CHAPTER X.

THE LOWER SILURIAN GASTROPODA OF MINNESOTA.

BY E. O. ULRICH AND W. H. SCOFIELD.*

INTRODUCTION.

The *Gastropoda* are *Mollusca* with a more or less distinct head and a well developed tongue which as a rule is armed with a plate or band set with teeth. The body is nearly always more or less unsymmetrical, the mantle never divided into two lobes, and the shell, when one is present, is univalve, except in the chitons in which it consists of numerous pieces. The "foot" is generally well developed, broad and horizontally expanded, being used by the animal in creeping about; or it may be variously modified to adapt it for swimming or burrowing purposes. The eyes and organs of feeling and hearing are contained in the head, while the viscera (organs of alimentation, reproduction, etc.) are found in the posterior portion of the body.

Three principal portions are distinguishable in the body,—head, foot and visceral sac,—the last of these being protected by a fold of the dorsal integument called the "mantle." Typically, the foot is in the form of a flattened muscular disk, developed upon the ventral side of the body, and not divided into distinct parts. In certain types, however, the *Heteropoda* especially, the foot exhibits a division into three portions,—an anterior, a middle and a posterior lobe,—and besides forms either a ventral fin, or a fin-like tail, by means of which the animal swims, the back down wards.

The head is usually very distinct and is generally provided with tentacles and eyes. Within the pharynx is found the singular dental apparatus known as the

*Before my part of the work on the Lower Silurian Gastropoda of Minnesota could be finished, my friend and colaborer. Mr. W. H. Scofield, died. In his death science has lost an earnest and able, though too modest, worker, the Geological and Natural History Survey of Minnesota one of its best friends, and the world a true man. In finishing the work without his assistance. I may here and there have taken a stand that he might not have sanctioned. Some of the material which is described as new, he never saw, and, as it would be unjust to make him bear half the responsibility in these cases, I have thought it right to distinguish such species by placing my own name in parenthesis after the proposed names. Further, I wish it to be understood that whatever credit may attach to the following work Mr. Scofield has every right to share it with me. On the other hand, permit me alone to bear the blame for the errors. E. O. ULRICH.

"odontophore." The principal portion of this is a chitinous band called the "radula" or "lingual ribbon." This is beset with minute, regularly arranged teeth, and, as it is supported on a cartilaginous cushion, which can be given a rotary motion by a special set of muscles, the ribbon is made to act as a file or saw. The arrangement of the teeth in the radula, taking the whole class into consideration, is subject to considerable variation; yet, within narrower limits, their form and disposition are so constant that they afford one of the most reliable aids to classification. As a rule they are disposed in a medium series, flanked by two or more lateral rows.

Two principal modes of respiration pertain to the *Gastropoda*, the first by means of gills variously constructed and adapted to breathe air dissolved in water, and the second by means of a pulmonary chamber which is adapted for aerial respiration.

The alimentary canal, nervous and vascular systems, and some of the senses (seeing, feeling and hearing) are well developed. The sexes may be separate or united in one individual. Generally the young are developed in eggs laid in horny capsules or in the form of a string or band. With very few exceptions the young when first hatched are provided with a shell, which in some cases may subsequently entirely disappear through resorption. Very commonly the embryonic shell forms a nucleus at the apex of the fully-grown shell which is often very different from the following portions.

Most of the *Gastropoda* are water animals and a large proportion of them are inhabitants of the sea. Only the *Pulmonata* and certain groups of the *Prosobranchiata* are terrestrial in habit or live in fresh waters. The pteropods and heteropods of the present day are oceanic in habit and are found swimming in the open sea, near the surface and far from land; but the majority of the marine prosobranchs and the opisthobranchs live in shallow seas, many of them between tide-marks. In depths exceeding five hundred fathoms the number of *Gastropoda* is greatly reduced; still a few forms are found to inhabit depths of two or three thousand fathoms, or even more.

The *shell*, with which, for manifest reasons, the paleontologist is chiefly concerned, is a secretion of the mantle. It is wanting in the adult stages of the nudibranchs, while in other cases, notably the slugs, it is very minute and hidden in the mantle. In its chemical composition carbonate of lime, either in the form of calcite or aragonite, constitutes 95 per cent. or more of the whole. The inner layer is often nacreous (*Pleurotomariidæ*), but as a rule the whole shell, aside from the horny epidermis, consists of an apparently homogeneous porcellaneous mass, which when carefully examined is seen to be made up of three layers composed of parallel lamellæ, those in the outer and inner layers having the same direction, i. e. perpendicular to the surface and mostly at right angles to the external lines of growth. The lamellæ of the inner layer, which is commonly the strongest of the three, are also perpendicular but their direction is opposite. Tertiary *Gastropoda* often retain the microscopic structure of the shell in a very satisfactory manner, but as a rule the minute details are obscure, when not entirely obliterated, in fossil species.

The *form* of the shell varies greatly, yet within the limits of genera and species it is remarkably constant. Three types are distinguished,—the *tabular*, of straight or only slightly curved form and occurring only among the *Scaphopoda* and *Pteropoda;* the *symmetrical*, in which the shell is either conical or patelliform (*Archinacella*) or involute (*Bellerophon*); and the *spiral.*

