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N. H. WINCHELL,

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NEW LOWER SILURIAN LAMELLIBRANCHIATA, CHIEFLY FROM MINNESOTA ROCKS.

BY E. O. ULRICH.

In the following pages I endeavor to give full descriptions and, it is hoped, sufficient illustrations of the principal and generally the more striking of the new Minnesota forms of this class that have been brought to my notice since 1885. Much of the material now described I owe to the disinterested kindness of Prof. C. W. Hall, of the State University, and to the unfailing friendship of my co-laborer, Mr. W. H. Scofield, of Cannon Falls. The last sent me every shell and cast of the interior contained in his extensive private cabinet. Many were in a good state of preservation, several belonged to species that I had not before seen (among them the remarkable shell from which I was enabled to work out the characters of the new genus *Plethocardia*), and all proved of material aid to me in determining the essential characters, variations, and limits of the species studied. The value of such aid may be better appreciated when I state that the Minnesota Trenton Lamellibranchiata are no exception to a rule that seems to prevail nearly every where in these rocks, namely, that in most cases the individuals of the species are anything but abundant. Yet, a few forms have been found in considerable numbers, and my observation would indicate that the majority of these shells are more or less gregarious in their habits, so that the number of known specimens of a species may at any time be greatly augmented.

In the Minnesota Lower Silurian rocks, excluding the beds beneath the top of the St. Peter's sandstone, the Lamellibranchiata are confined very largely to six horizons. The first of these is in the upper part of the Trenton limestone in which the fossil itself is almost invariably dissolved away so as to leave good moulds of both the exterior and interior in the matrix. This method of preservation is most favorable, since with the aid of gutta percha the judicious collector may study the most important of the original characters of the shells with comparative ease. Individuals of *Cypricardites rotundus* Hall, are abund-

ant, while another form of the genus near *C. ventricosus* Hall, and *Modiolopsis plana*, of the same author, are not uncommon. The types of *Cypricardites sardesoni* and *C. obtusifrons*, of this paper, are from the same bed, as are several other forms not yet specifically determined.

The second horizon is in the middle third or "Rhinidictya beds" of the Trenton shales. It has afforded *Modiolopsis similis*, *Orthodesma minnesotense*, *Technophorus extenuatus*, *Tellinomya nitida*, *Cypricardites cingulatus*, *C. glabellus*, *C. obtusifrons?*, *Whitella compressa*, and *W. concentrica*, all described by the author. Several other species are represented in my collections by specimens too illy preserved to admit of a satisfactory determination of their affinities.

The third horizon is in a bed that I place near the top of the upper third of the Trenton shales. It is exposed at a locality about six miles south of Cannon Falls, Minn., where it is overlaid by the Galena shales. It is the most interesting horizon for these fossils known to me in the state. Perhaps it is a local deposit, at any rate, none of the Lamellibranchiata described by me from this locality are as yet known in the same position from other points. An incomplete list of the species is as follows: *Tellinomya compressa*, *T. levata* (Hall), *T. planodorsata*, *T. pulchella* (Hall), *Lyrodesma poststriatum* (Emmons), *Modiolopsis concava*, *M. faba?* (Emmons), *Matheria rugosa*, *Cypricardites tenellus*, *C. haynianus?* (Safford), *Whitella scofieldi*, and *Plethocardia umbonata*. All of these species are preserved with the shell, from which the matrix can be cleaned with unusual ease.

In the fourth horizon, a bed of light colored shales underlying the Galena limestone, known to the survey as the Galena shales, all the shells of this class are preserved as casts of the interior. These are sometimes highly satisfactory, yet too often the opposite is true. Many of the specimens from this horizon therefore remain unclassified, and until better material becomes available it will not be possible to give a full list of the species. At least two, and very likely three species of *Cypricardites*, one of them probably *C. haynianus* (Safford), can be made out, besides *Tellinomya levata* (Hall), *T. planodorsata*, *Modiolopsis subelliptica*, *Whitella truncata*, and *Plethocardia suberecta*. There is also an elongate *Tellinomya* near *T. nasuta* Hall, a *Modiolopsis* near *mytiloides* Hall, and enough of other distinguishable forms to bring the total number to fifteen or more.

The fifth horizon is a layer a few feet thick at the base of the Galena limestone that I have named the "Platystrophia beds"

in an unpublished section of the Lower Silurian rocks of Minnesota. From this bed I have seen *Cypricardites tenellus, C. nanus?, Tellinomya astartiformis* (Salter), *T. intermedia, Cleidophorus consuetus,* and several undetermined forms.

The sixth horizon occurs in the Hudson river group at Spring Valley and other points in the southern part of the state. This formation is very thin in Minnesota, and the part represented is equivalent to the upper beds of the group as developed in Ohio and Indiana. Fossils are exceedingly plentiful in some of the layers, but consist chiefly of Brachiopoda. As a rule the Lamellibranchiata have suffered through compression, but a good proportion are in an excellent state of preservation. Among them I have recognized *Ambonychia casei* Meek and Worthen, *Whitella obliqua, Lyrodesma major* (described originally by me as *Cleidophorus major*), *Tellinomya recurva,* and *T. similis,* all species occurring also in Ohio. The *Cuneamya sulcodorsata* is, so far as is now known, restricted to this locality. Among the undetermined forms there is a *Modiolopsis* near *pholadiformis* (Hall), another near *M. concentrica* (Hall and Whitfield), one or two species of *Orthodesma,* and a *Tellinomya* near *iphigenia* of Billings.

Respecting the classification of Silurian Lamellibranchiata, it may be well to state that with the progress of our studies we have now arrived at a point where we can appreciate the heterogeneous character of the numerous forms grouped under the generic names *Modiolopsis,* and *Cypricardites,* and in a less degree *Pterinea, Ambonychia, Tellinomya, Cleidophorus,* and *Orthodesma.* I realize fully the inadequacy of the present grouping of the species, yet follow in the same tracks because I fail to see any remedy giving both rapid and permanent relief. Now and then a sharply distinguishable, because essentially Silurian, generic type may be encountered, but many others are indicated which it would be unwise to separate before being closely compared with the wealth of Devonian and Carboniferous forms now known. But that involved more time and labor than I found myself able to devote to the subject, and rather than increase the difficulties of revision, which must be undertaken sooner or later, I have, perhaps unwisely, allowed many species that were determined over ten years ago to be new to science, to lie unpublished in my cabinet. After fully considering the matter, it now appears to me that an incomplete knowledge of our fossil Lamellibranchiata is better than none at all, since the necessity for work in the branch will become all the more evident to students. It was therefore largely in the hope of entic-

ing other energies to the field that I began a series of publications on the subject in the American Geologist. The first of these appeared in the May number, the second in the September, and the third in the December number of that journal, during 1890. It was my intention to continue the papers through the two volumes for 1891, but illness prevented. Among the contemplated papers, one or more which I hope to publish during the present year, is one on species of *Tellinomya* and *Lyrodesma*, a second on *Cleidophorus*, *Cycloconcha*, and *Matheria*, a third on *Orthodesma* and related genera, a fourth on *Cuneamya*, and a fifth on *Ambonychia* and *Pterinea*. When these are published, and the results added to the present paper and the previous publications by Hall, Miller, Meek, and others, the Lower Silurian Lamellibranchiata will have arrived at a promising stage for good classificatory or monographical treatment. Whether or not I shall extend my work on them beyond that stage depends upon circumstances and the success of my endeavors to induce some one of our young paleontologists to take up the group as his specialty.

Two disputed points of nomenclature came up during the preparation of the present paper. The first pertains to the claims for recognition of *Ctenodonta*, Salter, as opposed to *Tellinomya*, of Hall. The latter name has priority, but Hall's original description is so faulty that no blame can attach to Salter for failing to recognize the genus. *Ctenodonta*, on the other hand, was established in a manner so satisfactory that no marked improvement on his diagnosis has since been attempted. Salter's name was adopted by Billings and Safford in this country, and it is now quite generally used in Europe. Hall's name however is used by most American authors. My own views on the points at issue are undecided, and I wish it to be understood that the adoption of *Tellinomya* in the following pages is not to be considered as final, but rather as provisional and in deference to the views of friends and the claims of the venerable author of the name.

