LXI, LXII.)	777
	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.	

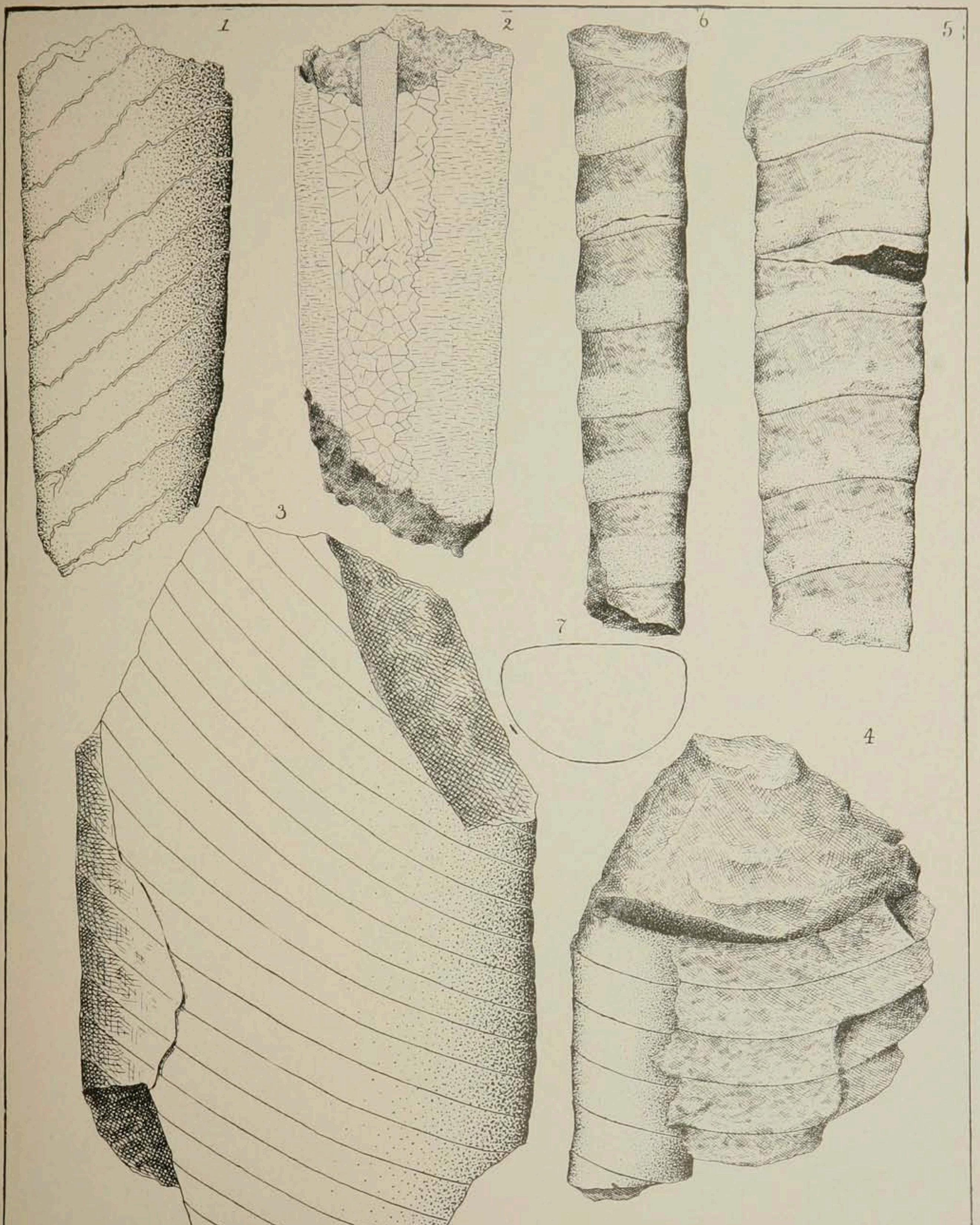
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PLATE LII.

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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.	


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PLATE LIII.

PAGE.

Figs. 1 to 3 CAMEROCERAS HENNEPINI, sp. nov. 779

(See also plate LII.)

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. 779

(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.

Fig. 5 CAMEROCERAS PROTEIFORME Hall 777

(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.