The last is by far the most common type, and may in fact be looked upon as the typical form of the shell in the *Gastropoda*. In it the shell is essentially a spirally wound, elongated, conical tube, the coils or "whorls" being in most cases in contact and tightly cemented or amalgamated where they join. Sometimes the whorls are coiled nearly in the same plane, when the shell is said to be "discoidal," as in many of the *Euomphalidæ*. More generally, however, the whorls are wound about the axis in an oblique manner, a true spiral being formed, the shell becoming "turreted," "trochoid," "turbinated," etc. Occasionally the last whorl rises above the first or apical portion of the spire (*Ophileta, Maclurea*), but usually the embryonic shell or "nucleus" is at the top of a cone formed by the gradually enlarging and descending whorls, the mouth or "aperture" occurring at the extremity of the last and largest whorl, termed the "body-whorl." The whorls above the last constitute the "spire" of the shell. The line or groove marking the junction of the whorls is called the "suture." A shell is said to be "imperforate" when the axis or "columella" is solid (*Fusispira*), or it is "perforated" when the axis is hollow (*Trochonema*), the axial cavity itself being known as the "umbilicus." The "peristome" refers to the margin of the aperture; it is composed of an outer and an inner (or columellar) lip, of which the former is often expanded (*Bucanospira, Salpingostoma*) or fringed with spines. The peristome may be continuous or "entire" or it may be interrupted or "incomplete," in the latter case the left side of the aperture being formed only by the body-whorl. Not infrequently the aperture is drawn out and notched below, or there may be two notches, the second being above near the suture. These serve to protect the respiratory siphons. The posterior (upper) notch is probably represented by the median slit and perforation in *Scissurella* and *Fissurella*, and the same perhaps is true of the slit or notch in the outer lips of *Bellerophon* and *Pleurotomaria.*

In most spiral shells the whorls normally are wound to the right, the aperture when in view being on the right hand. In others, as for instance the recent *Physa* and the Lower Silurian *Clisiospira*, the volutions proceed in the opposite direction with such constancy as to be eminently characteristic. The apical part of the shell, which is directed backwards in all except some of the *Patellidæ*, presents important characters, as it contains the nucleus, or part formed in the egg, and the primative whorls, which are often very different from the succeeding turns. Careful investigation of the apex is likely to throw very reliable light upon the evolution of the fossil types.

In a large proportion of the *Gastropoda* the posterior portion of the foot secretes a calcareous, horny, or fibrous plate called the "operculum," which serves to close the aperture. Its inner surface is marked by a muscular scar whose lines bear no relation to its external lines of growth, nor is its form like the muscular scar in the shell. It begins its development in the embryo, the point from which it commences its growth being called the nucleus. Further growth may take place around the nucleus in a concentric or spiral manner, or the nucleus will be marginal the additions occurring on one side only. The spiral forms may make only one or two turns, or there may be as many as twenty. Opercula that were fit for preservation as fossils seem to be comparatively rare in Paleozoic rocks. When they are found it is nearly always as separate pieces so that it is in most cases very difficult to decide to which of the associated shells they really belong. Still, some of the early Paleozoic forms are interesting, being of unusual types, that of *Maclurea* especially being remarkable for the strong internal process to which the muscle was attached.

Regarding the markings of the external surface of the shell, the "lines of growth," which are more or less fine lines or stronger plications running parallel with the edge of the apertural lips, are nearly always distinguishable. Their importance to the paleontologist, who only too often must be satisfied with imperfect specimens, is obvious. Sculpture and color markings are *longitudinal* or *vertical* when they take the direction of the axis, and *revolving* when they follow the spiral. Of the more common varieties of sculpture we may mention the *striate*, in which the surface is covered with fine lines either longitudinal or revolving; the *carinate*, when the revolving sculpture is prominent and sharp; the *plicate* referring to a vertically ribbed sculpture; the *cancellate*, in which fine and straight vertical and revolving lines cross each other nearly at right angles; the *reticulate*, in which the decussating lines are not straight; the *punctate*, *granulose*, *nodose* and *spinous*, referring to conditions sufficiently expressed by the terms applied to them.

Finally, as regards the application of measurements, the distance between the apex and basal extremity of a gastropod shell is termed the *hight*, while the *width* or *diameter* of a spiral shell is the distance through the body-whorl at its periphery. *Length* should be applied only to patelliform shells, in which it refers to the distance from the anterior to the posterior margin. A whorl represents a single complete revolution of the spiral cone; its *periphery* is an imaginary spiral upon the outer wall corresponding with the line of greatest width. In counting the number of whorls we begin with the apertural margin from which to a point on the suture next above it constitutes one whorl. Repeating this process to the apex gives the total number. The *apical angle*, which is the angle formed by the diverging sides of the conical spire, is determined by means of a goniometer.

CLASSIFICATION.

It is very difficult to decide which of the numerous systems of classification that have been proposed is the most convenient and at the same time the most natural. The old school of naturalists paid little attention to anything save the shell. Another and later school bases a classification almost solely upon the modification of the lingual dental apparatus. As neither method has proved entirely satisfactory, the most recent authorities are seeking to frame a system that will combine the best features of previous classifications. But it cannot be denied that the system that will do full justice to the evolution of the class is still a thing of the future. Ontogeny and chronogenesis will have much to do with it, from which it is obvious that a large proportion of the work must fall to the paleontologist.

The classification adopted by Zittel in his "Handbuch der Palæontologie," embraces all the *Mollusca* which are provided with a tongue in one class, the *Glossophora*. These are divided into four subclasses, the *Scaphopoda*, *Placophora*, *Gastropoda*, and *Pteropoda*. Nicholson retains the first two of these subclasses as distinct classes, and unites the last with the third. The *Gastropoda* he divides into two primary groups or subclasses, the *Branchiogastropoda* and the *Pulmogastropoda*. The *Branchiogastropoda* again he divides into four orders, the *Prosobranchiata*, *Opisthobranchiata*, *Pteropoda* and *Heteropoda*. Tryon, in his great work on "Structural and Systematic Conchology," arranges the same organisms as follows: class *Pteropoda;* class *Gastropoda*, subclasses *Prosobranchiata*, *Opisthobranchiata* and *Pulmonifera;* class *Scaphopoda*. Fischer's arrangement again is different: class *Pteropoda;* class *Gastropoda;* subclass *Univalvia*, orders *Pulmonata*, *Opisthobranchiata*, *Nucleobranchiata* and *Prosobranchiata;* subclass *Multivalvia*, order *Polyplacophora*.