The second point, relating to *Cypricardites* of Conrad and *Cyrtodonta* of Billings, brings up questions equally difficult to decide. I shall not here enter upon a discussion of the claims so ably upheld by Hall on the one side, and Billings on the other, and my adoption of *Cypricardites* is to be considered as no more final than in the case of *Tellinomya versus Ctenodonta*.

The thirty two cuts which illustrate the species described in this paper have been reproduced from my own drawings. In

every case the figures have been drawn with great care, and may be relied upon as representing the characters of the species so far as they are known to me.

In describing the rostral portion of the shells it will be noticed that I have, contrary to common usage, often drawn a slight distinction between the terms *beaks* and *umbones*. To meet the want of some term to indicate that portion of the beak which is visible in a side view, I call it the *umbone*, while the application of the term *beak* was restricted to the incurved extremity that in most cases is visible only in a dorsal or anterior view.

TELLINOMYA NITIDA, n. sp.

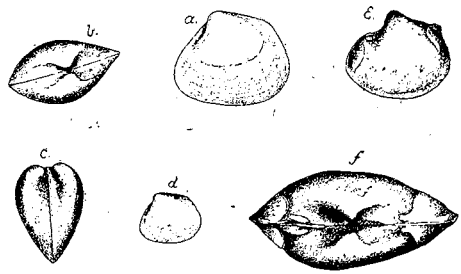


FIG. 1. *Tellinomya nitida*. n. sp. *a*, *b* and *c*, left side, cardinal, and posterior views x2, of a small specimen retaining the shell; *d*, natural size view of same; *e*, left side of a large and very perfect cast of the interior, nat. size; *f*, cardinal view of same, x2 to show the muscular scars.

Shell small, thin, moderately ventricose, subtriangular, the antero-cardinal region somewhat alated; umbones full, beaks closely incurved. 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 or nine strong teeth behind the beaks, and an undetermined number of smaller ones in front. Anterior

and posterior muscular impressions subequal, distinct, the posterior ones drawn out along the hinge margins. Above the anterior pair there is another much smaller elongated pair, lying close to the hinge. These features are all shown in fig. *f* of the above cut.

This species evidently belongs to the group of species of which *T. levata* Hall is a type, but its posterior end is shorter and more abruptly truncated, agreeing in that respect more closely with *T. abrupta* (*Ctenodonta abrupta* Billings). The latter however is a more ventricose and longer shell, and not as wide anteriorly.

Formation and locality:—Good specimens of this species with the shell are exceedingly rare, but casts of the interior are common in the middle third of the Trenton shales, of Minneapolis, Fountain and other localities in the state of Minnesota.

TELLINOMYA COMPRESSA, n. sp.

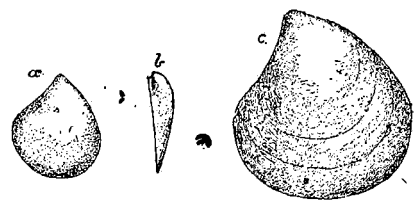


FIG. 2. *Tellinomya compressa*, n. sp. *a*, right valve of this species; *b*, posterior view of same; *c*, same, x2, showing the extremely fine concentric lines of the surface. These are preserved at the posterior end of the shell only.

Shell small, erect, the height greater than the length, subtriangular, compressed, thin; beaks small, almost acuminate, moderately incurved; umbones rather flat, the convex part of the shell 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 degrees, with the anterior gently convex and the posterior correspondingly concave. Aside from this difference in the curvature of the upper parts the ends are subequal, and round uniformly into the strongly convex ventral edge. Surface with faint lines of growth, and exceedingly fine, crowded, concentric striæ, six to eight in one mm.

Hinge line bent at a right angle, with about twenty teeth, the central ones very small, those on each side larger and bent. Muscular impressions not observed.

This species forms one extreme and *T. pectunculoides* Hall, the other, of a group of at least ten species of which *T. astartiformis* Salter, may be taken as the type. They are all much shorter than the species of the typical section of the genus.

Compared with related species *T. alta* Hall, is more erect, more ventricose, with the ventral margin less convex, and a thicker shell. *T. astartiformis* is near but differs in being more ventricose, more coarsely striated, and in having more obtuse beaks. Salter's species, excepting that it is more ventricose than either, is in all other respects very nearly intermediate between *T. compressa* and *T. intermedia.*

Formation and locality:—In the upper third of the Trenton shales, six miles south of Cannon Falls, Minnesota. It is here associated with *T. levata*? Hall, *T. pulchella* Hall, *Lyrodesma postritriatum* Emmons, *Modiolopsis concava*, n. sp. and a fossil very much like *Salterella billingsi* Safford.

TELLINOMYA PLANODORSATA, n. sp.

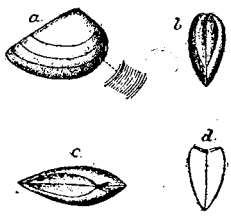


FIG. 3. *Tellinomya planodorsata*, n. sp., *a*, *b*, and *c*, left side, posterior, and dorsal views of the nearly perfect type specimen of this species, nat. size; *d*. sectional view of same, with the posterior dorsal side at the top of the figure.

Shell small, depressed convex, subtriangular or trapezoidal, the width and length respectively as ten is to fourteen; beaks small, incurved, scarcely projecting above the hinge, and situated about 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, anterior edge more strongly convex. Postero-cardinal side thick, with a large, sharply defined, and slightly concave lunette, reaching from the beaks to near the posterior extremity of the shell. Surface gently convex, scarcely sloping toward the lunette, marked with exceedingly fine striæ and a few stronger lines of growth.

Interior unknown, unless a cast of the interior from the overlying Galena shales belongs to this species. This cast which was formed by a shell of scarcely three fifths the length of the type specimen, agrees in most respects, only the beaks project considerably above the hinge line, causing the posterior cardinal line to be concave instead of straight or slightly convex. Still, we must remember that it is the inner or lower

side of the hinge plate that is represented in the internal cast, and as this is always thicker in these shells than the shell substance at the head of the beaks, it is to be expected that the latter would be more prominent in the casts than in the shell itself. The cast in question is considerably like those of *T. levata* Hall, differing mainly in being a little longer, less ventricose, with the back flatter, and in having the muscular scars much less distinct. Indeed, the latter are so faint that their shapes cannot be made out with certainty—a condition, again, to be expected in a species that evidently depended chiefly upon the large size and strength of the external ligament to keep its valves in position.

Taking the shell itself, I know of no species with which it might be confounded.

Formation and locality:– Same as the preceding.

TELLINOMYA INTERMEDIA, n. sp.

FIG. 4. *Tellinomya intermedia*, n. sp. *a*, and *b*, right and posterior views of an average example of this species, nat. size; *c*, cast of the interior of a left valve, nat. size, showing muscular scars, impressions of hinge teeth, and obtusely ridged character of the antero-cardinal region.

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 sub-equal, the posterior sometimes a little the longest (see fig. 4 *c*.). 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 plane. Surface with strong, closely arranged, thread-like, concentric lines, about twelve in 5 mm. At intervals of about two or three mm. generally a fold stronger than the rest.

Casts of the interior exhibit a faint ridge and sulcus in the anterior end, two sharply defined muscular scars and pallial line in each valve, and above the posterior pair a much smaller

pair of scars situated close to the hinge. Hinge plate rather narrow, the teeth numerous, over thirty, as usual very small centrally, growing larger gradually toward the ends of the hinge.

This species is associated with and closely related to *T. astartiformis*, described by Salter from the Black River and Trenton limestones of Canada, but is a less ventricose shell, with coarser striæ, and more rounded ends and ventral margin. *T. compressa*, occupying a lower horizon, is more compressed, higher, has sharper beaks, and much finer striæ. Both *T. subrotunda* and *T.* (?) *hamburgensis* Walcott (Mon. U. S. Geol. Sur., vol. 8, p. 76) have a more rounded outline.

