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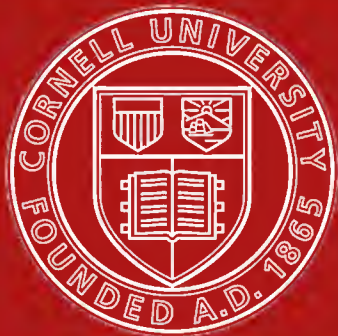
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The Lower Silurian Lamellibranchiata of



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CHAPTER VI.

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THE LOWER SILURIAN LAMELLIBRANCHIATA  
OF MINNESOTA.

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BY E. O. ULRICH.

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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 *Ambonychiidae* 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



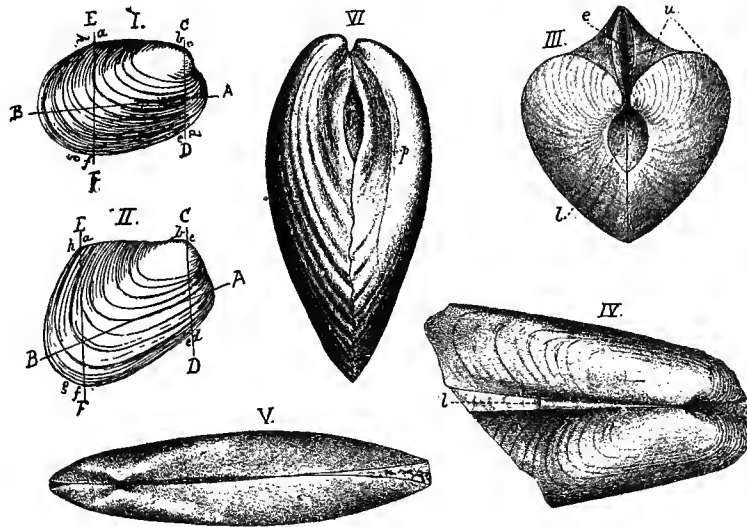
concentric, striation (growth lines) of the surface. But when the mantle edges are undulating or dentate the concentric growth lines are crossed by radiating striæ or plications.

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 high; E-F, posterior high; 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 *Cuneameya 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 *Orthodcsma* 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 *Chaenodomus 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 height 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 height 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 height*, the other across the posterior end, from the posterior extremity of the hinge, giving the *posterior height*. 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 *Ambonychiidae* 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.

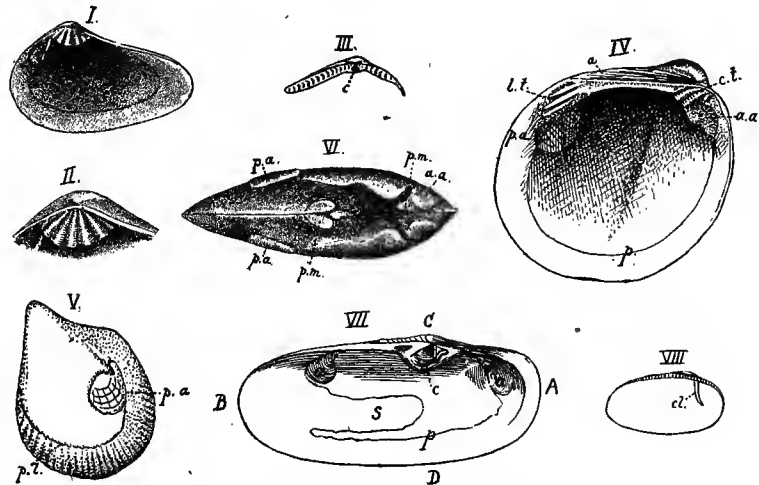


Fig. 36. Illustrating Hinge Types, Muscles and Pallial Impressions.

I and II, interior of a right valve of *Lyrodesma major* Ulrich, of the natural size, and the rostral portion of the valve  $\times 2$ ; 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 haynaldna* 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 classification 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.

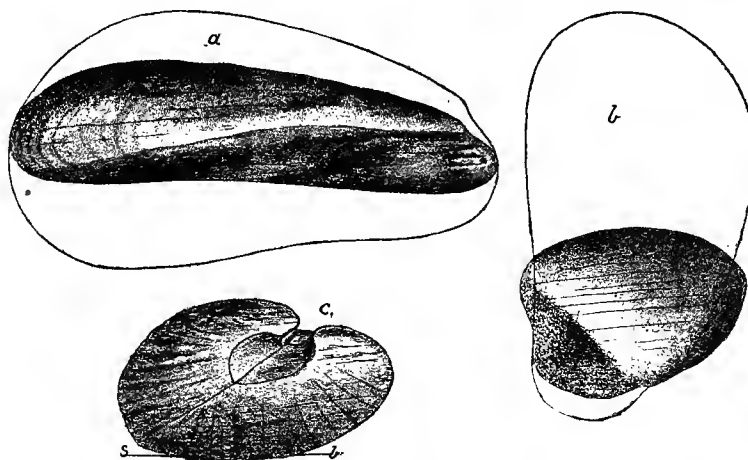


Fig. 37. Illustrating distortion of shells through pressure. *a*, right side of a specimen of *Modiolaris modiolaris* Conrad, the height of which has been reduced, as shown in outline, to less than half what it was originally. *b*, a shell of the same species greatly compressed lengthwise. *c*, the shell of an undescribed species of *Cuneameya*, 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 height; 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 laminae of the matrix, and an experienced student may, with their aid, at once determine the direction and perhaps the amount of the reduction of the particular dimension affected. It is to be remembered that the pressure under which the fossils suffer acts, except in comparatively rare instances, in a vertical direction only. Complete shells are generally compressed more or less obliquely, for the simple reason that after the death of the animal the natural position of the shell, with respect to the plane of the sea bottom, must be approximately as shown in fig. 37, c. For the same natural cause, the disunited valves are better calculated to preserve the original *outline*, because they are most likely to lie upon their inner edges, the latter being, therefore, at right angles to the direction of the pressure; in which case, under ordinary circumstances, the only dimension that can be altered is the thickness, this being reduced according to the amount of compression sustained by the surrounding rock.

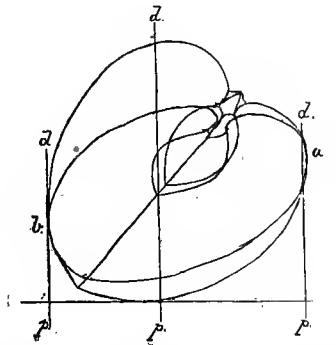


Fig. 38. Illustrating how to obtain a restoration of an obliquely compressed shell. The inner outline represents the specimen as it is now (see fig. 36-c), the outer one a restoration of its original form. S-B. plane of sea bottom; d.-p., direction of compressing force.

In making the restoration shown in fig. 38, only the two regions or points *a* and *b* can be assumed as having retained their positions on the original boundary, because there alone the outline of the shell coincides with the direction of the compressing force. The only effect the latter could have had upon them was to increase their convexity and to press them down slightly beneath their original positions. On all other points, however, the effect was a reduction in the convexity of the

outline and consequently of the size of the specimen. The rostral region of the right valve was greatly reduced and flattened, that of the left not so much reduced and made more strongly convex at *a*. In the lower half of the shell the result of distortion was reversed in the two valves. In the restoration, assuming the two valves to have been equal, we draw a curve through the point *a* that is intermediate in convexity between the flattened curve of the rostral half of the right valve and the sharpened one of the left. An equivalent curve is then drawn for the right valve and then continued to and beyond the point *b*. We now have the original outline of one of the valves as it would appear in an end view. The outline of the other valve being equally curved, only in an opposite direction, is then easily finished.

Having satisfied ourselves as to the original shape of the shell, it is first desirable to determine whether the valves are equal, as in *Modiolopsis* and *Whitella*, or unequal, as in *Pterinea* and *Aristerella*. Next we note the relation of the various parts of the outline to each other, the relative width of the two ends and other features bearing upon the determination of the *contour*. Now the position, altitude and degree of fulness of the beaks and umbones is taken into account. The former may be *terminal* (*i. e.*, situated at the anterior extremity of the hinge line and projecting as far forward as the margin beneath them), as in *Ambonychia*; or they may be nearly central in position, as in some species of *Ctenodonta*. Then the umbones may be strongly gibbous and the beaks curve over the hinge line (*Cuneomya*, *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 peculiarities, 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*); *Amphicoelia*, 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*, Koninek; *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; *Oræcardium*, 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; ? *Pyrenomæus*, Hall; *Yoldia*, Möller.