(Cephalopoda.)

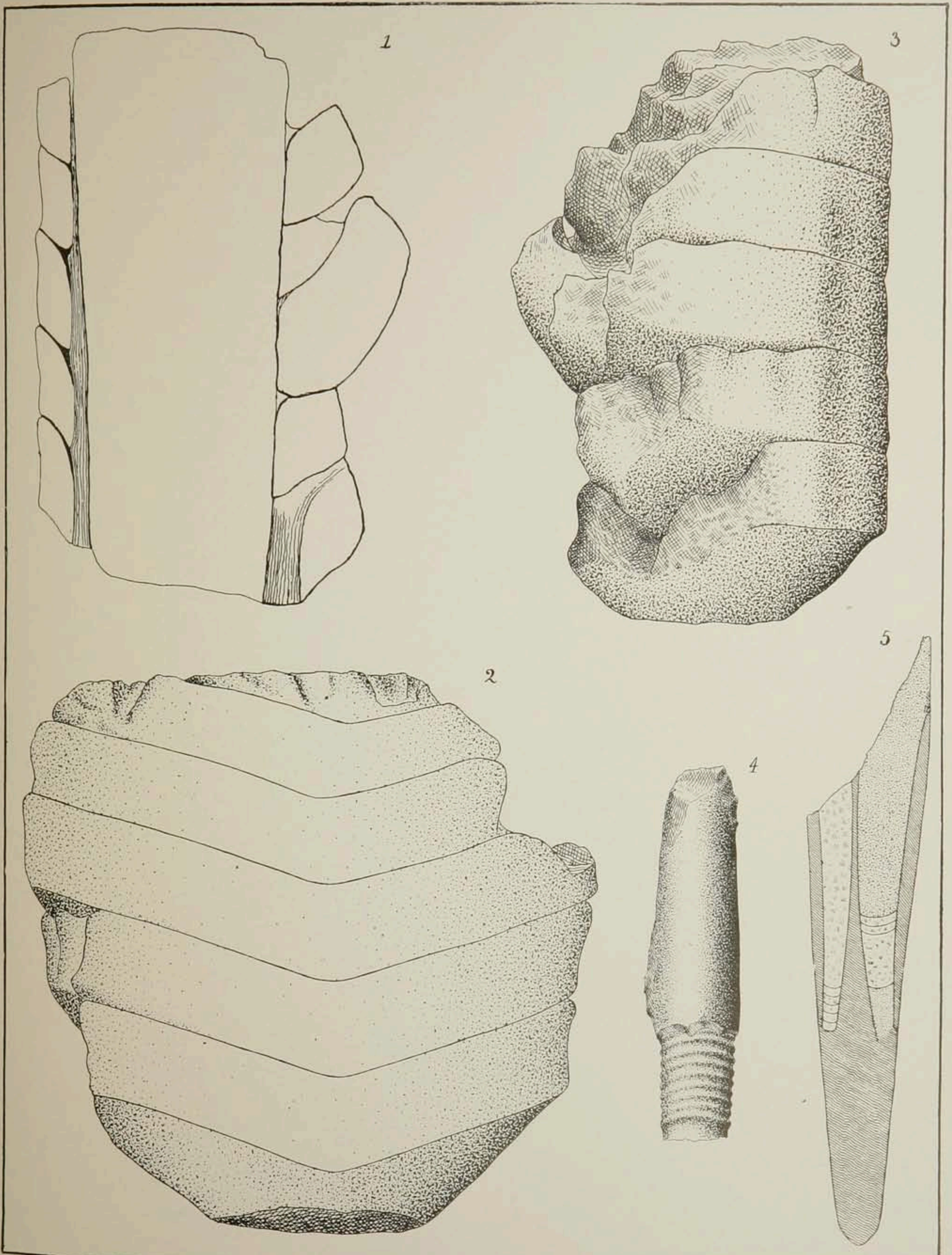

PLATE LIV.

		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.)