A very similar but smaller and clearly distinct species, differing chiefly in the crenulation of the hinge, occurs in the Utica horizon of the Cincinnati group, at Covington, Kentucky.

Formation and locality:—Not uncommon at the Platystrophia horizon at the base of the Galena limestones, near Fountain, Minnesota.

TELLINOMYA SUBROTUNDA, n. sp.

FIG. 5. *Tellinomya subrotunda*, n. sp. Two views, external and internal, of a well preserved right valve, nat. size.

Shell of medium size, comparatively thick, compressed, nearly circular in outline, with the beaks small, prominent, rather acuminate, curving inward and posteriorly. Posterior dorsal line straight except just beneath the beaks where it is concave. Anterior dorsal margin gently convex, rounding gradually into the general outline. Umbones small, the surface almost uniformly depressed-convex. At intervals of from two to three mm., the surface presents strong, lamellose lines of growth, and between these much finer concentric lines, about six in two mm.

Interior with subequal, ovate, moderately impressed, anterior and posterior muscular scars. Hinge plate strong, bent

at a little more than a right angle, with numerous (about thirty-five) small teeth, as usual strongest near the extremities of the hinge.

This species is more rounded and less ventricose than *T. intermedia*, is more rounded and evenly convex than *T. compressa*, and has more prominent beaks and more abruptly bent hinge than *T. pectunculoides* Hall. A species intermediate in character between the last and the present form, and the nearest relative of *T. subrotunda* known to me, occurs in the upper beds of the Cincinnati group at several localities in Ohio.

Formation and locality:—Base of the Trenton limestones, Mercer county, Kentucky. It is possible that certain illy preserved casts of the interior, from the upper part of the Trenton shales, near Cannon Falls, Minnesota, may belong to this species.

TELLINOMYA SIMILIS, n. sp.

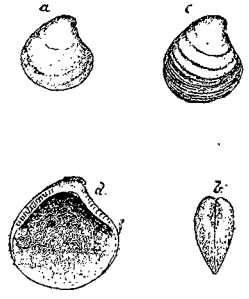


FIG. 6. *Tellinomya similis*, n. sp. *a* and *b*, left and posterior views of a rather small shell; *c*, left side of another specimen; *d*, interior of a large right valve. All the figures are of the natural size.

Shell small to medium size, moderately ventricose, subtriangular, the length and height respectively as five is to six. Umbones full, rounded, the rostral portion strongly recurved, with the beaks small, and projecting slightly above the hinge. Antero-dorsal edge convex, thick, flattened, but not sharply defined. Postero-dorsal edge rather strongly concave, impressed so as to form an illy defined, imperfect lunette. Anterior side almost uniformly convex, curving neatly into the well rounded ventral margin. Posterior side rather narrowly rounded and slightly produced in the lower half. Surface 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 (thirty-five to forty-two), in the largest example seen with about twenty-seven anterior and fifteen posterior to the beak. Posterior teeth the largest, bent. Muscular scars faintly impressed.

The shape of this species is exceedingly like that of *T. astartiformis* Salter, of the Black River and Trenton limestones, but it is not so ventricose. If the hinge of that species is correctly represented in Salter's figures, the form under consideration must be regarded as specifically distinct, since it has smaller, less bent and more numerous teeth. According to Salter the teeth of *T. astartiformis* are largest on the anterior side, while in *T. similis* the opposite is the case.

It is also very much like its associate, *T. 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, scarcely defined posterior lunette, and less strong 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 *T. recurva*.

Formation and locality:—Upper beds of the Hudson River group, Spring Valley, Minnesota, and Blanchester, Ohio.

TELLINOMYA RECURVA, n. sp.

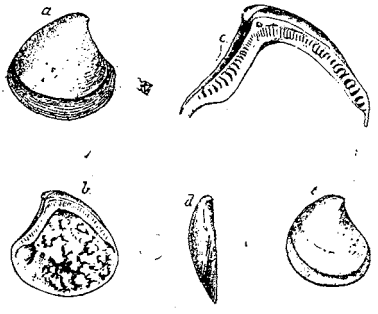


Fig. 7, *Tellinomya recurva*, n. sp. *a* and *b*, external and internal views of a left valve, nat. size; *c*, hinge of same, x2; *d*, posterior view of same; *e*, another left valve, nat. size, of somewhat different shape. Specimens from Spring Valley, Minn.

Shell small or of medium size, not thick, rather compressed, subtriangular, the length and height almost equal. Rostral portion strongly recurved, umbones small, depressed, beaks very prominent, posterior to the center of the shell. Dorsal slopes flattened, sharply defined, with the ridges projecting beyond or overhanging the edge of the hinge plate. This is true especially of the posterior side, where they form an elongated lunette. Anterior dorsal margin more strongly convex than in any other species known; posterior dorsal margin correspondingly concave. Outline, with the anterior side rather sharply rounded in the lower half, the ventral margin sloping

backward and most prominent a little behind the center, then curving upward to meet the concave posterior side at a point very nearly opposite the middle of the height of the shell. Posterior end rather narrowly rounded, most prominent just beneath the center. Surface with several strong growth lines, and between them fine concentric striæ, about ten in three mm. An obscure sulcus extends from the beak along the anterior margin to the antero-ventral region. Hinge plate very strong, bent at a right angle, the posterior half straight, with at least twenty small teeth, decreasing in size gradually toward the beak; anterior half gently convex, with about thirty teeth. Considering the unusual strength of the hinge plate, the teeth are very small. Anterior and posterior muscular scars large, moderately impressed.

Compared with other species the nearest appear to be *T. astartiformis* Salter, and *T. compressa*, and *T. similis* of the present paper. From the first it is distinguished by being less ventricose, in the flattening of the dorsal edges, and in the greater number and smaller size of the hinge-teeth. The second is more compressed, and has more erect beaks, finer surface striæ, and fewer hinge teeth. The third is without the anterior sulcus, has no sharply defined posterior lunette, is higher, generally of smaller size, and has the umbones more tumid, with the point of greatest convexity above the center.

Formation and locality:—Upper beds of the Hudson River group, Spring Valley, Minnesota. It is here associated with *T. similis*, *T.* near *iphigenia* Billings, *Lyrodesma major* Ulrich, and an abundance of Brachiopoda. Casts of the interior, apparently referable to this species, occur in equivalent beds at Oxford, Waynesville, and other localities in Ohio.

TECHNOPHOROUS (?) EXTENUATUS, n. sp.

Fig. 8, *Technophorus (?) extenuatus*, n. sp. Left side of the only example, a nearly perfect cast of the interior, seen. nat. size.

Shell small, compressed, elongate, alated and drawn out posteriorly. Beaks small, erect, moderately prominent, 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. 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, marked with obscure concentric lines of growth.

Length about 21 mm., greatest height 10 mm., greatest convexity about 3.5 mm.

This is a peculiar shell, and it is with considerable doubt that I refer it to the recently proposed genus *Technophorus*, Miller (North Amer. Geol. and Pal., p. 514, 1890). I do so because in another undoubted species of the genus in my possession the posterior extremity of the hinge is drawn out in a manner similar to what we see in the present shell. The prolongation however is much less extensive in the undescribed species. Both the latter and Miller's type of the genus (*loc. cit.*) have two posterior ridges crossing each valve, and in both again the hinge line is straight.

The Cincinnati species which I called *Nuculites yoldiaformis* (Jour. Cin. Soc. Nat. Hist., vol. 2, p. 24, 1879), is probably a related form. As it is clearly not a true *Nuculites* and seemingly without any near relations to any established genus, it might be well to erect a new genus for their reception.

Formation and locality:—Rare in the middle third of the Trenton shales at Minneapolis, Minnesota. I am indebted to the liberality of Prof. C. W. Hall, of the State University of Minnesota for the only specimen seen.

CLEIDOPHORUS CONSUETUS, n. sp.