If we should accept any of the foregoing arrangements it would be Zittel's, but as his scheme is not as well balanced as it might be a few changes are suggested in the following brief characterization of the principal divisions. Perhaps a more acceptable subdivision of the class would result if the various groups were reduced in rank, the subclasses to orders, the orders to suborders, and the suborders to superfamilies. The divisions *a* and *b* would in that case take the rank of subclasses. Though inclined to favor such a proceeding, we refrained from carrying it out because it entailed more responsibility than we cared to assume at the present time.

Class GASTROPODA, Cuvier.

Division a.

I. Subclass Scaphopoda, Bronn.

Mollusks having neither eyes nor a distinct head, yet with the lingual armature. Sexes separate. Foot vermiform, lobate. Shell a hollow cylinder, open at both ends. *Dentalium* is the principal representative.

II. Subclass Polyplacophora, Blainville.

Symmetrical mollusks having a distinct head, but neither eyes nor tentacles. Foot broad. Shell consisting of eight moveable calcareous plates arranged in a row. This division includes the chitons.

III. Subclass Pteropoda, Cuvier.

Head and organs of sense rudimentary. Foot modified into two lateral wing-like expansions used in swimming. Animal naked or protected by a shell.

Order *Thecosomata*, Blainville; with mantle and external shell.

Order *Gymnosomata*, Blainville; both shell and mantle wanting.

IV. Subclass Docoglossa. (Provisional.)

Approximately symmetrical gastropods, provided with dish-shaped or conical shells, or with spiral shells coiled in the same plane. A very primitive group of which the *Patellacea* and *Bellerophontacea*, comprised in the provisional order *Proteobranchia*, constitute the bulk, if not the whole.

V. Subclass Opisthobranchiata, M. Edwards.

Branchiæ more or less free, behind the heart. Animals rather highly developed, naked or with a shell; the sexes united in the same individual.

Order *Nudibranchiata;* without a shell.

Order *Tectibranchiata;* with a shell.

Division b.

VI. Subclass Prosobranchiata, M. Edwards.

Head and organs of sense well developed. Animals breathing by means of gills or branchiæ situated in front of the heart; mostly marine, and provided with a spiral shell, and generally an operculum. Sexes separate. This is the largest and most typical division of the class.

Order *Nucleobranchiata* or *Heteropoda*; foot laterally compressed, with fin-like swimming lobes. Shell sometimes wanting; when present it is more or less symmetrical, involute and very thin.

Order *Pectinibranchiata;* branchiæ pectiniform, better and more constantly developed than in preceding order; shell spiral, not symmetrical.

VII. Subclass Pulmonata, Cuvier.

Animal breathing by means of a pulmonary chamber or lung instead of gills. Sexes united in the same individual.

A classification of the Paleozoic genera of the *Gastropoda* and remarks on their geological distribution, especially of the Lower Silurian types, followed by a summary of the principal results of our work, will be found at the close of the chapter.

Class GASTROPODA.

Subclass DOCOGLOSSA.

Order PROTEOBRANCHIA.

Suborder PATELLACEA.

Family PATELLIDÆ.

The Paleozoic shells which are usually placed in this family are an exceedingly difficult group. While we may be reasonably confident that the relations of some of them are not far from the recent genus *Patella,* there are many others that remind one quite as much of *Lepeta* and *Acmæa.* These difficulties are of course largely due to the imperfect condition in which the shells are preserved. But, even when the muscular scars are retained, and this is all we can expect to learn of the internal and soft parts of the animals, it is not by any means easy to decide just what affinities they indicate most, because these scars, like the whole form of the shells, are in a general way very similar among the twenty or more recent patelloid genera and subgenera.

When, however, we consider the great diversity of structure of the soft parts that can exist in shells looking so much alike, it surely seems highly improbable that any of the Paleozoic types could have continued on till the present time without being materially modified structurally. And yet it is most difficult to sustain this supposition by a comparison with the fossils. While the latter, so far as known, can in no case be said to be strictly identical with any of the recent genera, the resemblances in several instances are still very striking. Thus, while *Tryblidium* differs from *Nacella* and the other *Patellidæ* chiefly in having the muscular scars separate, the otherwise very similar proposed genus *Archinacella* approaches the recent forms even more closely in having the scars indistinguishably merged into a continuous narrow impression. Little is known of the muscular scars of *Scenella* and *Helcionopsis*, but comparing external characters they agree very well, the first with *Acmæa* or *Lepeta*, and the second with *Helcion*.

While we admit freely that it may not be possible to prove that the Paleozoic *Patellidæ* are in all cases generically distinct from living types of the family, we are nevertheless fully convinced that such is the case. This conviction, as will be shown in the next paragraph, has something to support it besides the mere improbability of their identity. Obviously then we consider ourselves justified in proposing two new names and in retaining those which have already been proposed for those groups which it is convenient to distinguish. We were really forced to these views by the miserable failure of our efforts to distribute the Paleozoic species among the recent genera. After repeated endeavors, the results being different every time, we gave it up as being, to say the least, impracticable.

The distinctive evidence referred to in the preceding paragraph is shown in three specimens before us. It consists namely of a pair of rostral muscular imprints which seem not to belong to the usual ring of scars and which we do not find

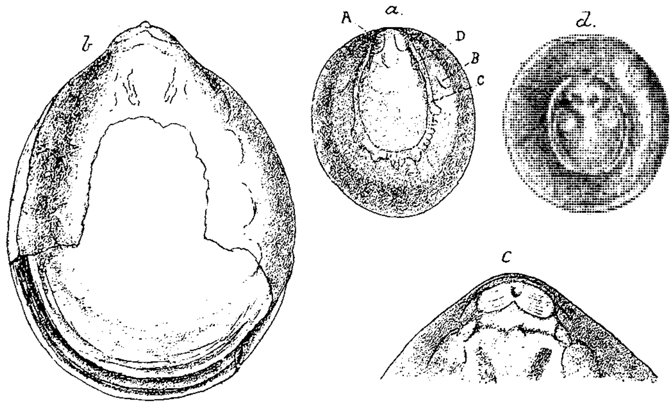

Fig. 1.—*a*, dorsal view of a cast of the interior of *Archinacella powersi* U. & S., showing the rostral scars at A; *b*, dorsal view of a partial cast of the interior of *Tryblidium unguis* Lindström; *c*, apical portion of same in a direct view to show the rostral scars; *d*, dorsal view of a cast of *Lepetopsis*, sp. undet., from Kansas City, Mo , showing muscular imprints very satisfactorily.

represented among recent forms. The first of these specimens (*a* of the accompanying cut) belongs to our new genus *Archinacella;* the second (fig. 1 *b* and *c*) is of the type species of *Tryblidium;* while the third (fig. 1 *d*) appears to belong to an undescribed species of *Lepetopsis.* The first, then, is a Lower Silurian fossil, the second Upper Silurian, and the third Carboniferous.