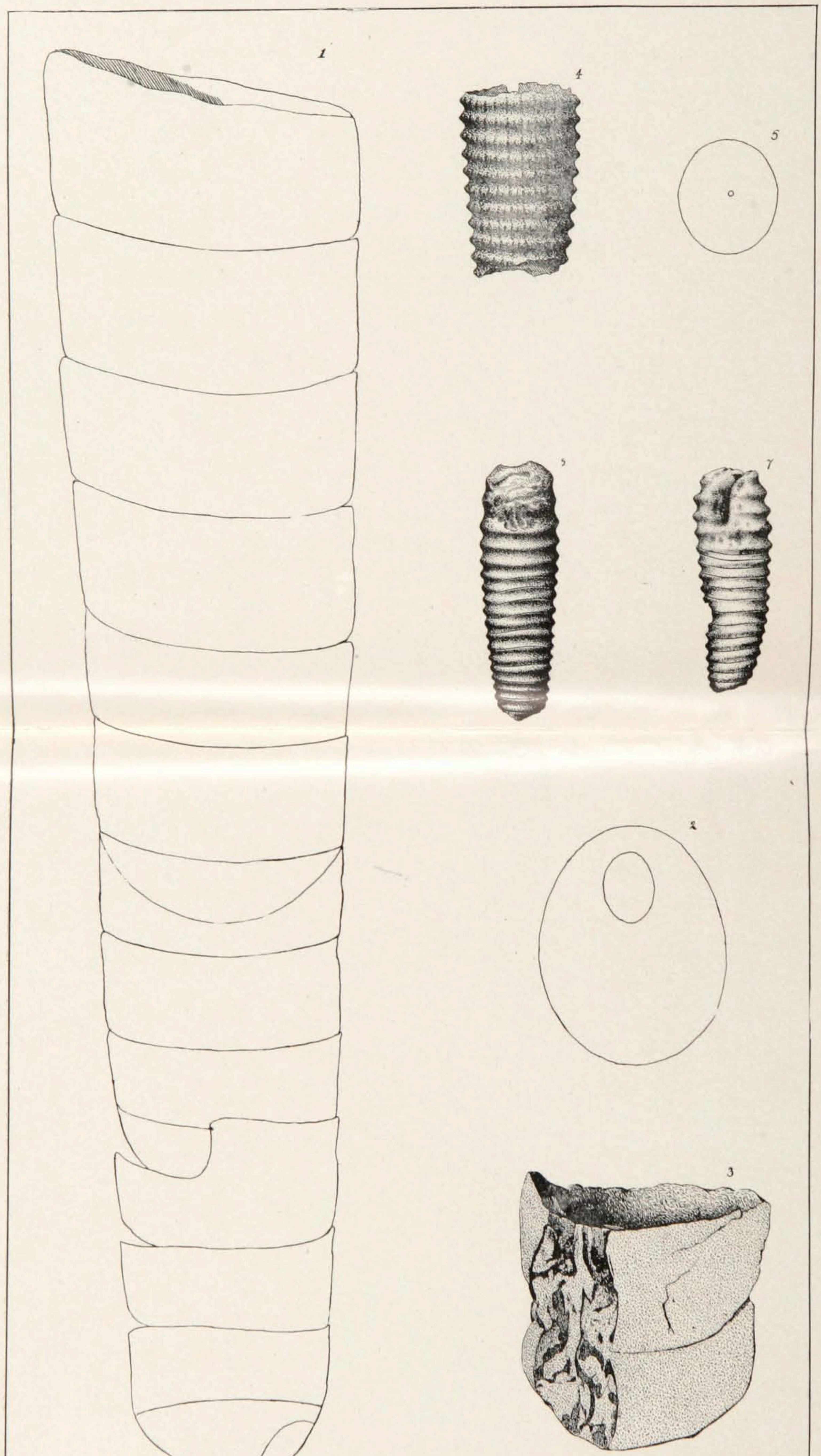

PLATE LV.

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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.	