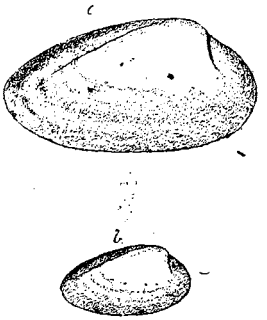


Fig. 9, *Cleidophorus consuetus*, n. sp. *a*, cast of a right valve of this species, x2; *b*, same of the natural size.

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, flat-

tened. 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 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.

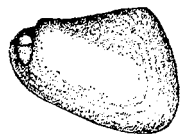
Length 17.2 mm., height 9.0 mm., thickness of both valves 5.3 mm.

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:—Rare in the Platystrophia horizon at the base of the Galena limestones. It is associated with *Tellinomya intermedia Ulrich*.

MODIOLOPSIS PLANA, Hall.

Modiolopsis planus HALL, 1861. Report Superintendent Geol. Sur. Wis., p. 30. Geol. Wis. vol. i, pp. 38 and 438, fig. 6.



The above cut represents an internal cast of the left valve of a shell that occurs rather rarely in the upper beds of the Trenton limestones at Minneapolis and other localities in the state. There can be no question of the identity of this Minnesota form with the Wisconsin types of the *Modiolopsis plana* Hall. The latter seem to have been smaller, being said to be about

three-fourths of an inch in length, but in all essential respects, our specimens agree sufficiently well with Hall's description and figure.

Among the most important features of the species is the elongate form and duplex character of the strongly impressed anterior muscular scar, the alate character of the postero-cardinal region, the length and straightness of the hinge line, and the wide truncated posterior end. The hinge also seems to have been unusually strong. In most of these respects the species approaches *M. truncata* Hall, of the Cincinnati group, more or less nearly.

These two species, together with several others, stand apart from the typical section of the genus, and should perhaps be separated under another generic name. But the whole genus *Modiolopsis* needs revision, and when this is done it will, I am satisfied, be found necessary to institute several subdivisions.

MODIOLOPSIS SIMILIS, n. sp.

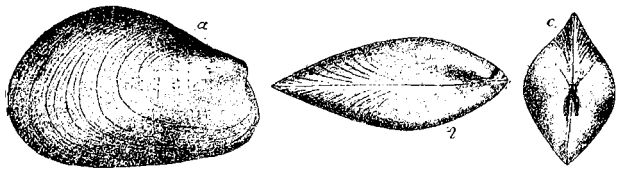


Fig. 11, *Modiolopsis similis*, n. sp. *a*, *b*, and *c*, right side, dorsal, and anterior views of a well preserved cast of the interior. nat. size.

Shell of medium size, elongate, ovate, widest in the posterior half, contracting to between one half and three fifths of the greatest width at the beaks. Hinge line nearly straight and about half as long as the shell posterior to the beaks. Anterior end small, neatly rounded; ventral margin nearly straight in the middle, curving up at the ends; posterior end broadly rounded, slightly produced in the lower half, sometimes forming an obtusely angular junction with the hinge line. Beaks nearly terminal, rather small, compressed, incurved, projecting moderately above the hinge. Surface moderately convex, most prominent along the posterior umbonal ridge, which is stronger than usual in 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.

Shell very thin, so that the muscular scars are scarcely visible in the casts. Surface with numerous fine concentric lines, and some stronger varices of growth.

Of all the described species of this genus known to me *M. concentrica* Hall and Whitfield, from the upper beds of the Cincinnati group, seems to be nearest. Excepting that the Minnesota shell is wider posteriorly, the two species agree very nearly in their outlines. In other respects however they are quite different, *M. concentrica* having a thicker shell, with the anterior muscular scar much more distinct, the beaks projecting less, the posterior umbonal ridge and median depression both lesser features, and the surface markings coarser. The outline of an undescribed species, from the base of the Trenton limestone of central Kentucky, agrees even better in its general contour with *M. similis*. But it too seems to be distinct, since in it the umbonal ridge and the mesial sinus are even less distinguishable than in *M. concentrica*.

Because of the exceeding thinness of its shell I would place *M. similis* into the same section of the genus that includes *M. cincinnatiensis* Hall and Whitfield, *M. pulchella* Ulrich, and *M. subtruncata* Ulrich. These are all widely removed from *M. modiolaris* Conrad, the type of the genus, and in some respects are nearer *Orthodesma*, Hall and Whitfield.

Formation and locality:—Rare in the middle third of the Trenton shales, at Minneapolis, Minnesota, where the illustrated specimen was found by Prof. C. W. Hall, of the State University, who kindly gave it to me for description.

MODIOLOPSIS SUBELLIPTICA, n. sp.

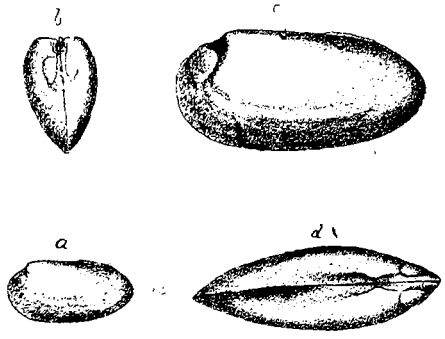


Fig. 12, *Modiolopsis subelliptica*, n. sp. *a*, left side of a cast of the interior, nat. size; *b*, *c*, and *d*, anterior, lateral, and dorsal views of same, x2.

Shell small, elongate-elliptical in outline, the length fully twice as great as the breadth, a little the widest anteriorly, with the dorsal and ventral margins subparallel and both gently

convex, the anterior end semicircular, the posterior more narrowly rounded and slightly produced in the middle. Beaks small, incurved, projecting but little above the hinge, situated about one-fifth of the entire length from the anterior extremity. Umbonal ridge slight, running close to the dorsal margin, causing the central part of the dorsal side of the shell to be somewhat flattened. Sides of valves moderately convex, with point of greatest convexity a little in front of and above the middle.

Casts of the interior show a sharply defined, ovate, anterior muscular scar, which must have been bounded on the inner side by a strong internal ridge, extending downward and curving forward from the hinge, at a point just in front of the beaks, to the lower end of the muscle. The posterior scar and pallial line are not distinguishable in the material at hand. The lower and anterior parts of casts exhibit a few, obscure, broad lines of growth.

This is one of a small group of species that remind one greatly of *Cleidophorus*, Hall, to which genus they might be referred were it not for the distinct impression of the anterior muscular scar. The shape and size of the present species is considerably like that of *Cleidophorus consuetus*, described in this paper, but, aside from other differences, the one relating to the presence of a muscular scar will distinguish them at once. I know of no described species of *Modiolopsis* sufficiently resembling this to necessitate comparisons.

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

MODIOLOPSIS CONCAVA, n. sp.

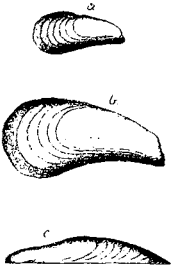


Fig. 13. *Modiolopsis concava*, n. sp. *a*, right valve of the natural size; *b*, and *c*, side and dorsal views of same, x2.

Shell very small, elongate, the greatest width less that half the length, curved, the posterior end much the widest, broadly rounded, the anterior end exceedingly short and narrow, con-

tracted beneath the beaks, which 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. Dorsal side gently arcuate; anterior two-thirds of ventral margin strongly concave, a fact due in a great measure to the width of the sulcus and the rapid slope of the surface included in it. Umbonal ridge slight, cardinal slope rather strongly 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 simply with concentric lines of growth. Internal characters not observed.

This peculiar species is another of the number that I am referring to *Modiolopsis* provisionally. I place it here, first, because it seems to be related to some forms of the *M. faba* section of the genus, and, second, because I know of no other established genus that would offer a more fitting placement.

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

ORTHODESMA MINNESOTENSE, n. sp.