The recent *Patellidæ* are distributed into generic groups according to the anatomical peculiarities of the animals, the characters of the shell being considered as of minor importance. Obviously such a rule cannot be applied to the fossil representatives of the family, seeing that their shells only are preserved. But that should not prevent the paleontologist from attempting a classification of the numerous species that have been discovered in the rocks. The geologist requires some convenient means of discriminating between the groups of species, and the systematist is in a great measure bound to respect this desire, especially if the convenience of an arrangement does not directly oppose what he conceives to be the natural affinities.

In arranging the Paleozoic species we have made use of the muscular scars whenever these were available. But they are so seldom preserved that their use is necessarily very limited. In a large majority of the species the scars are entirely unknown, and even under the most favorable circumstances they are generally rather indefinitely outlined. We are, therefore, obliged to rely largely upon striking external features, of which the form and outline, the position of the apex and the character of the surface markings seem to be the most available. The groups may be characterized briefly as follows:

TRYBLIDIUM, Lindström. Shell patelliform, obovate, narrowest anteriorly, forming a very low cone; apex anterior, nearly marginal. Mucular scars in seven or eight disconnected pairs, arranged in an oblong circle, the anterior pair drawn out and meeting in front beneath the beak. Surface usually marked by concentric lines of growth only; occasionally also by obscure broad radial plications. Type, *T. unguis* Lindström.

ARCHINACELLA, n. gen. Shell patelliform, ovate to subcircular, usually widest anteriorly, forming a low cone with the apex in front of the center and often submarginal. Muscular scars forming a continuous band. Surface markings concentric only. Type, *A. powersi*, n. sp.

HELCIONOPSIS, n. gen. General form and position of apex as in *Tryblidium*, from which the species differ in having the surface marked by fine radiating striæ. Muscular scars unknown. Type, *H. fissicostata*, n. sp.

PALÆACMÆA, Hall and Whitfield. Shell forming a low cone, the base rounded or elliptical, the apex subcentral. Surface thrown into broad, rather regular, concentric folds, without radial lines. Muscular scars unknown. Type, *P. typica* H. & W.

Scenella, Billings. Shell conical, rather high, apex subcentral, surface with distinct radial lines or ribs crossed by fine lines of growth. Muscular scars large, situated above the mid-hight, forming a complete circle in which the impression of each muscle may or may not be distinguishable. Type, *S. reticulata* Billings.

Lepetopsis, Whitfield.* Shell patelliform, broadly oval, conical, low, with the apex subcentral. Muscular impression horseshoe-shaped, open in front, consisting of an irregular band. Surface with concentric lines of growth, occasionally perhaps also with a few radial lines. Type, *L. levettii* White, St. Louis group.

Stenotheca, (Salter) Hicks. Shell small, high, the whole curved so that the apex generally projects beyond the basal margin. Surface usually with strong transverse (concentric) folds and fine radiating lines. Type, *S. cornucopia* Salter.

Besides the above groups the Paleozoic strata doubtless contain others equally distinct that for want of material cannot now be characterized satisfactorily. The two Wisconsin Calciferous species which Whitfield describes in "Geology of Wisconsin" (vol. iv), under the names *Metoptoma recurva* and *retrorsa*, are, as has already been suggested by Lindström and Koken, certainly not *Metoptoma*. Nor can we consider them as being much nearer either *Tryblidium* or *Archinacella*. The peculiar retral bending of their apices is so unusual that it may well be considered as indicating a new generic type.

Another peculiar type is shown in *Metoptoma alceste* and *M. orithyia*, both described by Billings in "Palæozoic Fossils" (vol. i), the first from the Hudson River group of Anticosti and the other from the Calciferous of Canada East. These are relatively high conical shells, with a narrow vertical fold or blunt carina on one side running from the apex to the margin. The general form and the fold remind one of *Hercynella*, Kayser, founded upon Upper Silurian shells of Europe, and it is possible that they should be referred to that genus. Koken, however, refers *Hercynella* to the *Calyptrœidœ* near *Capulus* and *Platyostoma*, a position we can scarcely believe proper for the two species in question.

Metoptoma angusta Billings, from the Quebec group, is another species of doubtful affinities. It is a large shell, with the apex "a little in advance of the middle, and apparently a little curved backwards," and "the anterior side flattened." The last feature suggests *Metoptoma*, but we doubt very much that it really belongs to that genus. *M. anomala*, of the same author and formation, cannot be a *Metoptoma*, but

* Bull. Amer. Mus. Nat. Hist., vol. i, no. 3, p. 67; 1882. All the known American Carboniferous patelloid shells seem to belong to this genus. In Europe the genus is represented by *Metoptoma*, Phillips, from which it differs in its rounded outline and in wanting the truncation and flattening of the posterior side which characterizes the species of Phillips' genus. Although *Metoptoma* has been used very frequently by American authors, it is quite clear that none of the species described by them really possess the essential features of that genus.

we are completely in the dark as to its probable affinities. The other species referred to this genus by Billings fall more or less naturally into one or the other of the generic groups above outlined and will be referred to in discussing the genera further on.