## Family LYRODESMIDÆ, Ulrich.

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

## Family TRIGONIDÆ, Lamarck.

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

## Family UNIONIDÆ

GENERA: ? *Amnigenia*, Hall; ? *Anthracosia*, King; *Priscoaia*, 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.

Classification of paleozoic Lamellibranchiata.]

Family PHOLADELLIDÆ, Miller.

GENERA: *Allorisma*, King; *Chænomya*, Meek and Worthen; *Cimitaria*, Hall; *Pholadella*, Hall; *Physatomya*, 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; *Ethydesma*, Hall; *Protomya*, Hall.

Family SOLENIDÆ, Adams.

GENUS: *Solenopsis*, McCoy; *Palæosolen*, Hall; ? *Orthonota*, Courad.

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 synonymy 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 synonymy 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 *Amphicælia*, 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, *Amphicælia* 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, *Amphicælia*, Hall, may

*Ambonychia planistriata*.]

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 *Amphicælia*) 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 *Amphicælia*. 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 PLANISTRATA *Hall*.

PLATE XXXV. FIGS. 3 and 4.

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

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

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

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

*Mus. Reg.* No. 8327.

AMBONYCHIA BELLISTRIATA *Hall*.

PLATE XXXV, FIGS. 1 and 2.

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

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

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

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

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

AMBONYCHIA AFFINIS, *n. sp.*

PLATE XXXV, FIGS. 5-7.

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

\*An examination of the types of the species, which are now preserved in the American Museum of New York City, proves that figs. 4a and 4b (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. 4d.



*Ambonychia affinis*.]

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. Rept. 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

*Clionychia nitida.*]

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 impossible 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  $85^{\circ}$ , postero-cardinal angle about  $115^{\circ}$ . 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 height about as eleven is to fourteen; gibbous in the umbonal, anterior and central regions, compressed and subulate posterodorsally. 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 somewhat 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 TENUISTRATA, *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 *Psiliconcha*, 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 particular, 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 *Cyrtodontidae*. Another feature in which the *Modiolopsidae* resemble the *Cyrtodontidae*, 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 modularis* 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 *Mytilidae*.

The many points of agreement that may be noticed between the *Modiolopsidae* and the *Cyrtodontidae* 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 height. 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 locality.*—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 height 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 height, and three times the height 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 nana*.]

*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 height 9.3 mm., the anterior height 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 4a, 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 height. 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 height 5.2 mm., anterior height 4.5 mm., thickness 3.3 mm.

This species is not elongate, like the *M. angustata* Ulrich, of the Cincinnati rocks, its anterior end is shorter and the sides of the valves flatter; with a better defined umbonal ridge than in *M. subparallela* Ulrich, also occurring in that higher series of strata at Covington, Kentucky. Compared with Minnesota species, it is perhaps



nearest *M. arguta*, with which it is also associated. It is, however, readily distinguished by its surface markings, which are not visible on the casts of that species, and by its less oblique anterior and posterior ends and more nearly parallel ventral and dorsal margins. In *M. faba* Hall, which is probably not a true *Modiolopsis*, the mesial depression is much more distinct. *M. nana* is wider and more oblique posteriorly, and has more regular surface markings.

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

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

PLATE XXXVI, FIGS. 11 and 12.

Shell small, elongate ovate, the length twice the greatest or posterior height. 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 height 6.6 mm., anterior height 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 height 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. Height of posterior third about two and one-half times as great as at the beaks. Dorsum gently arcuate; anterior two-thirds of ventral margin strongly concave, a fact due in a great measure to the

width of the mesial sulcus and the rapid descent of the surface included in it. Umbonal ridge slight, cardinal slope, convex. In a dorsal view the anterior half of the shell appears compressed, yet the point of greatest thickness is very near the middle of the length. Surface marked with simple concentric lines of growth. Hinge plate very thin, without teeth or appreciable thickening under the beak. Muscular scars not observed.

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

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

*MODIOLOPSIS CONCENTRICA* Hall and Whitfield.

PLATE XXXVII, FIGS. 15 and 16.

*Modiolopsis concentrica* HALL and WHITFIELD, 1875. Pal. Ohio, vol. ii, p. 86.

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

In casts of the interior the concentric furrows are distinctly visible on the posterior half of the cardinal slope. The mesial sulcus is much deeper and rather sharply defined on the posterior side by a strongly convex ridge extending obliquely across the cast from a point a short distance behind the beaks toward the basal margin, which, if the ridge did not become obsolete before reaching it, would be intersected at a point about three-fifths of the length of the shell behind the anterior extremity. In front of this ridge the surface is impressed and flattened to the

strongly elevated filling of the anterior adductor scar. The latter is large, of oval shape, horizontally marked in its upper half, sharply defined all around and, because of the brevity of the anterior end, is situated partly beneath the point of the beak. Posterior scar large, but so faintly impressed that its exact shape cannot be determined with the material at hand. Pallial line distinct only in the anterior half, where it consists of an obscurely pustulose raised line.

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

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

#### MODIOLOPSIS EXCELLENS, *n. sp.*

PLATE XXXVI, FIGS. 13-14.

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

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

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

*Mus. Reg.* No. 8374.

## Genus EURYMYA, n. gen.

*Modiolopsis* (part.) HALL and ULRICH.

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

Type: *Modiolopsis plana* Hall.

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

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

EURYMYA PLANA Hall.

PLATE XXXVI. FIGS. 27 and 28.

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

Shell rather small, compressed, subtriangular in outline, alate and highest posteriorly, the greatest height and length (the latter measured parallel with the hinge line) respectively as six is to seven. Cardinal margin straight, nearly as long

*Modiolopsis nana.*

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 height 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. modioliiformis* 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 height posteriorly. Anterior end comparatively long, contracted in front of the beaks. Valves moderately convex, usually with a strong umbonal ridge and a broad mesial depression in front of it, their edges fitting tightly along the straight or sinuate ventral margin, but leaving a narrow gape at each end. Umbones prominent, wide, compressed, often extending posteriorly as low cardinal ridges between which the hinge 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 neces-



sary. 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. cunei-forme* Miller, has recently been made the type of his new genus *Sphenolium*. This genus seems to be related to *Cuneamyia* and therefore cannot belong to the *Modiolopsidae*. *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 height is equal to once and a half times the height 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 height and more than three and a half times the height 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 synonymy 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 height; 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 *Cyrtodontidae*.

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.

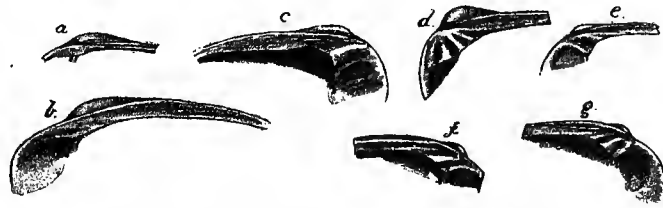


Fig. 40. Hinges of *Modiolopsis*, *Modiomorpha* and *Modiolodon*. *a*, anterior half of hinge of a right valve of *Modiolopsis versailensis* Miller, from the upper part of the Cincinnati group at Versailles, Indiana. *b*, hinge of a right valve of *Modiolopsis valida*, a new species from the top of the 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 margin. 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 *Modiolopsidae* 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 into 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 height 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 *Modiolopsidae* 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 height, 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 (height) 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 height; 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 subtruncated, 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 height 22 mm., anterior height 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 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*.

\*In Billings' figure 45 b (Palæozoic Fossils, vol. 1, 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. orthotum* M. and W., sp., being elongate, with the length a little more than twice and a half the height; 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 sharply 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 irregular 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. orthotum* 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 height. 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 illly 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.