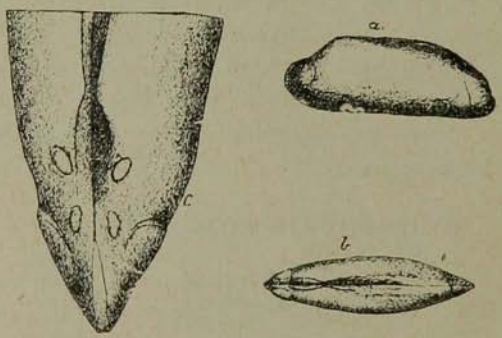


Fig. 14. *Orthodesma minnesotense*, n. sp. *a* and *b*, left side and dorsal views of a cast of the interior; *c*, dorsal view of anterior third enlarged to show the muscular scars. x4.

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 a few obscure folds of growth.

This species is related to *O. curvatum* Hall and Whitfield, though more nearly approaching *O. contractum* Hall, in the general outline. It differs from both in having the posterior end narrower, and in wanting the strong wrinkles 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 SAFFORDI, n. sp.

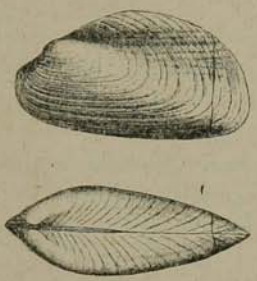


Fig. 15, *Orthodesma saffordi*, n. sp. Two views, side and dorsal, of a rather small specimen of this species, nat. size. The largest specimen seen is at least one-third larger.

Shell of medium size, elongate, trapezoidal, widest posteriorly, the length somewhat less than twice the greatest width; hinge line straight, with a narrow, concave ligamental area, extending about one-half of the entire length from the anterior extremity; ventral margin nearly straight or slightly convex, forming an angle of about 38 degrees with the hinge line. Anterior end narrow, about half as wide as the posterior part of the shell, its length equalling about one-fifth of the entire length, the outline erect above, subangular where it joins the extremity of the hinge, rounding below into the basal line. Posterior end wide, sharply curved and produced below, more gently curved and sloping forward in the middle and upper thirds, meeting the extremity of the hinge line without forming any perceptible angle. Beaks small, incurved, somewhat flattened on the umbones, projecting slightly above the hinge; umbonal ridge

strong, subangular, traceable generally to the postero-basal margin; cardinal slope at first concave, gradually flattening posteriorly; with a distinct, linear sulcus running midway between the umbonal ridge and the dorsal margin, and both above and beneath this, several other, but more obscure, radiating lines may be detected; ventral slope flattened.

Surface of the shell marked strongly with rather irregular and unequal concentric lines of growth. The radiating lines on the cardinal slope have been mentioned.

One of the specimens preserves a considerable part of the hinge. It is, so far as can be seen, perfectly straight both in front and behind the beaks, and without teeth or thickenings. The ligamental area, however, is rather wide and concave. Muscular impressions unknown.

This species is wider posteriorly than any other *Orthodesma* known to me. In the general outline, excepting that the beaks are too far from the anterior extremity, and the hinge too straight, it is more like *Modiolopsis*. But it has the same kind of hinge as *Orthodesma rectum* Hall and Whitfield, the type of the genus.* The depressed line in the cardinal slope is another feature that is frequently met with, especially in the casts of species of *Orthodesma*.

It gives me much pleasure to name this fine species for Prof. Jas. M. Safford, of Nashville, Tennessee, as a slight token of my appreciation of his valuable and long continued labors in American geology.

Formation and locality:—In the lowest member, Safford's "Central limestone," of the Trenton formation, at Murfreesboro, Tennessee. The beds holding this fossil are equivalent to either the Chazy or the lower part of the Birdseye.

*Hall and Whitfield say, in their generic description (Pal. Ohio, vol. ii, p. 93), that the hinge line is "contracted or bent beneath or anterior to them", *i. e.* the beaks, and this supposed feature they relied upon chiefly in distinguishing their genus from *Orthonota*, Conrad. But this supposed bending or contraction of the hinge line does not exist in *O. rectum* nor in *O. curvatum* or in any other species of *Orthodesma* known to me. The evidence bearing upon the disputed point afforded by my collections is, at any rate in the two species mentioned, unequivocal.

CYPRICARDITES SARDESONI, n. sp.

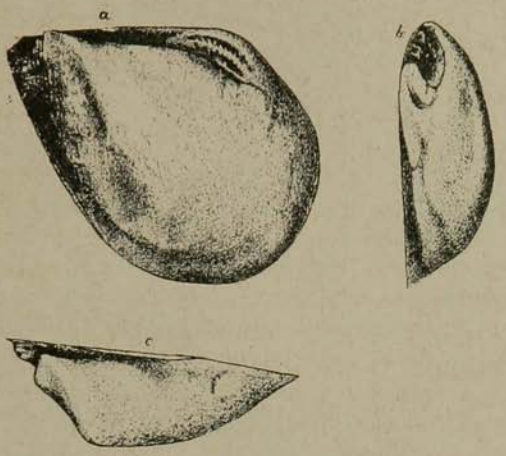


Fig. 16. *Cypricardites sardesoni*. n. sp. *a*, *b* and *c*, lateral, anterior, and dorsal views of a cast of the interior of a right valve, nat. size.

Shell of 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 degrees; anterior extremity subacute 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 degrees; 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 antero-basal part of the cast; 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.

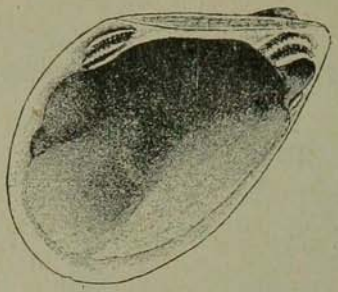


Fig. 17. Interior of left valve of *Cypricardites sardesoni*, n. sp., as shown in gutta-percha impressions.

Gutta-percha impressions, as shown in fig. 17, 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 strong 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, double or prolonged below, and but faintly impressed.

I know of no associated species, nor of any now referred to this genus, that is at all likely to be confounded with *C. sardesoni*.

The specific name is given in honor of the discoverer, Mr. F. W. Sardeson, of Minneapolis, Minnesota, an enthusiastic collector and a promising student of paleontology.

CYPRICARDITES OBTUSIFRONS, n. sp.

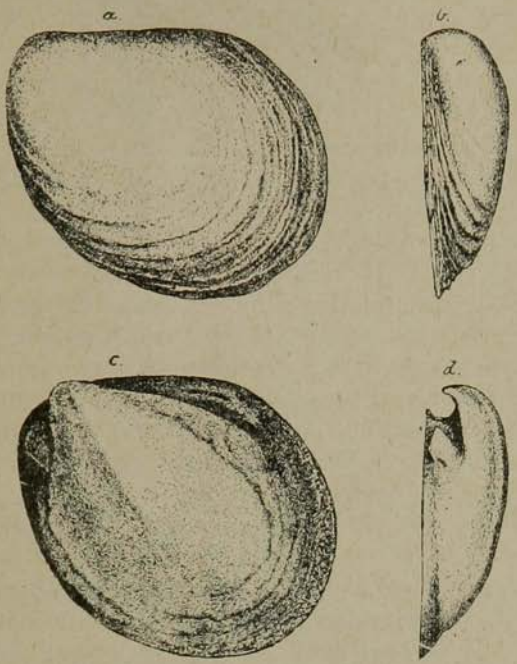


Fig. 18. *Cypricardites obtusifrons*, n. sp. *a*, and *b*, lateral and anterior views of a gutta percha impression of the exterior of a left valve; *c*, and *d*, similar views, of the cast of the interior of same shell; all nat. size.

Shell of medium size, scarcely ventricose, oblique, subovate, widest and broadly rounded posteriorly, with the beaks subterminal, small, projecting very slightly; umbonal region full, but scarcely distinguishable in the general convexity of the surface; anterior end obtuse, forming nearly a right angle with a straight hinge line, the junction between the two rounded; posterior and basal margins semicircular. Surface with the greatest convexity in the antero-dorsal third, the cardinal and anterior slopes more gently convex; surface markings consisting of rather irregular, fine and coarse, sublamellose lines of growth.