We ought perhaps to have included the illy characterized genus *Conchopeltis*, Walcott, among the Paleozoic *Patellidæ*, especially since the types of the second species described by the author of the genus came from the Lower Silurian of Minnesota. As neither is illustrated, we must rely upon Walcott's description of the genus. That gives us to understand that it is founded on conical patelliform univalves having the apex subcentral and the surface radially striated. So far as it goes it agrees with *Scenella* and that indeed is the position we assign to *C. minnesotensis* Walcott.

After considerable trouble Prof. N. H. Winchell succeeded in having drawings prepared of *C. alternata*, the first species described by Walcott, and the one therefore to be regarded as the type of the genus. As may be seen from the accompanying figures, the slopes in this species are divided into four, slightly convex, lobe-like

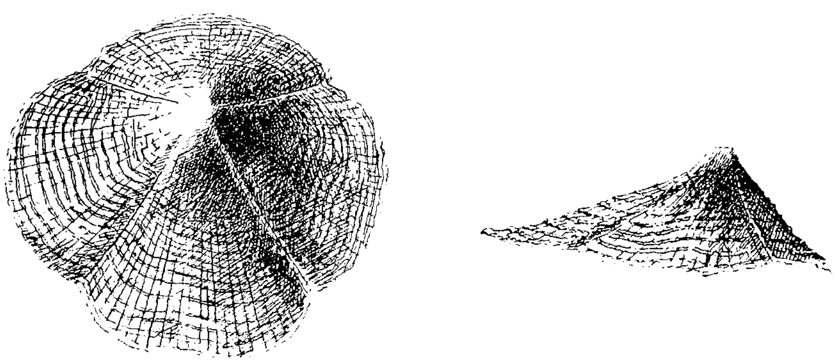

Fig. 2.—*Conchopeltis alternata* Walcott, Trenton limestone, Trenton Falls, N. Y. Two views prepared from the original types of the species (now preserved in the Cambridge Museum) showing the four lobe-like divisions of the shell, its form and surface workings.

parts by an equal number of narrow depressions radiating from the apex. So far as we are aware, none of the other described patelliform shells exhibit such a lobing of the shell, and we are therefore quite uncertain as to the affinities of the genus We should mention, however, that a similar peculiarity occurs in three new species of an undescribed genus of patelliform shells, two of them from the Cincinnati rocks, the other from the Devonian. In these there is a strong transverse division passing immediately above the beak and separating a lobe corresponding to the upper one in our figure of *Conchopeltis*, but the rest of the shell is not lobed. The outer layer of these shells is minutely and beautifully punctate.

Genus TRYBLIDIUM, Lindström.

Tryblidium, LINDSTRÖM, 1880, Fragmenta Silurica, p. 15; 1884, Silurian Gastropoda of Gotland, p. 52.
Tryblidium (part.), WHITEAVES, 1884, Paleozoic Fossils, vol. iii, p. 30. WHITFIELD, 1888, Bull. Amer. Mus. Nat. Hist., vol. i, p. 303.
Metoptoma (part.) of BILLINGS and other authors.

For generic diagnosis see page 821.

Our description of this genus does not agree in all respects with that given by Lindström. This is partly because we believe his to be incorrect in several particulars, and partly because we have seen fit to leave out as unimportant one or two features, and to mention the style of surface markings. Of the three species described by Lindström in his last work (*op. cit.*), *T. reticulatum*, *T. unguis* and *T.? radiatum*, we would strike out the first and the last, while to the second we would assign the rank of type of the genus. This proceeding is not strictly in accordance with usage, since when, as in this case, no type is specified, it is customary to regard as such the first species following the generic description. The rule is both a good and a necessary one, yet there are cases, and we believe this is one of them, where it is best not to follow it.

The species *reticulatum* and *unguis*, of which we have through the kindness of Dr. Lindström good examples before us, represents according to our views two generically distinct types, of which the first is limited to one or possibly two species,* while the second is recognized in numerous Lower and Upper Silurian species. Herein lies the reason for the course here pursued with respect to the type of the genus, for, should our view of the generic distinctions of the two species available as types prevail, the greater justice and credit would accrue to the learned author of the genus if his name is adopted for the more abundant group of the two. As to the third species, *T.? radiatum*, we refer it with much confidence to our new genus *Helcionopsis*.

T. unguis and all the other species which we leave under *Tryblidium* have a concentrically striated thin shell composed, as far as known, of thin glossy lamellæ which are never porous. *T. reticulatum*, on the contrary, has a thick shell, especially at the edges, the external layer is minutely porous, and the surface strongly marked by salient oblique concentric laminæ, which in the anterior part cross each other, producing an "engine turning" style of network. Lindström is inclined to regard the porous character of the outer layer as produced by some parasitic organism. Such an explanation of the origin of the pores would no doubt be a good one if they occurred only occasionally, but considering the fact that they are always present in the Gotland specimens, and what is more, that they seem to be uniformly distributed over the whole exterior stratum, we may well question its sufficiency. The view

* Lindström mentions a Lower Silurian species from Esthonia which he says is closely related to *T. reticulatum*.

that these pores are really a normal feature of the external layer receives strong support from the fact that a porous outer layer occurs also in other patelliform shells. We have, namely, specimens before us of two shells belonging to an undescribed genus in which the whole external surface is beautifully punctate. One of these specimens is from the top of the Cincinnati group at Richmond, Indiana, the other from the middle Devonian at the falls of the Ohio.

Prof. J. F. Whiteaves, paleontologist to the Geological Survey of Canada, was the first to recognize the application of *Tryblidium* to American fossils. In referring to Canadian patelliform shells (*op. cit.*, p. 31), he subscribes to the suggestion of Mr. Dall (Amer. Journ. Conch., vol. vi, p. 281, 1881) that none of the nineteen species provisionally referred to Phillips' genus *Metoptoma* really belong to that genus as now understood. Continuing he says that in his judgment "*Metoptoma quebecensis* Billings, belongs to the genus *Palæacmæa* of Hall and Whitfield. *M. niobe*, *M. nycteis*, *M. eubule*, *M. erato* and *M. hyrie* Billings, are typical species of *Tryblidium*, Lindström." So far he expresses our views exactly, but when it comes to the new species, which he names *T. canadense*, we, as did also Lindström in his second work on the genus (p. 54), note differences that necessitate its removal from *Tryblidium*. To us it is an undoubted member of our new genus *Archinacella*.