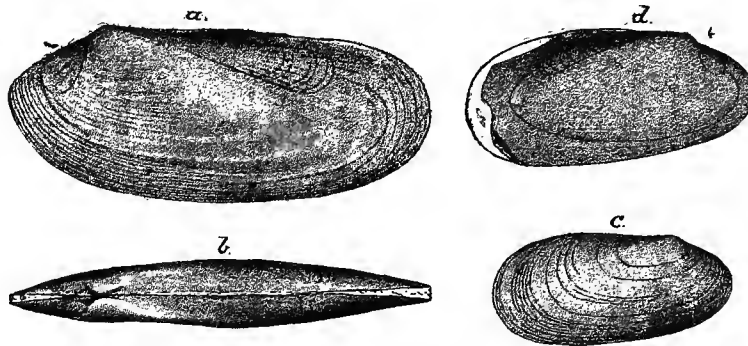


Fig. 42. *a.* and *b.* the left side and a dorsal view of an excellent cast of the interior of *Psiloconcha grandis*, n. sp., from the upper beds of the Cincinnati group, at Waynesville, Ohio. *c.* a right valve retaining the shell, and *d.* the right side of an internal cast of *Psiloconcha elliptica*, 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 height. Hinge line straight, nearly as long as the entire shell; anterior end rounded, much narrower than the posterior; basal margin gently and uniformly convex; posterior end subtruncate above, slightly produced and strongly rounded in the lower half. Valves rather strongly convex for the genus, the greatest convexity in front of and above the middle. Beaks small, situated between one fifth and one sixth of the length of the shell behind the anterior extremity. Umbonal ridge subangular in the rostral 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 distin-



guished by its greater height, 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 far at least as to claim that the case is far from proved. So far as we can now tell the last species of *Cyrtodonta* (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 *Cyrtodontidae* 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 *Cyrtodontidae*, 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 *Modiolopsidae*, 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 *Modiolopsidae* 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 *Ambonychiidae* and *Modiolopidae* were provided with a well developed epidermis those of the *Cyrtodontidae* preserve no trace of such a covering.

#### Genus CYRTODONTA, Billings.

*Cyrtodonta*, BILLINGS, 1858, Can. Nat. and Geol., vol. 3, p. 431.

*Palcearea*, 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 preceded 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. breviscula*, *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 supplementary 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 *plebeta* of Billings; *megambonus* and *quadrangularis* of Whitfield; *sterlingensis* Meek and Worthen; and *ventricosa* of Hall. The new genera *Ortonella* is founded upon *C. hainesi* S. A. Miller. *C. haymiana* 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 *Cyrtodonta*. 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 synonymous, 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, Kentucky. 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 height 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. janesevillensis* 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. janesevillensis* 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 indetical.

*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) height 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.; height 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 height, 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; height 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.; height 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 height 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.; height 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 *Cyrtodonta* 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 height 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.

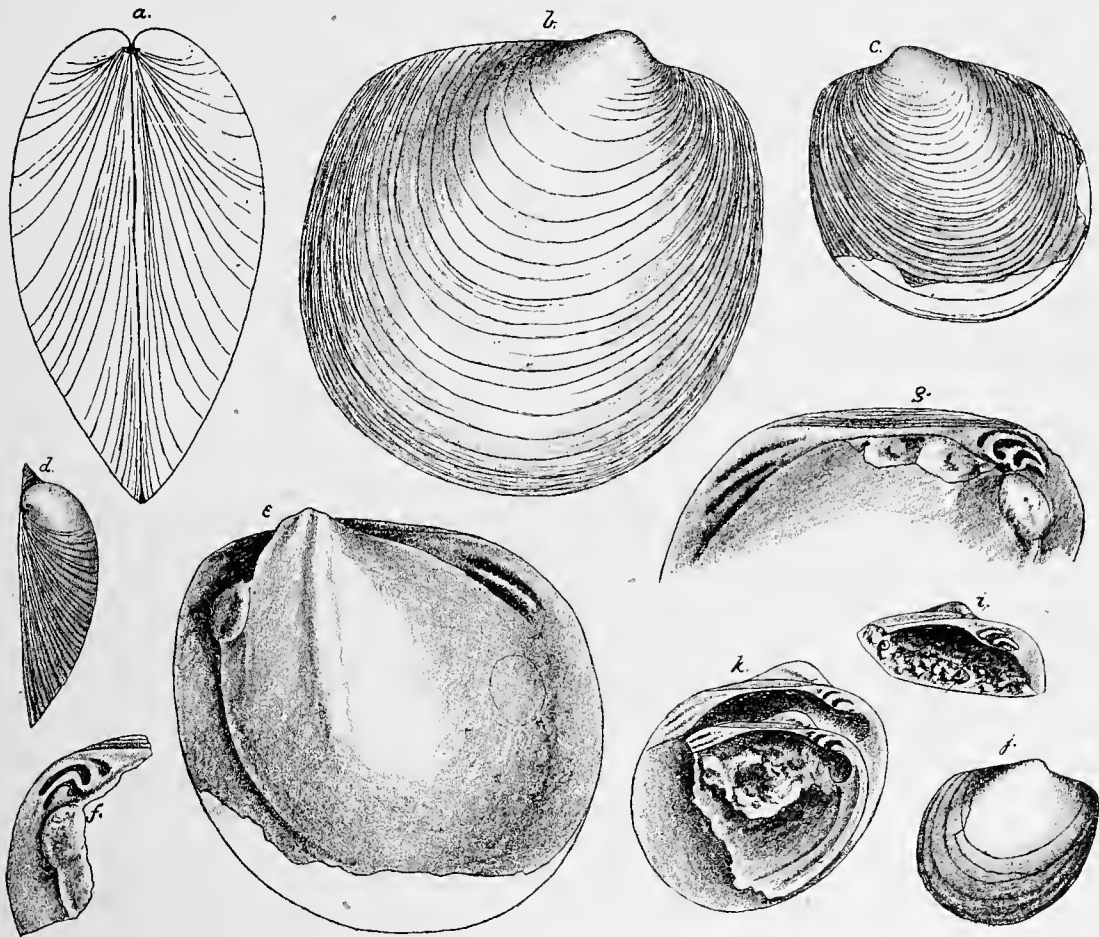


Fig. 43. *Cyrtodonta grandis*, and varieties. *a* and *b*, anterior and lateral views of a perfect specimen, upper Trenton, two miles south of Burgin, Kentucky. *c* and *d*, lateral and antero-cardinal views of a small left valve of same, with stronger surface markings than usual; from same formation 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. *h*, hinge of specimen shown in figure *c* and *d*. *i*, hinge of specimen shown in figure *c* and *d*. *j*, original type of *C. germanus*, 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. 5a, 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

*Vanuxemia dixonensis*, var. *insueta*.]

shell itself, and a flattening of the surface beneath them is usually distinguishable. Anterior muscular impression distinct, reniform, the pair forming a strongly defined lobe at the base of the beaks. Posterior scar large, but very faint. Pallial line rather indistinct, except in the anterior part.

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

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

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

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

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

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

PLATE XXXVIII, FIGS. 6 and 7.

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

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

VANUXEMIA ROTUNDATA *Hall*.

PLATE XXXVIII. FIGS. 8-14.

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

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

This species is very similar to *V. dixonensis* Meek and Worthen, and in another direction quite as much like *V. suberecta* Ulrich. Still, as it is very constant in its peculiarities, and not at all difficult to distinguish, it should be recognized as a distinct species. From the first it differs in being shorter from the beaks to the base and therefore circular rather than ovate in outline. The form of the casts, the only condition in which the species has been observed, is more erect, the beaks curving much less forward so that the anterior margin projects considerably beyond them. The anterior sulcus is on the whole stronger, the pallial line more distinct, and the average size of the shells little more than half what it is in *V. dixonensis*. In other respects, including the hinge, the two species are practically identical. 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. 25101, 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. 232.

*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  $62^{\circ}$ ; 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  $135^{\circ}$ ; 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 height 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 defined, 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 *Ambonychiidae* are an off-shoot from the same line of development that produced *Vanuxemia* and the rest of the *Cyrtodontidae*.

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 height 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 height; 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  $40^\circ$  with the hinge line. Cardinal teeth varying in number and size. As a rule they are at least  $10^\circ$  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 height 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, *Cryptodonta glabella* Ulrich, has a similar outline, but there is no relationship between them since that species is as true a *Cryptodonta* 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. 1, 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 *Cypricardites niota* reads as follows: "Shell broadly subovate, broadest at the posterior end; umbones very gobbous, beaks incurved, little elevated, situated about one-fourth of the length of the shell from the anterior end. Cardinal line straight or little curved; anterior, posterior and basal margins rounded." Anterior muscular impression situated near the cardinal line, well defined; posterior imprint obscure. Surface of the shell marked by concentric lines of growth. This species differs from *C. rotundata* in being more oblique, in the straighter cardinal line, and less ventricose form. It is intermediate between that species and *C. ventricosa*, from which it differs in less obliquity and the greater length from beak to base." "Length, one inch and a quarter; height, 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. 189.