Casts of the interior with the beaks large, compressed, strongly, incurved; a moderate umbonal ridge and sulcus crosses the casts from the beaks in a direction nearly parallel with the anterior margin, becoming obsolete before reaching a point near the middle of the basal line. Anterior muscular scar deeply impressed, rather large, partly overhung by the projecting beak. Posterior scar illy defined.

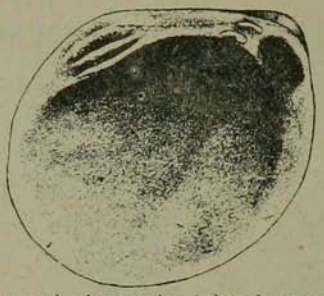


Fig. 19. View of a gutta percha impression taken from a mould of the interior of a left valve of *Cypricardites obtusifrons*, n. sp.

The gutta percha impression illustrated in fig. 19, was prepared from the cast of the interior represented by fig. 18, *c* and *d*. It shows that the hinge plate was strong, nearly flat in the central part, with three strong lateral teeth, and two small anterior cardinal teeth. Just in front and beneath the latter is the large and strongly impressed anterior muscular scar.

In some respects this species is like *C. sardesoni*, which is also associated with it in the limestone, but a comparison of the figures here given of the two species will show so many striking differences that there is really no danger of confusion between them. Some resemblance is also to be noted to species like *C. obtusus* Hall, *C. saffordi* Hall, and *C. haynianus* Safford, but they are all really quite different internally, and in having the umbones more prominent. *C. niota* Hall, occupying a similar position in Wisconsin, is likewise to be compared. It is a more erect shell, and differs in other particulars as well.

Formation and locality:—Collected by Prof. C. W. Hall, of the State University, in the upper beds of the Trenton limestone, at Minneapolis, Minnesota.

CYPRICARDITES GLABELLUS, n. sp.

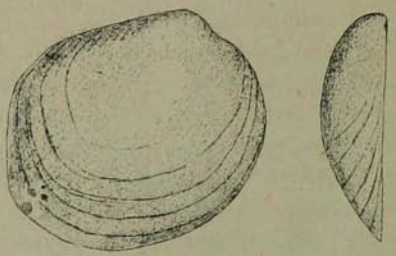


Fig. 20. *Cypricardites, glabellus*, n. sp. Lateral and anterior views of a right valve.

Shell scarcely reaching medium size, broad-ovate or subquadrangular in outline, with the back straight, the posterior margin sloping forward in the upper fifth, straightened and

nearly vertical in the middle, and curving forward below into the broadly rounded ventral margin; anterior side convex, short. Beaks small, the umbonal region full, very slightly prominent, with the line of greatest convexity—not sufficiently defined to be called a ridge—extending obliquely across the valves from the beaks toward the postero-ventral edge; point of greatest convexity very near the center of the shell. Cardinal slope flat, rather abrupt; between this and the undefined umbonal ridge the surface is again slightly flattened; anterior and basal slopes gently convex. Surface nearly smooth, near the margins marked simply with a few lines of growth. Internal characters unknown.

The outline of this species is about intermediate between *C. ventricosus* Hall, and *C. niota* Hall, but the relations between them are, I am satisfied, quite remote. Both those species are at once distinguished by the greater prominence of their umbones.

Formation and locality:—Rare in the middle third of the Trenton shales, at Minneapolis, Minn. A cast of the interior from the "Buff limestone" at Beloit, Wis., now before me, may belong to this species.

CYPRICARDITES CINGULATA, n. sp.

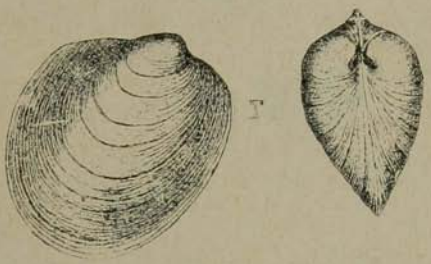


Fig. 21, *Cypricardites cingulata*, n. sp. Lateral and anterior views of a nearly perfect specimen of this species, nat. size.

Shell scarcely reaching the medium size, ventricose, oblique, the outline, excepting a slight prominence at the postero-cardinal edge, regularly ovate, but narrow anteriorly and broadly rounded posteriorly; hinge line rather short posterior to the beaks, slightly convex; beaks of good size, strongly incurved, projecting well above the hinge, situated one fifth of the entire length from the anterior extremity; umbones prominent, full, with an obtuse ridge or line of greatest altitude running from the beaks toward the postero-basal side; anterior and cardinal slopes both slightly concave, the latter descending more abruptly. 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. ventricosus* Hall, is not so wide posteriorly, and on the whole has a different outline, being, besides, more ventricose. *C. grandis* Ulrich, is a larger and almost circular shell.

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

CYPRICARDITES GERMANUS, n. sp. or var.

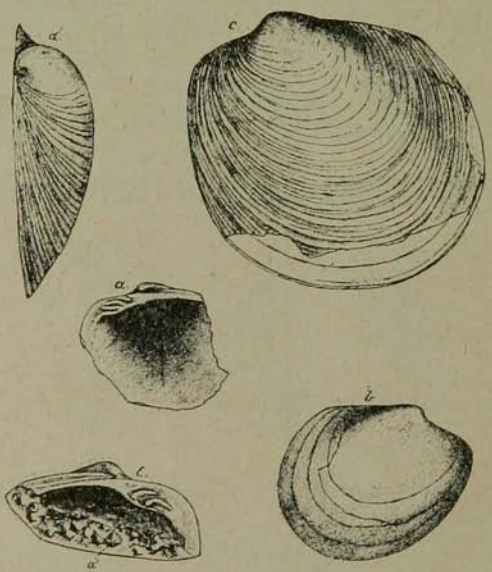


FIG. 22, *a* and *b*.

FIG. 22, *a* and *b*. *Cypricardites germanus*, nov. nom. *b*, fragment of a right valve of this species or variety, restored, nat. size; *a*, interior of same, showing the thin hinge, anterior teeth, and the faintly impressed muscular scar; *c*, *d*, and *e*, lateral and anterior views, and the greater part of the hinge of a small left valve of *Cypricardites grandis* Ulrich, from the upper Trenton near Danville, Kentucky. Introduced for comparison with *C. germanus* and *C. tenellus*.

Of this form I have several fragmentry shells, none of them better than the one above illustrated. Ordinarily, I would not consider such material as sufficient to justify description and naming, but in the present instance it has seemed right to set good custom aside. The specimens, namely, exhibit a

striking departure from usual *Cypricardites* in the great projection beyond the beaks of the anterior end of the shell. In most species the anterior end is very short,—occasionally the beaks are quite terminal—but in *C. grandis* Ulrich (Amer. Geol., vol. 6, p. 387, 1890) of which a small and unusually oblique example is illustrated in fig. 22, *c*, *d*, and *e*, it is longer than in any other species heretofore described, while in the proposed *C. germanus* the projection is comparatively greater yet.

The shell in *C. germanus* is very thin, so that even the anterior muscular impression is scarcely recognizable, the hinge too is very thin, while the anterior teeth are small and drawn out to an unusual distance in front of the beaks. Excepting that the teeth are less curved and the hinge plate less expanded where they occur, the characters of the form are not greatly different from *C. grandis*. It is very likely merely a small variety of that species. Both are found in the upper beds of the Trenton near Danville, Kentucky, the small form a few feet higher in the series than the large *C. grandis*. I have seen also a number of internal casts, in the lower part of the Galena limestone and in the shales immediately beneath them, at localities in Goodhue and Fillmore counties, Minnesota, that may belong to one or the other of these forms, but they are all too illy preserved to admit of determining their relations with certainty.

CYPRICARDITES TENELLUS, n. sp.