In 1886 Prof. R. P. Whitfield (*op. cit.*) described two species, *ovale* and *ovatum*, which are unquestionably congeneric with *T. unguis* Lindström. In his remarks on the species he points out some differences which exist between his species and the generic description given by Lindström, and suggests that some of the characters mentioned in the latter are only specific and not generic. This is true of the aperture so far as its being straight or arched is concerned, but we cannot agree with him when he places in the genus species like his *T. conicum*, in which the apex is almost central. Such species should in most cases be regarded as belonging to *Scenella* or *Palæacmæa*. Further, he notes a difference in the number of the muscular scars, Lindström stating that the Gotland species have only six pairs, while his species have eight pairs. Again, he found that his species differed from Lindström's generic diagnosis in having the muscular scars "continuous around and below the apex of the shell, in a deep and continuous line, from the elongated clavate scars on the sides of the beak or apex, as they are in *Nacella*," instead of "open or nearly so towards the outer end."

A careful study of *T. unguis*, which we owe to the kindness of Dr. Lindström himself, enables us to show that there is no essential difference between the muscular scars of this Gotland type of the genus and those shown to exist in the Fort Cassin beds species by Whitfield. The fact is that *T. unguis* has eight instead of six pairs of scars, and the narrow ends of the anterior pair, which is smaller than usual, curve around in front to meet beneath the apex. (See fig. 1*c*, p. 820.) Lindström probably overlooked these anterior pairs because he noticed a slightly elevated, transverse, medially disconnected band just in front of the sixth pair. But this band is really the posterior boundary of the scars of an umbonal pair* of muscles which we have shown to exist in a number, if not all, of the Paleozoic *Patellidæ*.

As already stated, we regard *T. conicum* Whitfield, as a *Scenella*, while *Metoptoma simplex* Billings, which Whitfield places under *Tryblidium*, and *T. piliolum* Whitfield probably belong to *Archinacella*. *T.? acutum* Whitfield, with its flattened area-like slope beneath the projecting apex, seems to us to indicate an undescribed generic type.

TRYBLIDIUM MODESTUM, *n. sp.*

PLATE LXXXII. FIGS. 1 and 2.

Shell small, somewhat acutely ovate in outline, the apex being pointed, scarcely incurved and projectly slightly beyond the narrowly rounded anterior margin of the aperture; the latter is scarcely, if at all, arched. Surface not well preserved, apparently marked by faint lines of growth. Internal characters unknown. Length 10.3 mm.; width 8.5 mm.; hight of apex about 2 mm.; greatest hight (near center of length) about 2.8 mm.

This species is founded upon a single imperfect shell. As the muscular scars have not been observed the generic reference is perhaps a little doubtful. Still, the form of the shell is such that we are fairly confident that it will prove to be a true *Tryblidium*. Of described species *T. erato* Billings sp., from the Black River limestone of Canada, appears to be the nearest. On comparison with the description of that species (it has not yet been figured) it is evident that *T. modestum* is much smaller, relatively wider posteriorly and not so convex. The fact that the shell is narrower in front than behind will distinguish it at once from all the species of *Archinacella*. Otherwise it looks very much like *A. patelliformis*. It also resembles *Stenotheca unguiformis*, but is wider and the beak is not so prominent in front, while the surface markings are quite different.

Formation and locality.—Black River group, Ctenodonta bed, near Cannon Falls, Minnesota.
Collection.—E. O. Ulrich.

Genus HELCIONOPSIS, n. gen.

For generic description see page 821.

Of this genus we have at present only three species, the two about to be described and an Upper Silurian one from Gotland, which Lindström placed doubtfully

*These umbonal scars are shown in fig. 37, pl. I, of Lindström's "Gastropoda and Pteropoda of Gotland."

in his genus *Tryblidium* with the specific name *radiatum.* It is very closely related to our *H. striata.* Unfortunately we know very little of the muscular scars of these species, so that it is difficult to decide whether their affinities are nearer *Tryblidium* or *Archinacella.* What is known of them agrees better, as does also the form of the shells, with species of the former genus, while they are distinguished from both by the distinct radial sculpture of their surfaces. The marginal position of the apex separates them from *Scenella,* Billings. *Stenotheca,* Salter, includes laterally compressed and much higher shells.

The generic name is from the external resemblance which the species bear to the recent species of the genus *Helcion,* Montfort.

HELCIONOPSIS STRIATA, *n. sp.* (*Ulrich.*)

PLATE LXI, FIGS. 29 and 30.

Shell rather strongly convex, acuminate-ovate in outline, broadly and regularly rounded behind, pointed in front where the apex projects slightly beyond the margin of the aperture; apex incurved. Surface marked by distinct, rounded, radiating lines, which in the outer half maintain an approximately equal size through bifurcation; about ten lines in 5 mm.; whole surface with very fine concentric lines; at intervals of 1 to 3 mm. irregular wrinkles marking stages of growth. Length 24.5 mm.; width about 19 mm.; greatest hight 9 mm.; hight of apex about 4.5 mm.

This species is quite distinct from all American patelliform shells, but is closely related to the Upper Silurian *H. radiata* Lindström sp.* As figured that species is a little more convex, the anterior outline blunter and the apex more incurved.

Formation and locality.—Rare in the upper beds of the Cincinnati formation, Marion county, Kentucky. Also, though of smaller size, in the Loraine group at Cincinnati, Ohio.

Collection.—E. O. Ulrich

HELCIONOPSIS SUBCARINATA, *n. sp.*

PLATE LXI, FIG. 28.