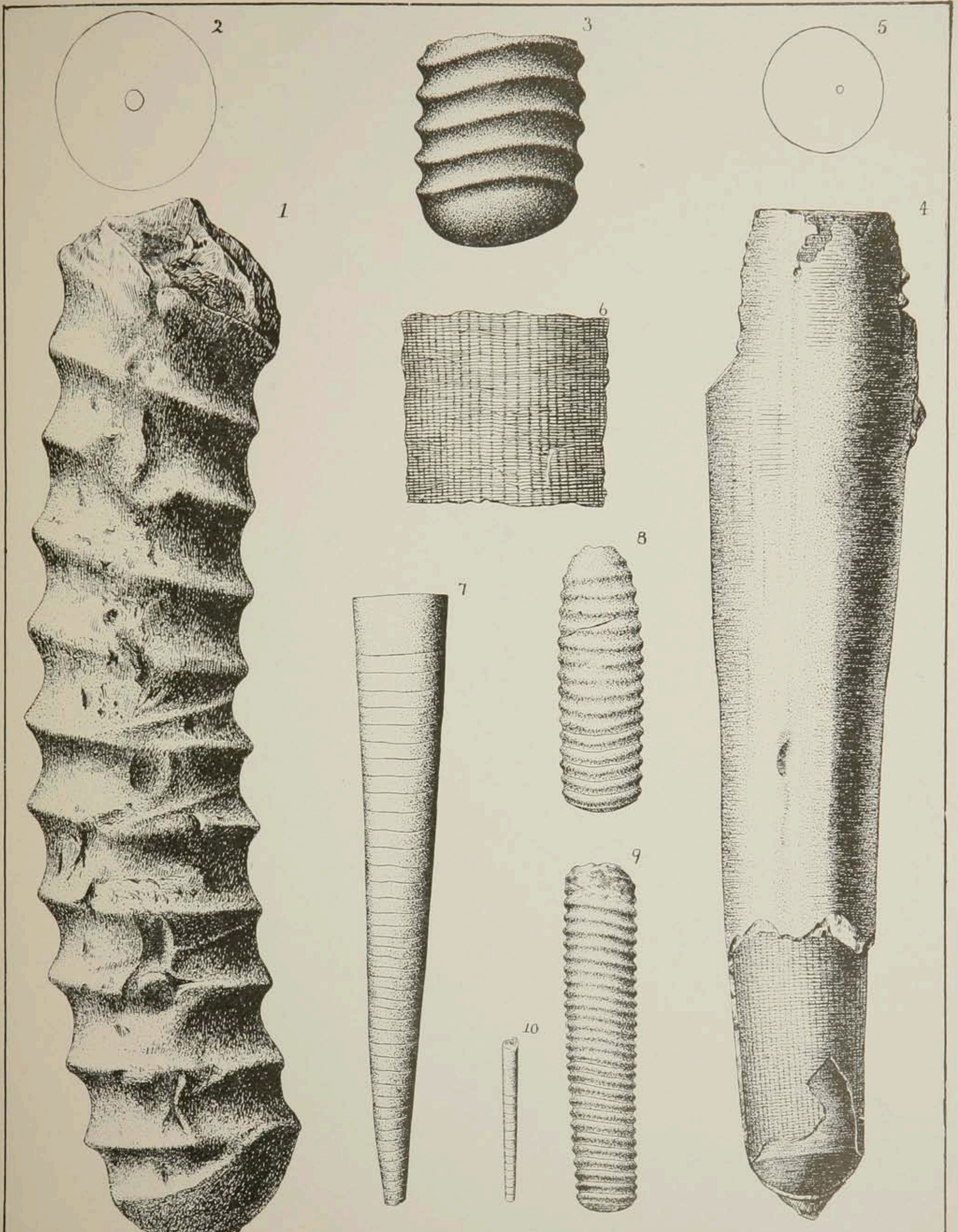
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PLATE LVI.

			PAGE.
Figs. 1 and	2	TRIPTOCERAS LAMBI Whiteaves	937
	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.	