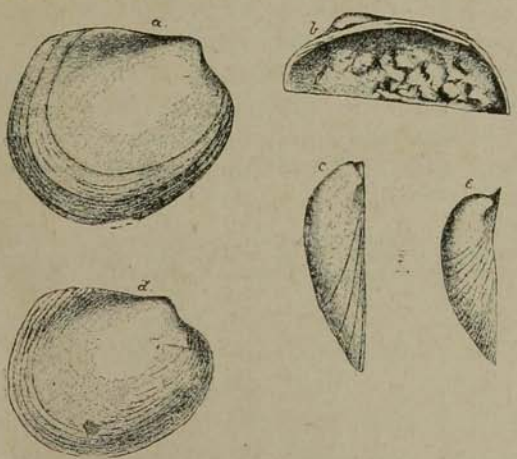


Fig. 23, *Cypricardites tenellus*, n. sp. *a*, right valve, with strongly marked lines of growth; *b*, hinge of same; *c*, anterior view of same; *d*, a smaller valve with finer surface markings and wider anterior end; *e*, anterior view of same; all of the natural size.

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, and 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 almost linear when compared with the majority of the species of the genus; with two very slender posterior lateral teeth in the right valve, and probably only one in the left; anterior teeth obscure in the specimen, consisting apparently of one or two slight longitudinal folds in the margin of the shell. Muscular impressions very faint.

In this species the hingement is reduced to the minimum of strength so far noticed in the genus. It is possible that this reduction has gone beyond the just limits of *Cypricardites*, but in view of the fact that the species is approached in this respect by *C. germanus*, which, as well as several other undoubted species of the genus, as now understood, it also resembles in the general expression of its shells, it did not seem to me worthy now of greater recognition than specific.

C. cingulata, from a lower horizon in the shales, is a more ventricose shell, with the umbonal ridge stronger, and the outline a little different, being longer from the beaks to the postero-ventral margin, with both the anterior end and the hinge line shorter.

Formation and locality: - Upper third of the Trenton shales, about six miles south of Cannon Falls, Minnesota. A cast of the interior, collected by Mr. Wm. H. Scofield from the lower part of the Galena Limestone, at Wykoff, Fillmore county, probably belongs here.

CYPRICARDITES NANUS, n. sp.

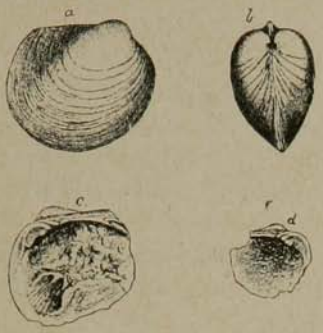


Fig. 24, *Cypricardites, nanus*, n. sp. *a* and *b*, side and anterior views of a silicified specimen, nat. size; *c*, anterior part of the hinge of a small left valve; *d*, hinge of a right valve.

Shell small, ventricose, slightly oblique, the outline subcircular, a little the widest posteriorly, with the hinge line straight or very slightly arcuate, and the anterior end produced a little beyond the line of the circular curve formed by the posterior and ventral margins; height and length respectively as five is to six; postero-cardinal border subangular. Beaks small, strongly incurved, projecting well above the hinge; situated about one-fifth of the entire length from the anterior extremity; umbones full, prominent, with a strongly rounded ridge traceable from the beak nearly to the postero-ventral margin. Cardinal slope rather strongly concave. Surface marked with fine lines of growth. With age a few strong marginal wrinkles may be formed. Shells ubstance thin.

Hinge of moderate strength, considering the size of the shell, with two anterior teeth in each valve, the lower and forward one forming the sharp upper boundary of a narrow and horizontally extended muscular impression. Posterior teeth not well shown in the material at hand; probably two or three, and much like those of *C. haynianus* Safford.

This species is closely related to *C. haynianus* Safford, a common species of the Trenton of Kentucky and Tennessee, but is smaller, more ventricose, with the outline more nearly circular, the beaks less nearly terminal, the umbonal ridge stronger, and the shell thinner. It has also only two instead of three or more anterior hinge teeth. None of the other species known to me are very closely related.

A similar, though not a strictly identical species, is indicated by a cast of the interior, collected by Mr. Wm. H. Scofield, at

Wykoff, in Fillmore county of this state, where he found it at the base of the Galena limestone. This cast belonged to a larger shell than has been noticed of *C. nanus*. Its outline is also a little different, being too wide posteriorly, and more sharply curved at the postero-basal border, while the beaks are more nearly terminal. In short, the outline is more nearly like that of *C. haynianus* (see fig. 25*b*), slightly longer, perhaps, but I am satisfied that it is distinct from Safford's species, having obviously been formed by a thinner shell in which the internal ridge, which is always present in his species, was absent or, as is the case with *C. nanus*, too illy defined to leave a certain mark on the casts.

Formation and locality:—The nine, more or less defective specimens of this species contained in my cabinet, were collected from the upper beds of the Trenton, in Mercer county, Kentucky.

CYPRICARDITES HAYNIANUS (?) Safford.

Cyrtodonta hayniana SAFFORD, 1869. Geol. Tenn., pl. F., fig. 1.

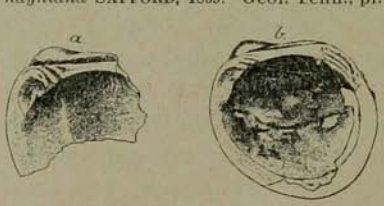


Fig. 25. *Cypricardites haynianus* Safford. Upper Trenton, near Danville, Kentucky; *a*, a well preserved fragment of a right valve, showing the anterior part of the hinge, with its teeth, the muscular impression, and the internal ridge; *b*, the interior of a smaller right valve with the anterior teeth disposed more horizontally than usual in this species.

I am nearly convinced that this species is represented in the Galena shales of Minnesota, but all of the specimens seen by me are internal casts, and none of these are sufficiently well preserved to permit an unequivocal determination of their relations. The internal ridge and the compressed beaks (they are concave on the inner side) required by casts positively known to belong to the species, are determinable in some of the specimens, but each of these is either incomplete or has suffered compression in the shales, so that the original shape of the shells is left in doubt. Under the circumstances I thought it well to call the attention of Minnesota collectors to the forms, in the hope that some of them may find better specimens.

Among some lamellibranch shells received from Mr. Wm. H. Scofield, there is a fragment of a *Cypricardites* that he obtained

from the upper third of the Trenton shales, at the locality six miles south of Cannon Falls that has furnished so many interesting shells of this class. This specimen consists of the anterior third of the shell itself, showing about half of the hinge with three anterior teeth and a muscular impression beneath them. Every point that is preserved corresponds so nearly with fig. 25 *a*, that it would surprise me greatly if it turned out to be distinct from *C. haynianus*.

MATHERIA RUGOSA, n. sp.

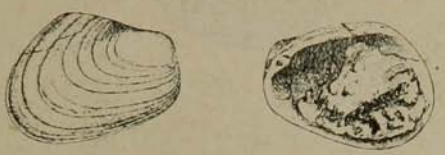


Fig. 26, *Matheria rugosa*, n. sp External and internal views of the only specimen seen, nat. size. The posterior part of the hinge is broken away and that portion of the figures is to be regarded as a restoration.

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 and probably 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. Posterior extremity of hinge wanting in the specimen, probably without teeth.

This species is almost certainly a true *Matheria*, a genus described by Billings for a single species occuring in the Trenton rocks of Canada and Kentucky, and which he called *M. tener*.*

*Can. Nat. and Geol., vol. 3, p. 440, 1858.

Several other species, as yet undescribed, are known to me from the same rocks in Kentucky, but all are smaller and less wide posteriorly. *M. tenera* has the dorsal and ventral margins nearly parallel.

Formation and locality:—Upper third of the Trenton shales, six miles south of Cannon Falls, Minnesota.

ISCHYRODONTA OVALIS, n. sp.

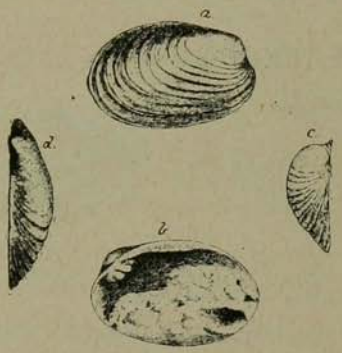


FIG. 27. *Ischyrodonta ovalis*, n. sp. *a*, and *b*, external and internal views of a right valve; *c*, and *d*, anterior and cardinal views of the same; nat. size.