Shell large, moderately ventricose, suberect, subcircular, the length a little greater than the height, 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 height 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 height 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 interior has been produced the difficulties will have been overcome, since the *Vanuxemia* may then be distinguished at once from the *Cyrtodonta* by the much greater distinctness and character of the anterior muscular scar. (Comp. figs. 3 and 42 on plate xxxix.)

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

*Mus. Reg.* No. 5100.

#### Genus MATHERIA, Billings.

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

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

Type: *Matheria tenera* Billings.

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

#### MATHERIA RUGOSA Ulrich.

PLATE XXXVI, FIGS. 29 and 30.

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

Shell large for the genus, trapezoidal, widest posteriorly, with the beaks nearly terminal, small, incurved, projecting slightly above the hinge; a strongly convex

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

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

Several additional specimens of this well marked species were collected during the summer of 1892, among them an entire left valve showing the hinge. This has two cardinal teeth and no posterior laterals, so that there can be no longer any question as to the generic position of the shell. Only two other species belonging to this genus are known to have been described. These are *M. tenera* Billings and *M. recta* (*Modiolopsis recta* Hall), from both of which *M. rugosa* differs in the much greater height 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 oblique 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 height, 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.

*Cypriocardites 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 height subequal, the latter probably a little the greater; thickness more than two-thirds of the height. 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 margin; 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 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 may 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 reappearance 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. precipita*, 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 Minneapolis, 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 height, 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 height, 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 height, 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 considered 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 Whitfield in 1882, since in these cases we are dealing with unequivocal 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. præcipita* 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 præcipita* 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 *Megalodontidae*. 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 convex 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 height. In many the outline is elliptical, in some subrhomboidal, in others rounded and in a few subtriangular. In some the umbones are comparatively 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, *planodor-sata* 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.

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\*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 *Axincea* and other *Arcidae*. If this work was not already growing beyond the limits allotted 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 *Axincea* (e. g. *A. sulplanata* *Stoliczka*) are strikingly similar to the *C. petunculoides* section, the only difference of real consequence

being the presence of a low triangular striated area between the beaks and the hinge in the *Axincea*. Other *Arcidae* 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 height; 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 Pauquette'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 height 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.; height 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 striae. 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 height, 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 striae 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 Canadian 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. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 217.

Shell small, moderately convex, subtriangular or trapezoidal, the height, length and thickness, 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  $105^\circ$ ; 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 omission 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 height. 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. planadorsata*, 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 sub-triangular, 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 differentiations 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. levata* 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 striae 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.; height, 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. scoufieldi*, 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 numerous denticulated. Similar differences distinguish *C. albertina*, a well marked species having also a stronger hinge and geniculated teeth. The following species, *C. calvini*, is probably nearer than any other species now known.

*Formation and locality*.—Very abundant in the lower so-called Maquoketa shales near Dubuque, Iowa; Scale's Mound, Illinois, and Platte's Mound in Lafayette county, Wisconsin. The species occurs also in Fillmore county, Minnesota, in equivalent beds (Hudson River group), though but rarely.

CTENODONTA CALVINI, *n. sp.*

PLATE XLII, FIGS. 61-64.

Shell subquadrate-ovate, about 15 mm. long, 12 mm. high and 6 mm. thick; anterior end rounded, a trifle narrower than the slightly truncate posterior end; the latter is a little oblique, gently convex except below, where the outline turns rather sharply into the broadly rounded base; above it forms an obtusely angular or rounded junction with the straight post-cardinal margin; in front of the scarcely prominent beaks, which are situated about one-third of the entire length behind the anterior extremity, the outline is more or less concave. Surface of valves rather uniformly convex, with the posterior umbonal ridge strongly rounded, though in no case conspicuous. External surface markings not observed. Casts of the interior exhibit a few concentric undulations, and in the central and ventral parts a variable number of obscure rays. The test seems to have been unusually thin. Hinge plate very narrow, bent at the beak, straight behind, gently concave in front; denticles small, oblique, about sixteen posterior and eight or ten anterior in each valve. Adductor muscular scars very slightly impressed, the posterior one extended above, larger and longer than the anterior, and placed in the middle of the cardinal slope, so that its long axis is parallel with the umbonal ridge; several small umbonal scars may be observed.

This fine species, though closely related, is at once distinguished from *C. fecunda* by its greater posterior height 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 striae, 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 height, 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.; height, 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 FILISTRATA, *n. sp.*

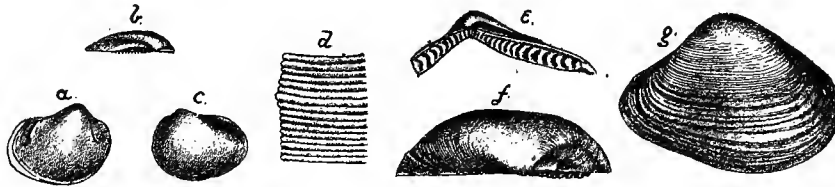


Fig. 44. *a*, right side of a cast of the interior of *Ctenodonta filistriata*, *n. sp.*; *b* and *c*, cardinal and lateral views of left valve of same; *d*, small portion of surface of same, highly magnified; *e*, hinge of a right valve of same,  $\times 2$ ; specimens from lower beds of the Cincinnati 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 height 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 immediately 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 height 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, height 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 height almost equal, the thickness equalling about one-third of the height. 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 striae, 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 height 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 illly-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 height 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 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 height 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 species. 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 height. 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.; height, 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 height 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 transversely 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 semi-circular 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 *Ischyрина*, 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 CANNONSENSE, *n. sp.*

PLATE XLII, FIGS. 6-8.

*Nucula poststriata* HALL, 1847. Pal. N. Y., vol. 1, p. 151, pl. 34, fig. 2a, 2b. (Not p. 301, pl. 82, figs. 10a, 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.

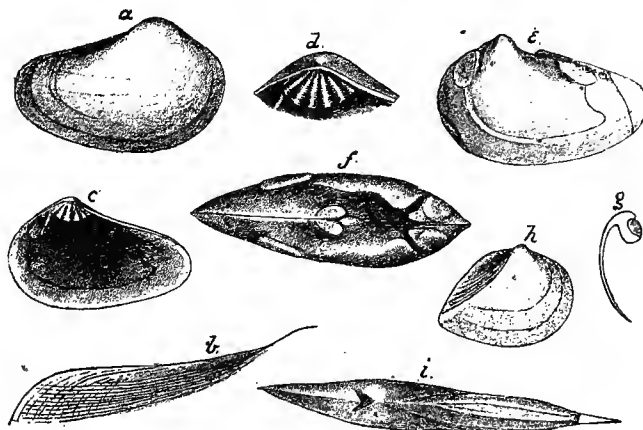


Fig. 45. *a*, right valve of *Lyrodesma major* Ulrich; *b*, cardinal slope of same,  $\times 2$ , showing the fine radiating striæ; *c*, interior of a right valve; *d*, hinge of same,  $\times 2$ ; *e*, left side of a cast of the interior of same, showing the muscular scars and pallial line with unusual 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,  $\times 2$ , 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 height of same (from beaks to basal margin) respectively, 11, 15 and 18 mm.; greatest thickness subcentral, somewhat greater than half the height; anterior margin rounded, most prominent immediately above the middle of the height, 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 *Ischyryna* 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. *Ischyryna*, 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 *Ischyryna*.\*

\* 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 *Ischyryna 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. 45-4.

*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 height 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. 191.