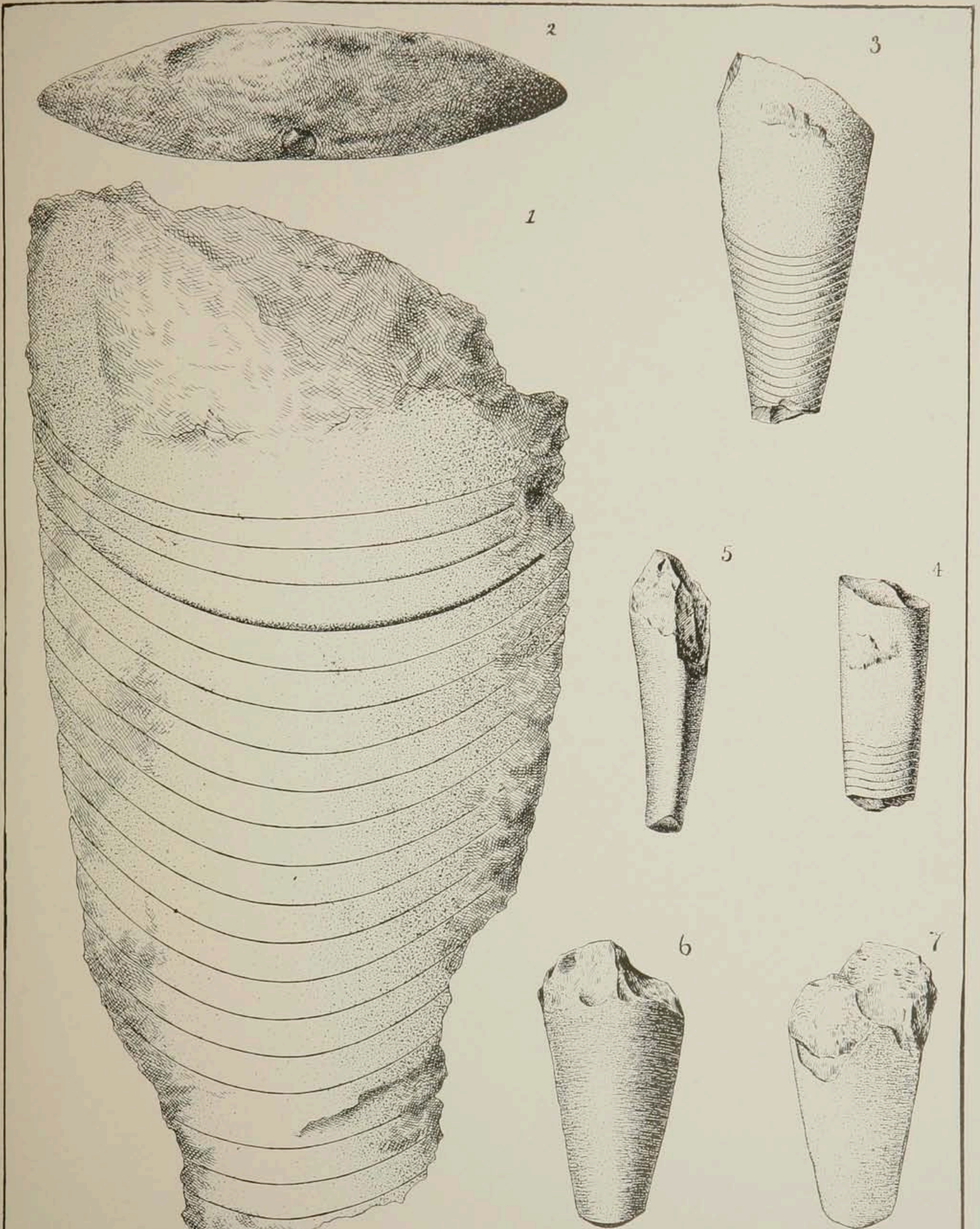
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PLATE LVII.