Shell small, subovate in outline, the anterior and posterior margins subequal and sharply rounded in the middle. In the cast the apex is depressed, small and not quite marginal; an obtuse carination extends across the length of the shell. Surface of cast showing remains of very fine radiating lines, scarcely visible without a magnifier, and a few obscure lines of growth. Length 10 mm.; width 8 mm.; greatest hight 3.5 mm.; hight of apex 1.5 mm.

We have only two specimens of this interesting species. Both are casts and show impressions of the rostral muscles. One exhibits besides a series of muscular scars similar to those of *Tryblidium.* The lines converging from them towards the

* Silurian Gastropoda and Pteropoda of Gotland, p. 58; 1886.

apex are a peculiar feature, though probably of the nature of "progressive tracts."

The obtuse angulation of the back of the shell distinguishes the species from all the Paleozoic forms of this family known to us. When not in a good state of preservation it might be confounded with *Archinacella patelliformis* Hall sp., but in that species the angulation of the back does not extend to the extremities of the shell, while the anterior end is wider, the apex higher and the surface without radial markings.

Formation and locality.—Trenton group, Clitambonites bed, Goodhue county, Minnesota.

Collection.—E. O. Ulrich.

Genus ARCHINACELLA, n. gen.

Metoptoma (part.), BILLINGS, 1865, Palæozoic Fossils, vol. i. WHITFIELD, 1878, Geol. Wis., vol. iv. *Tryblidium* (part.), WHITEAVES, 1884, Palæozoic Fossils, vol. iii, p. 31. WHITFIELD, 1886 and 1889, Bull. Amer. Mus. Nat. Hist., vols. i and ii.

For generic diagnosis see page 821.*

The shells which we propose to refer to this genus are decidedly like those of *Tryblidium*, especially so far as the position of the apex and the surface markings are concerned. Their internal markings, however, are readily distinguished, that genus having the muscular scars in eight detached pairs, while they form a continuous band in *Archinacella*. Unfortunately the muscular imprints are in most cases very faint, even on well preserved casts, so that we are generally obliged to rely upon another character in determining the generic position. Namely, in all the species of which the muscular scars are known to occur in detached pairs the anterior outline is acuminate, or at any rate more narrowly rounded than the posterior margin. On the other hand, the anterior margin is as broadly rounded or wider than the posterior outline in all the forms of which it is known that their muscular scars are not detached. We have, therefore, considered it good practice to assume that when the anterior end is narrowly rounded the species is a *Tryblidium* and when this end is the wider the species belongs to *Archinacella*.

There may be some doubt about the affinities of that group of shells in which the outline, as viewed from above, is almost circular or regularily elliptical. In no case have we been able to make out the muscular scars, although we have studied some well preserved casts. Still, as the form of these shells agrees best with *Archinacella*, and as we know nothing seriously opposing our view, we think it best to arrange them, at least provisionally, under this genus. Besides the species of

*We omitted from the generic diagnosis one feature that ought perhaps to have been included, namely, a pair of scars (? muscular) occurring one on each side of the apex. They lie on the outside of the usual muscular band and have been observed in two species, *A. powersi* and *A. (Tryblidium) canadensis* Whiteaves. The latter is a Guelph species and, as shown in Whiteaves' figures (Pal. Foss., vol. iii, pl. v), has these scars more strongly impressed (in the cast) and further forward than they are in *A. powersi*.

this type described in the following pages, we refer to *Metoptoma instabilis* Billings (Quebec group), *M. simplex* Billings (Calciferous group), *M. trentonensis* Billings (Trenton group) and *M. estella* Billings (Hudson River group).

In addition to the species of which descriptions follow and those mentioned in the preceding paragraph, we regard *Tryblidium piliolum* Whitfield, *T. canadense* Whiteaves, *Metoptoma phillipsi* Walcott, and *M. similis* Whitfield, as belonging to this genus.

ARCHINACELLA POWERSI, *n. sp.*

PLATE LXI. FIGS. 3–5.

Shell large for the genus, moderately convex, subovate, widest in the anterior half; anterior outline semicircular, the posterior semielliptical; margins of aperture rather strongly arcuate; apex rather blunt, slightly incurved, the extreme point just over the margin and at least two-thirds of the greatest hight of the shell above it. Surface with fine, distant, impressed lines of growth; near the margin the markings become somewhat lamellose. Length 29 mm.; width 25 mm.; greatest hight 10 mm.; hight of apex 6.5 mm.

Impressions of the interior markings are excellently preserved on the cast figured on plate LXI. The loop of muscular scars forms one continuous narrow band curving distinctly down in front so as to pass beneath the apex. The posterior third is somewhat wider and prolonged on the outer side into numerous irregular processes. Within the anterior end of the loop we see the pair of rostral scars, and just behind them a narrow pair lies close to the band. Finally, we observe faint impressions of a larger anterior pair without the band, which may be called antero-laterals.

This fine species is readily distinguished from all described heretofore. Collectors seem to have confounded it with *A. perovalis* Whitfield sp., which occurs in the same strata, but is smaller, decidedly narrower—in front especially—and has the apex not quite marginal.

Formation and locality.—Stone's River group, Beloit, Wisconsin, where the types were collected by Mr. H. C. Powers, for whom the species is named.

Collections.—University of Wisconsin; E. O. Ulrich.

ARCHINACELLA CINGULATA, *n. sp.* (*Ulrich.*)

PLATE LXI, FIGS. 1 and 2.

Shell large, rather strongly convex, subovate in outline, very broadly rounded in front, more narrowly behind; hight, width and length respectively as 4.5 to 10 to 12; margin of aperture horizontal; apex bluntly pointed, curved downward to about half the hight of the shell, projecting distinctly beyond the margin. Surface with well marked sublamellose lines of growth, averaging in the outer half about 1 mm. apart. Length 32 mm.; width 26 mm.; greatest hight 11 mm.; hight of apex 5 mm.