Shell small, rather ventricose, alated posteriorly, the height and length respectively as two is to three. Cardinal margin nearly straight, anterior end uniformly rounded, ventral edge more gently curved, the posterior 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., height 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 height 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., height 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 height. 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., height at the beaks, 5.8 mm., height 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 height; 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 height. Cardinal outline declining anterior to the beaks, slightly sinuate posterior to them;

\* A recent examination of Billings' original types of Canadian Lower Silurian Lamellibranchs 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 height, 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 certainty. 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 height, 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 height 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 *Grammysiidae* and the *Pholadellidae*. 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, height 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 striae 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 height and length very nearly as four is to five; beaks small, declining, situated at the anterior extremity of the distinctly arcuate dorsum, and projecting forward as far as the margin of the shell beneath it. Anterior margin distinctly concave in the middle, the lower part narrowly rounded; ventral margin rather strongly convex, posterior margin subtruncate, a little oblique, the upper half straight or slightly sinuate, the lower rounded. Surface of valves moderately convex, with a very inconspicuous umbonal ridge between which and the dorsal edge there is a shallow sulcus. Escutcheon well defined, extending the full length of the hinge, in a dorsal view very narrow between the beaks, wide at the middle, and narrowing again posteriorly. Lunule sharply defined, very deep, nearly twice as long as wide. Surface marked by subimbricating concentric growth lines. These are rather small but sharp and of nearly equal size for a short distance beneath the cardinal edge, and only a few of them seem to cross the umbonal ridge. Internal characters of hinge as shown in figures 37 and 41. Anterior muscular scar of medium size, subcircular, deep, showing very prominently on casts of the interior; pallial line and posterior muscular impression very faint.

This species is distinguished from *S. sulcodorsata* by its shorter form, terminal beaks, and more rounded ventral margin.

*Formation and locality*.—Upper beds of the Hudson River group near Spring Valley, Minnesota, and Iron Ridge, Wisconsin.

*SAFFORDIA SULCODORSATA* *Ulrich*.

PLATE XLI, FIGS. 32 and 33.

*Cuneamya sulcodorsata* ULRICH, 1892. Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 248.

Shell small, moderately convex, oblong-subquadrate, with the dorsal and ventral margins subparallel and gently convex, the posterior end truncate, very slightly produced and sharply rounded at the base, anterior end very short (long for the genus), narrowly rounded. Beaks subterminal, declining forward, strongly incurved, projecting forward rather than upward; umbonal ridge moderately prominent, not angular. Dorsal slope with a distinct expanding sulcus; ventral and anterior slopes gently and uniformly convex. Hinge line, posterior to the beaks, long, the edge

inflected so as to form a well marked escutcheon. In front of and beneath the beaks a deep lunule. Surface marked with regular, concentric folds, obsolete on the cardinal slopes, and by two or three times more numerous fine striæ, which seem to have extended over all parts of the surface.

This neat shell was at first described as a *Cuneamya*, but with the discovery of the closely allied *S. ventralis* it became evident at once that the species had been misplaced. Compared with the type species it is found to differ in its form, the dorsal and ventral margins being much less curved and the outline decidedly oblong instead of rather broadly oval. The umbonal ridge also is somewhat better defined and the anterior end of the shell projects beyond the beaks which is not the case in *S. ventralis*.

*Formation and locality.*—At the top of the Hudson River group, Spring Valley, Minnesota.

SAFFORDIA MODESTA *Ulrich.*

PLATE XLI, FIGS. 29–31.

*Cypricardites? modestus* ULRICH, 1892. Amer. Geol., vol. x, p. 100.

Shell small, moderately ventricose, obliquely ovate in outline, known from casts of the interior only. In these the anterior end is very small, sharply rounded, abruptly depressed beneath the beaks, projecting very little beyond them, and almost entirely occupied by a subcircular muscular scar. Beaks small, only slightly incurved, appearing prominent. Umbonal ridge scarcely distinguishable, the cardinal slope faintly concave between it and another low ridge-like swelling that forms the back of the cast. Along the hinge line there is a narrow impressed area. The lunule, like the escutcheon, is proportionally narrower than in the other species. Shell thin; hinge plate narrow, apparently with the characters (as shown by recently obtained material) required by the genus.

As near as can be determined from casts of the interior only, this species would appear to occupy an intermediate position between *S. ventralis* and *S. sulcodorsata*, being longer than the first and shorter than the second.

*Formation and locality.*—Lower half of the Galena at Oshkosh, Wisconsin, and several localities in Goodhue and Fillmore counties, Minnesota.

*Errata for the Chapter on Lamellibranchiata.*

## PAGE.

- 477, 6th line from bottom, for *Chænodomus* read *Cymatnота*.
- 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 LYRODES MIDÆ should be restricted to the typical genus, and *Allodesma*, Ulrich, referred to the family CYCLOCONCHIDÆ (next page) while *Technophorus*, Miller, and *Ischyryna*, Billings, should follow as a distinct family, TECHNOPHORIDÆ. (See p. 608.)
- 504, 17th line from bottom, refer *M. truncata* Hall, to *Modiolodon* instead of *Eurymya*.
- 512, 9th to 14th line from bottom, *dele* remarks on *Modiolopsis truncata* Hall.
- 513, 5th line from bottom, for ACTINOMYA read WHITEAVESIA. It was learned too late to make the corrections in their proper places that the name *Actinomya* had been preoccupied by Mayer for a Cretaceous or Tertiary genus of shells. A new name is therefore necessary for the Silurian genus, and it gives me much pleasure to propose *Whiteavesia*, after Prof. J. F. Whiteaves, the successful paleontologist to the Geological Survey of Canada. The reader will please substitute the new name for the other in the following places: Page 485, 4th line from bottom; p. 501, 12th line from top; p. 504, 14th line from bottom; p. 505, several instances in second and third paragraphs; p. 506, 1st line from top; p. 513, 5th line from bottom; p. 514, several instances in third and fourth paragraphs; p. 515, 1st and 6th lines from top, and 4th and 5th lines from bottom; p. 516, 5th and 7th lines from top; p. 517, 7th and 17th lines from top; p. 518, 16th line from top; p. 524, 8th and 10th lines from bottom; and p. 531, 5th line from top.
- 520, 1st line from top, after ORTHODESMA CANALICULATUM add *n. sp.*
- 563, 19th line from top, for 5100 read 8626.
- 592, 19th line from bottom, for CTENDONTA read CTENODONTA.
- 593, 9th line from bottom, for *C. leveta* read *C. levata*.





PLATE XXXV.

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10. A small, but unusually well preserved cast of a left valve showing the impressions of the posterior adductor and pedal muscles, pallial line and ligamental area. This specimen is precisely like those which Hall named <i>A. attenuata</i> , but its less quadrate shape is evidently the result of pressure. Trenton limestone, Minneapolis, Minnesota.	
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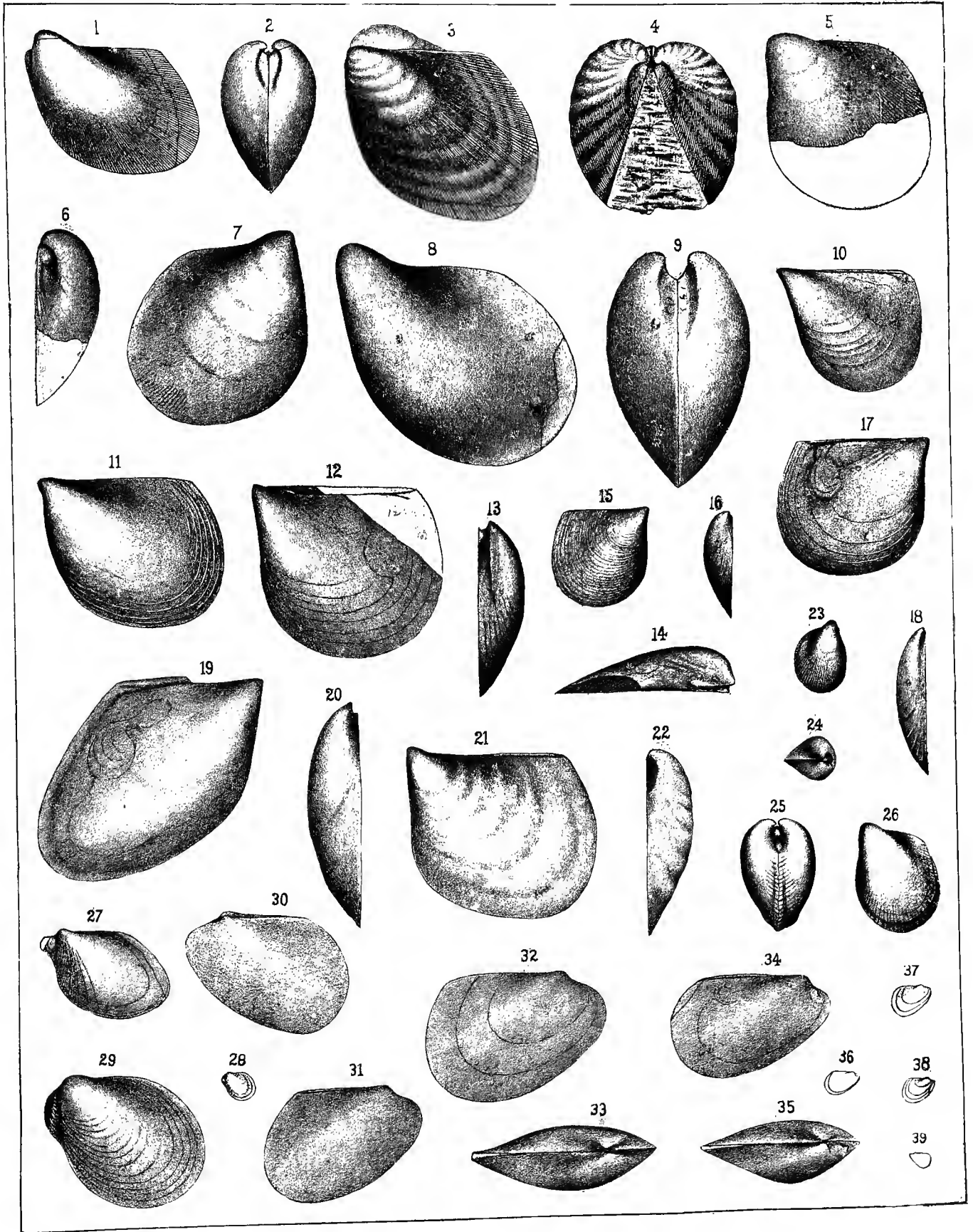