		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

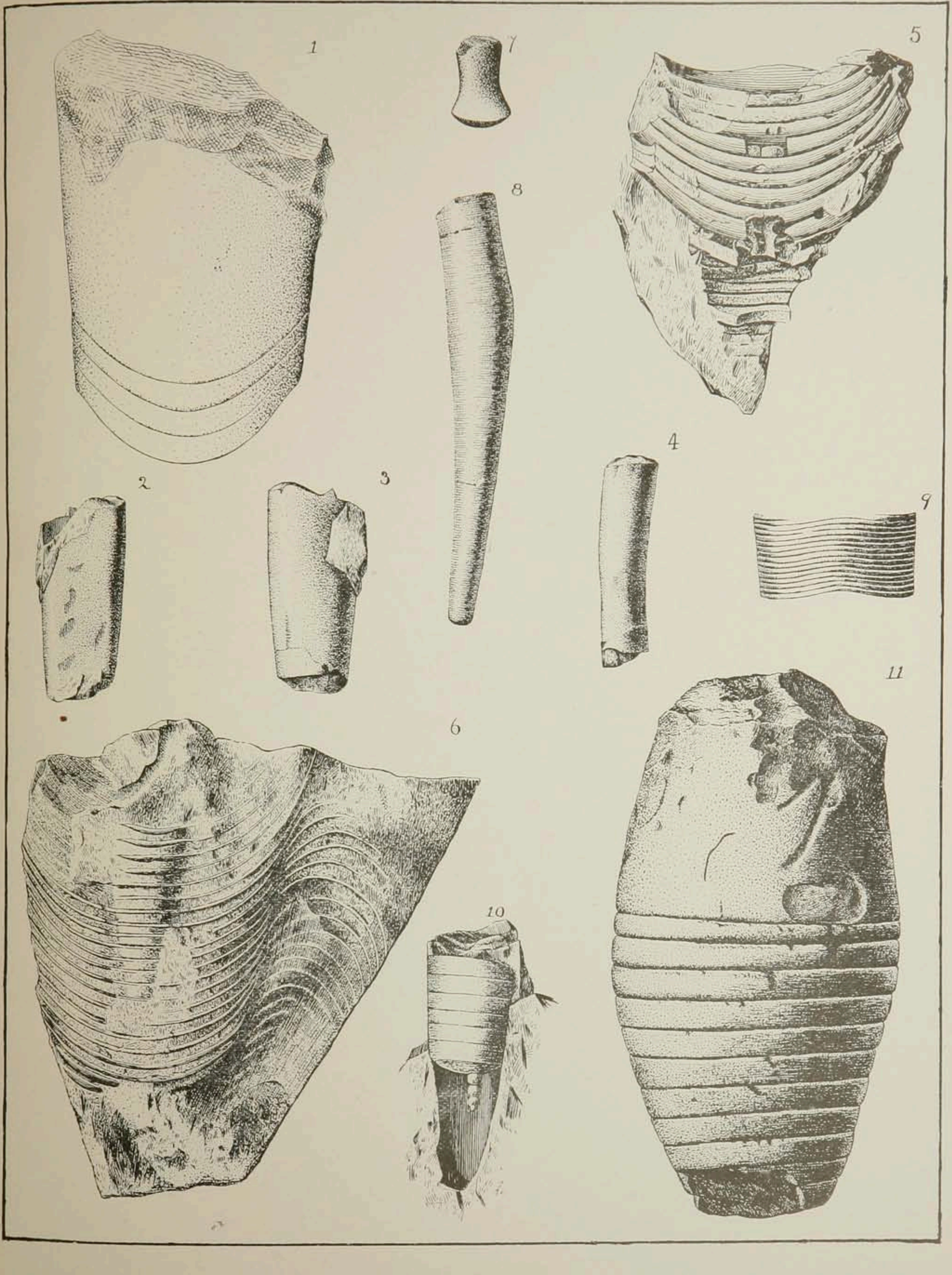
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PLATE LVIII.

		Page.
Figs. 1 to 3*a*	ONCOCERAS LYCUM Hall	799
1, 2, 3	Views of the body-chamber and a few air-chambers; showing the form of the aperture and contraction of the conch.	
3*a*	Outline of the septa. From the Trenton limestone, Minneapolis.	
Figs. 4 to 6*a*	ONCOCERAS PANDION Hall	799
4	Side view of an internal cast retaining the body-chamber and its apertural edge.	
5, 6	Ventral and lateral views, showing the course of the septa.	
6*a*	Outline of the septa, showing the ventral position of the sipho. Janesville, Wis.	
Figs. 7 to 9	ONCOCERAS CARVERI, sp. nov	799
	Dorsal, lateral and ventral views of an internal cast; showing the lateral compression of the conch, the slight constriction of the body-chamber and the form of the aperture. Trenton limestone, Minneapolis, Minn.	
Figs. 10 and 11	ONCOCERAS EXIGUUM Billings	798
	Two imperfect internal casts. From the Galena horizon at Fountain, Minn.	
Figs. 12 to 15*a*	CYRTOCERAS FEATHERSTONHAUGHI, sp. nov	807
12, 13, 14, 15	Lateral, dorsal and ventral views; showing the characters of the species.	
15*a*	Outline of a septum; showing the ventral position of the sipho. Cannon Falls, Minnesota.	
Figs. 16 to 18*b*	ONCOCERAS MINNESOTENSE, sp. nov	798
16, 17, 18	Dorsal, ventral and lateral views of a specimen leading to the body-chamber; showing the longitudinal ridges of the surface.	
18*a*, 18*b*	Outlines of septa, showing the ventral position of the sipho. From the Galena beds at Lime City, Minn.	