Shell small, moderately ventricose, almost regularly elliptical in outline, with the greatest width and thickness midway between the ends; width and length about as two is to three. Beaks small, situated near the anterior extremity, compressed by a flattening of the surface which, expanding, extends over the greater part of the ventral slope. Edges of valves meeting at the center of the ventral margin, apparently gaping a little at the ends. Umbonal ridge prominently rounded, cardinal slope abrupt, very little concave. Surface marked with strong lines of growth and a few finer concentric striae, both inclining to be irregular.

Hinge plate arcuate, widening posterior to the beaks, grooved as for the reception of an internal ligament. Cardinal teeth two, projecting downward and backward from the hinge plate, which is thin at this point, and supported by an internal process that seems to extend up into the cavity of the beak, and projects on each side of the teeth so as to give the whole the appearance of a quadrifid tooth. Anterior muscular scar rather small, occupying the anterior extremity of the shell.

This species is not strictly congeneric with the types of *Ischyrodonta* (Amer. Geol., vol. 6, pp. 173-175), but there is no other established genus known to me offering a closer agree

ment, and before I can consider the erection of a new genus as fully justified, I wish to see the main peculiarties of the shell confirmed in other species. The uncertainty of the position of the species is increased by the fact that it might be referred, with equal propriety perhaps, to the genus *Matheria*, of Billings. I infer therefore that we are dealing with an undescribed generic type having somewhat intermediate relations between *Matheria* and *Ischyrodonta*.

Formation and locality:—At present known only from Richmond, Indiana, where it was found in the upper beds of the Cincinnati group. Equivalent strata are exposed in the vicinity of Spring Valley, Minnesota.

PLETHOCARDIA, n. gen.

(*Pletho*, to be full; *kardia*, heart, in allusion to the shape of the closed valves.)

Shell thin, inequilateral, oblique, tumid, with the margins closed; beaks large, prominent, spirally enrolled, and curving forward. Cardinal margin, posterior to the beaks, with a narrow, but deep escutcheon or lunette. A strong and large, bifid, cardinal tooth projects forward and downward from the thin edge of the straight hinge plate; 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 tooth. In casts of the interior the filling of the anterior impressions forms a small but sharply defined lobe. Posterior muscular scars and pallial line unknown. Type: *P. umbonata*, n. sp.

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 cardinal tooth 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, the two genera are practically the same.

It is possible that this genus represents an early type of those heavy and otherwise peculiar shells which Zittel has embraced in his family *Megalodontidæ*. A general resemblance is to be noted yet I doubt very much that any true relationship existed between them.

PLETHOCARDIA UMBONATA, n. sp.

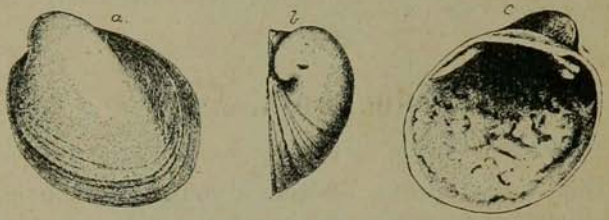


Fig. 28. *Plethocardia umbonata*, n. sp. *a* and *b*, lateral and anterior views of a left valve; *c*, inner side of same, showing the escutcheon, the bifid cardinal tooth, anterior muscular impression, and the internal ridge-like thickening of the shell just within the postero-dorsal border; natural size.

Shell rather small, moderately oblique, strongly ventricose, widest posteriorly, subovate in a side view. 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 vertical, rather sharply rounded above; dorsal margin arcuate, graduating into the posterior curve; the latter is produced slightly in the lower part and quickened 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. Cardinal tooth large, bifid, projecting obliquely forward from the lower side of the hinge line. A strong, ridge-like thickening of the shell, probably representing the support of an internal ligament, occurs just within the postero-cardinal margin. Anterior muscular scar situated in a cup-like depression formed by a curved ridge which proceeds from the underside of the cardinal tooth, and the antero-cardinal margin of the shell.

It is possible that this species is not distinct from the *Cyrtodonta cordiformis* of Billings. His figures of that species look so much like the Minnesota 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 third of the Trenton shales, six miles south of Cannon Falls, Minnesota. Collected by Wm. H. Scofield.

PLETHOCARDIA SUBERECTA, n. sp.

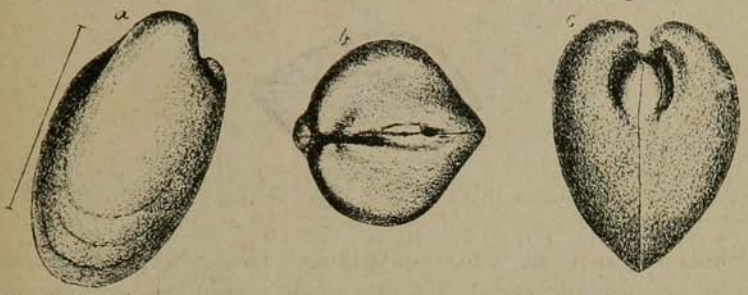


Fig. 29. *Plethocardia suberecta*, n. sp. *a*, *b*, and *c* lateral, dorsal, and anterior views of a cast of the interior; natural size.

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 the beaks 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 from that species that comparisons are unnecessary.

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

WHITELLA PRÆCIPTA Ulrich.

Whitella præcipta ULRICH, 1890. The American Geologist, vol. vi, p. 386.

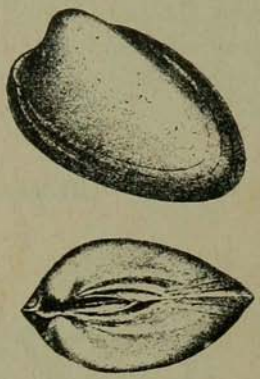


Fig. 30, *Whitella præcipta* Ulrich. Lateral and cardinal views of a cast of the interior; nat. size.

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, very 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 cartilage supports have left distinct impressions of unusual width, on each side and behind the impression produced by the escutcheon. A low and obscurely defined ridge 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 near and parallel with the margin of the cast. It can be traced from the anterior scar to the impressions of the internal ligament supports.

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, with the beaks

and umbones smaller, and the anterior end larger. The impressions of the internal ligament supports also are very much less distinct.

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

WHITELLA CONCENTRICA, n. sp.

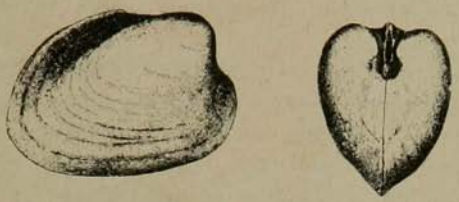


Fig. 31, *Whitella concentrica*, n. sp. Lateral and anterior views of a cast of the interior, nat. size. The beak of the left valve has been restored.

Shell rather beneath the medium size, oblique, ventricose, widest posteriorly, trapezoidal; beaks large, prominent, in curved; umbones full, with a sharply rounded ridge or line of gibbosity extending backward from the beaks to the posterior extremity of the shell. 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 forward rapidly above, merging gradually into the curve of the dorsal side. Cardinal and posterior slopes slightly concave. 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 ligament 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 marks of growth are stronger in this species than in any other known to me. It is shorter than *W. præcipta* more ventricose than *W. compressa*, and has much fuller umbones than *W. obliquata*.

Formation and locality:—Middle third of the Trenton shales, at Minneapolis, Minnesota

CUNEAMYA SULCODORSATA, n. sp.

Fig. 32, *Cuneamya sulcodorsata*, n. sp. Lateral and anterior views of the type specimen, nat. size.

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, almost angular at the base; anterior end very short, narrowly rounded. Beaks subterminal, full, decumbent, 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, though seeming to be a true species of *Cuneamya*, cannot be confounded with any species of the genus so far described.

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