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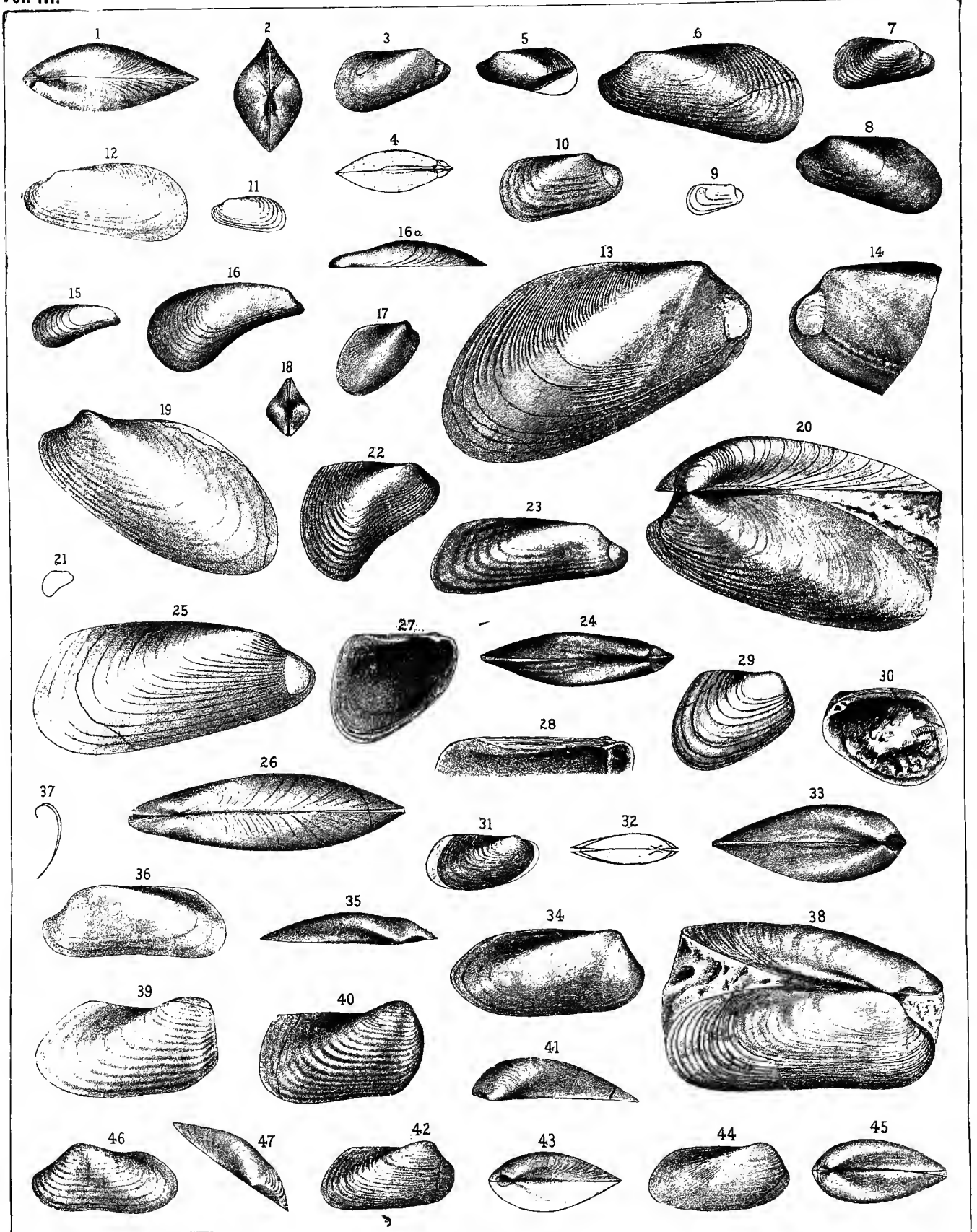








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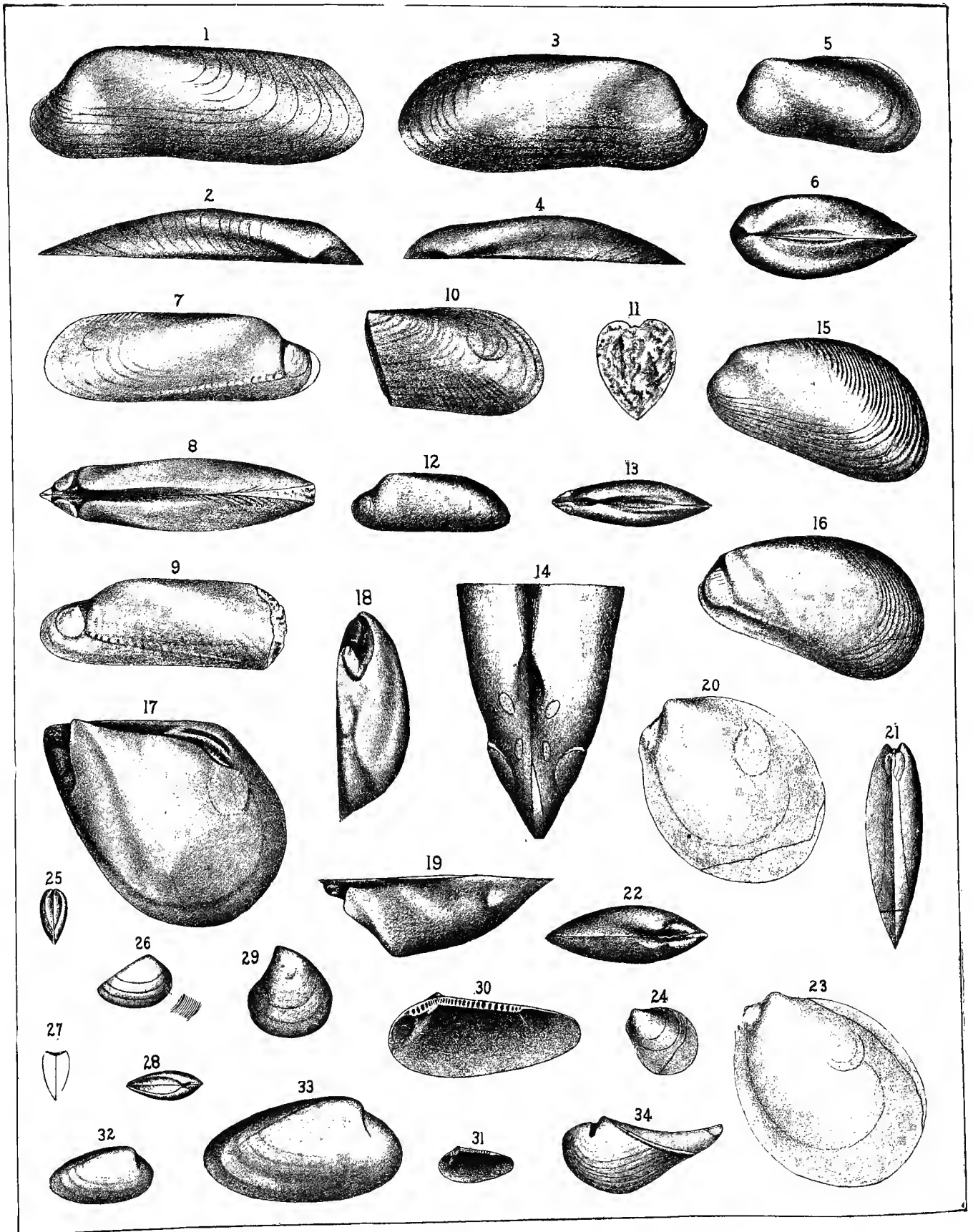