[Cephalopoda.]

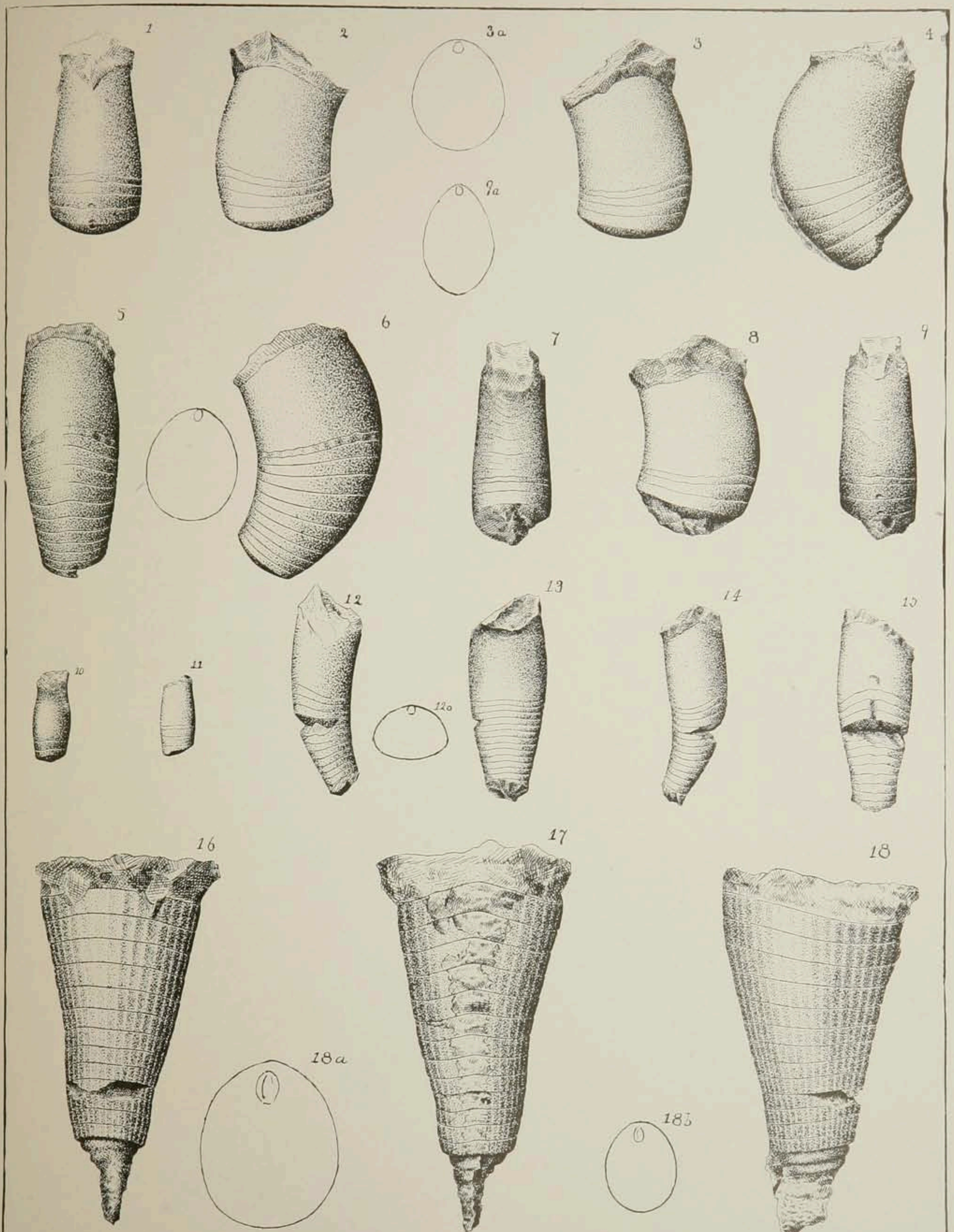

PLATE LIX.

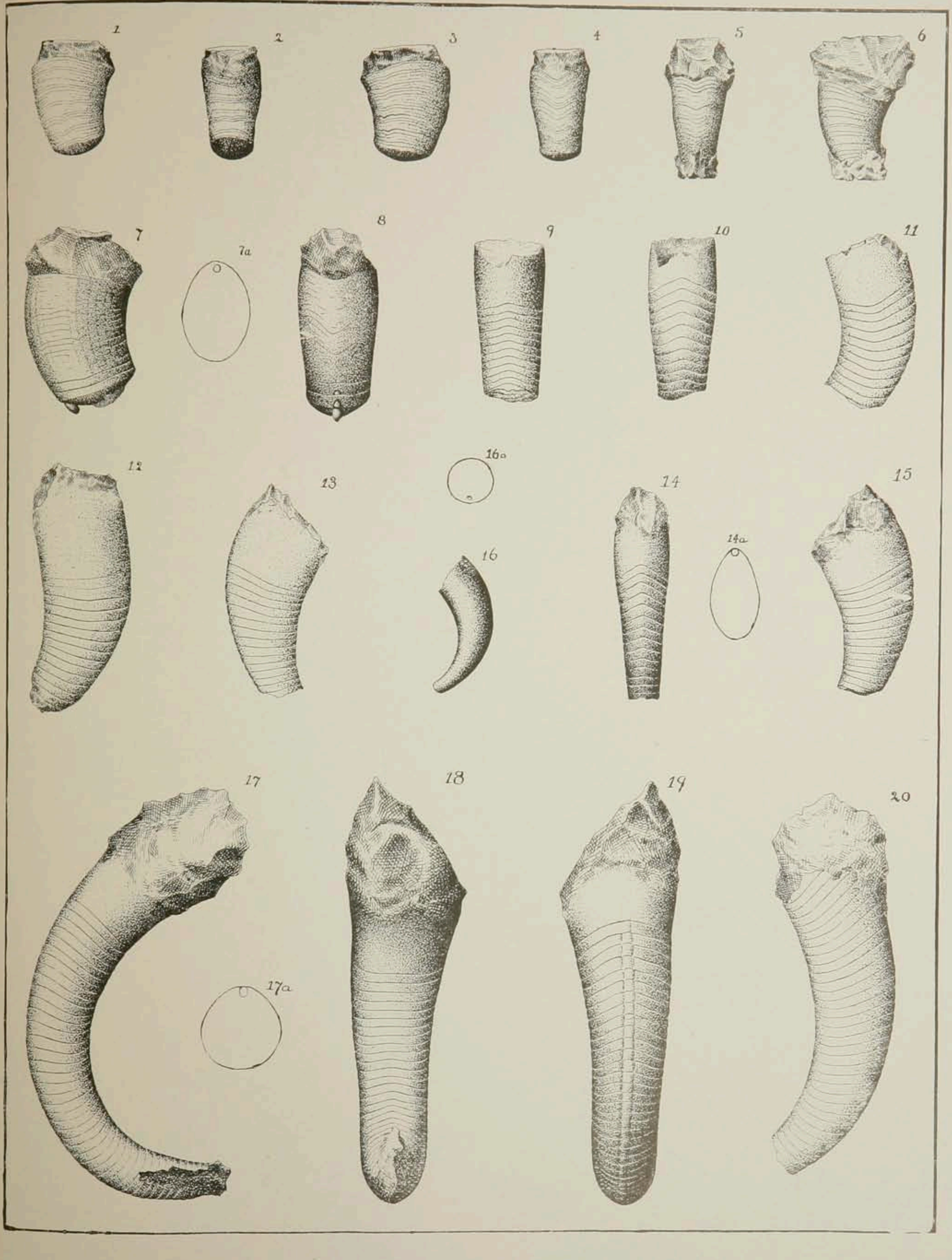
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PLATE LX.

		PAGE.
Figs. 1 to 4	CYRTOCERAS SHUMARDI, sp. nov. Dorsal, lateral, ventral and septal views of the typical specimen; showing its robust form, broad venter, outline and convexity of septum and position of sipho. Trenton limestone, Cannon Falls, Minn.	810
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(Cephalopoda.)