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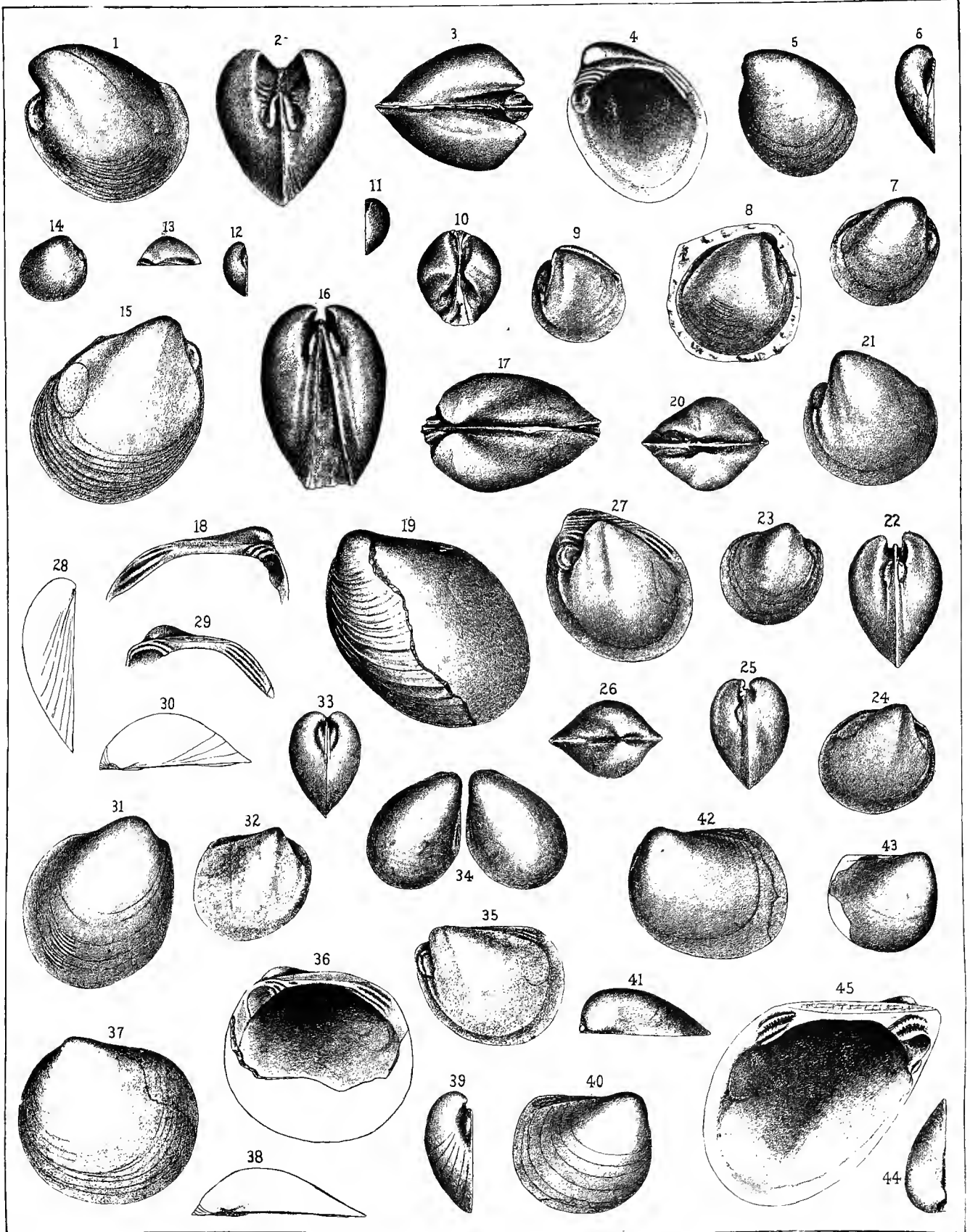








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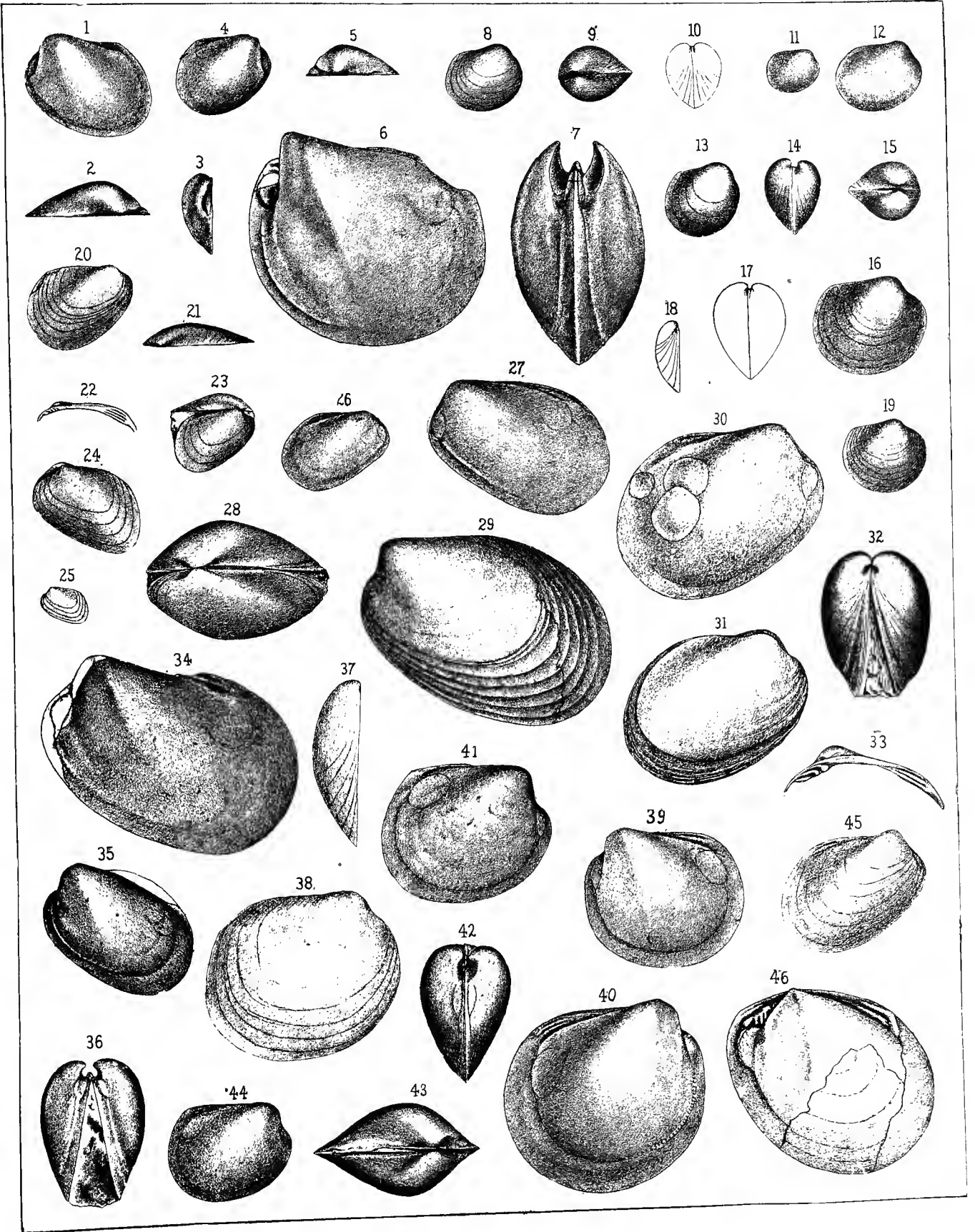






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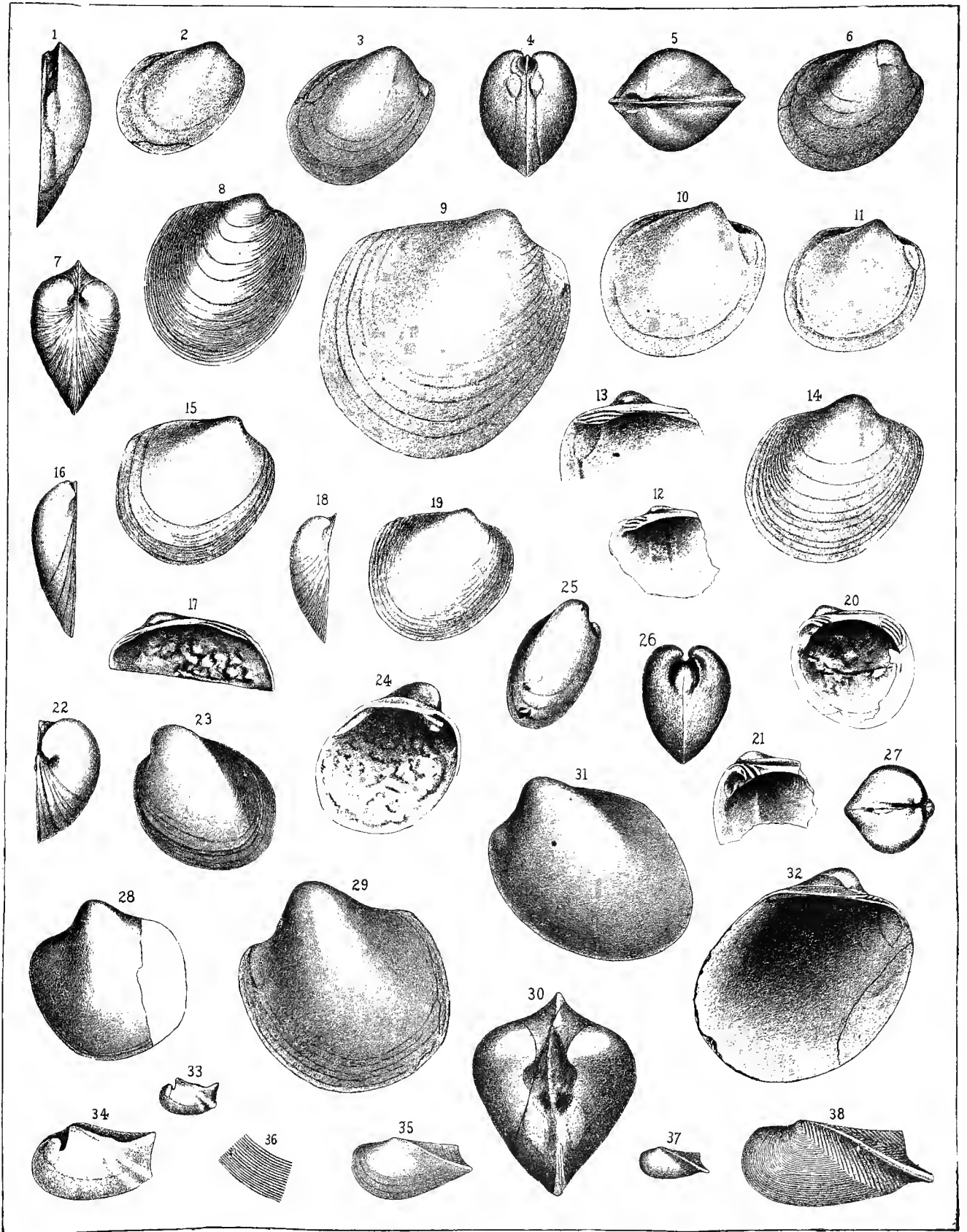








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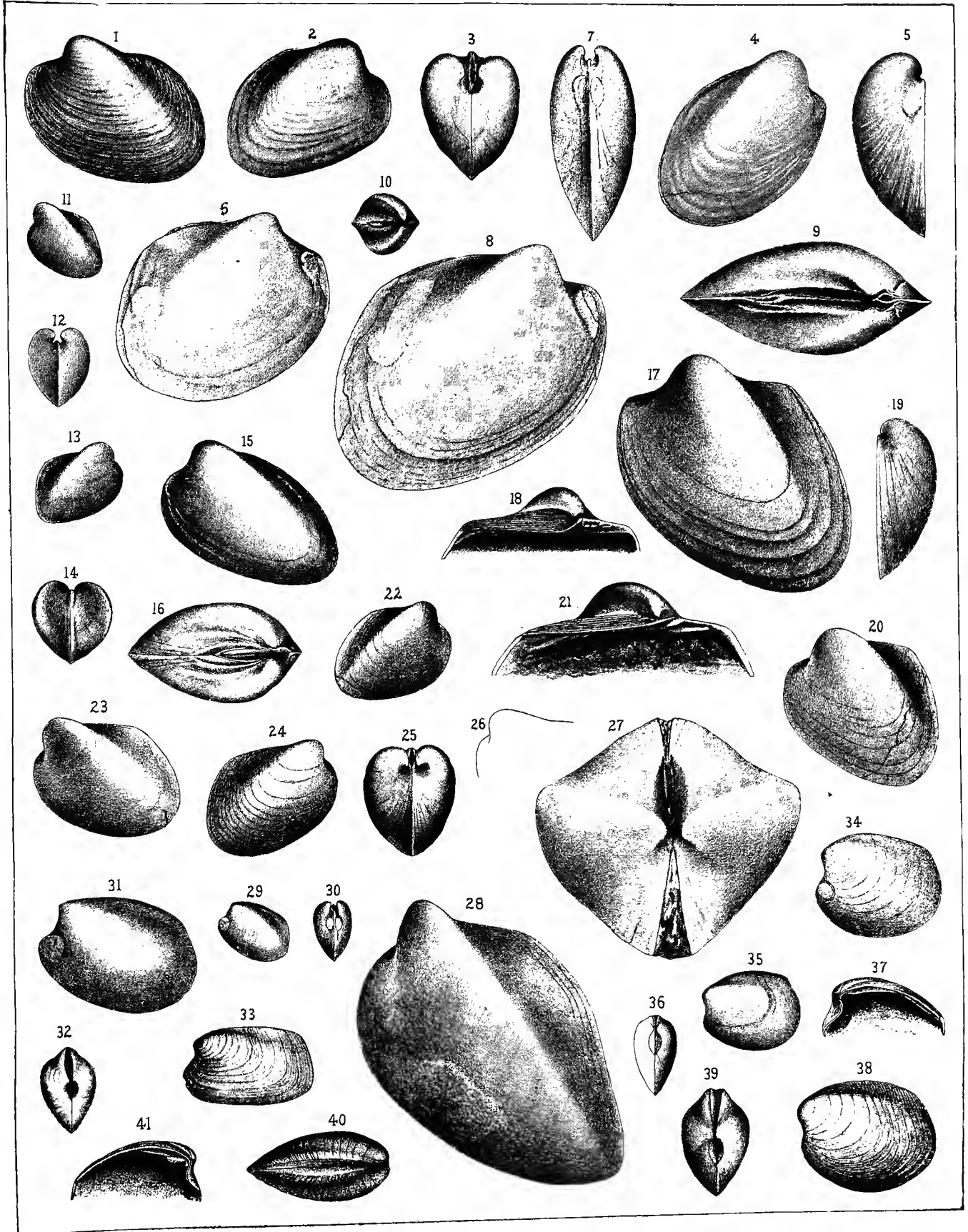




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