This species resembles *A. powersi,* but may be distinguished at once by the contour of its aperture, the margins being strongly arched in that species while in this one they are horizontal. The surface markings are also stronger in *A. cingulata,* while the anterior outline is broader, the apex projects farther forward and the transverse section of the shell is more convex, especially in the post-central region. *A. patelliformis* Hall sp., and *A. simulatrix,* though much smaller, are probably more intimately related to *A. cingulata* than is *A. powersi.*

Formation and locality.—Trenton group, Amygdalocystites bed, Mercer county, Kentucky.
Collection.—E. O. Ulrich.

ARCHINACELLA DEPRESSA, *n. sp.*

PLATE LXI, FIGS. 8 and 9.

Shell of medium size, depressed-conical, the outline almost regularly oval, rather wide; the width and length about as seven is to eight; apex situated about one-seventh of the length from the anterior margin; the point, which is a little imperfect in the specimen, seems not to have been much elevated or incurved; apertural margin arched. Surface exhibiting a few obscure concentric lines. Muscular scars not observed. Length 20.5 mm.; width 18 mm.; greatest hight (at apex) about 5.2 mm.

This shell agrees with *A. powersi* in the arched apertural margin and broad form, but differs decidedly in having the apex situated some distance from the margin. As the convexity of the shell also is somewhat less, the profiles are different. There is also a slight difference in the outline as seen from above. In all these features the species approaches *A. perovalis* Whitfield sp., but it is readily distinguished from that species by its greater width and lower form.

Formation and locality.—Stone's River group, Vanuxemia bed, Minneapolis.
Collection.—Geological and Natural History Survey of Minnesota.
Museum Register, No. 5523.

ARCHINACELLA PEROVALIS *Whitfield sp.*

PLATE LXXXII, FIGS. 3 and 4.

Metoptoma perovalis WHITFIELD, 1878, Ann. Rept. Geol. Surv. Wis., p. 74; 1882, Geol. Wis., vol. iv, p. 211, pl. v, figs. 13 and 14.
Metoptoma explanata SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 336.

This species agrees very closely with *A. depressa,* the only difference of any consequence that we can now point out being the greater width of that shell. In

A. perovalis the width is to the length about as eleven is to fifteen, while in the other it is as seven is to eight. Specimens vary in length from 16 to 30 mm. The muscular scars, so far as they have been determined, agree very well with those of *A. powersi.* The apertural margin is slightly arched, and the surface appears to have been nearly smooth.

Whitfield describes and figures this species as being flattened and truncate in front, and the absence of anything of the kind in the Minnesota specimens led Mr. Sardeson into giving a new name to the latter. We also failed to notice such a feature in any specimen, even those from Beloit, Wisconsin, the typical locality for the species, being without it, though agreeing in every other particular with Whitfield's figures. It seems, therefore, to us that the slight anterior truncation exhibited by the type specimen may be due to some abnormal cause.

Formation and locality.—Stone's River group, Vanuxemia bed, Minneapolis, Minnesota, and Beloit, Wisconsin.

ARCHINACELLA DELETA *Sardeson sp.*

PLATE LXI, FIGS. 16–20.

Carinaropsis deleta SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 335.

Shell small, obliquely subconical, rather convex, elliptical in outline, the width and length usually as three is to four; aperture nearly horizontal; embryonic shell very small, involute, forming about one volution, rarely preserved, the apex usually appearing as but little incurved; the apex situated constantly a short distance behind the anterior margin. Surface almost smooth, occasionally exhibiting a few lines of growth. Length 9.25 mm.; width 7.1 mm.; greatest hight 4.25 mm.; hight of apex about 3 mm.

This species commonly grew upon the shells of other mollusks and it is often attached to them. We have before us several specimens that, having grown upon the concave inner sides of dead shells of *Protowarthia pervoluta* and *Holopea obliqua*, are now represented by a biconvex fossil reminding one greatly of casts of some discinoid brachiopod. Two of these specimens are represented on plate LXI.

This is the first of a group of species that seems to be related to *A.* (*Carinaropsis*) *patelliformis* Hall (Pal. N. Y., vol. i, p. 183; 1847). One or the other of these forms occurs in, or in the equivalent of, every one of the principal beds between the base of the Black River group and the top of the Cincinnati formation. None of the western and northwestern species however seem to be strictly identical with the New York types of *patelliformis*, all of them having a nearly smooth surface, while Hall's species according to his figures and descriptions has the surface marked by regular, concentric, sublamelliform striæ.* The present species differs further in wanting the obtuse carination of the dorsum and in having a smaller apex.

Formation and locality.—Black River group, Rhinidictya and Ctenodonta beds, Minneapolis, St. Paul, Cannon Falls. Chatfield, and near Fountain, Minnesota. Of all the patelliform shells occurring in Minnesota rocks this is the only one that is reasonably abundant. We have seen about twenty specimens.

Collections.—Geological and Natural History Survey of Minnesota; Geological Department, University of Minnesota; W. H. Scofield; E. O. Ulrich.

Museum Register, Nos. 4067 and 8723.

ARCHINACELLA VALIDA *Sardeson sp.*

PLATE LXI, FIGS. 14 and 15.

Tryblidium validum SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 337.

Shell rather small, oblique-subconical, strongly convex, the dorsum narrowly rounded; outline elliptical, the width and length about as four is to five; aperture not arched; apex just within the anterior margin, laterally compressed, but little incurved in casts, the point about two-thirds of the hight of the shell above the edge of the aperture; beneath the apex the outline is deeply cut out in a side view. Surface markings consisting of rather obscure lines of growth. Length (small specimen) 16.5 mm.; width 13.4 mm.; hight nearly 7 mm. In another specimen, proportionally larger, the length reaches 20 mm.

We believe the specimens here figured and described are specifically the same as the one which Mr. Sardeson recently proposed to call *Tryblidium validum.* A comparison of our figures with his, it is true, brings out some differences, the outline of the aperture in ours being more regularly elliptical and the profile in the side view less convex centrally. It would appear, however, that in Mr. Sardeson's figure 2 the convexity is exaggerated, since in his description he gives the hight of the shell as equalling only half the width. And this is true of both the specimens here referred to his species. In this same figure 2 he shows three detached muscle scars, of so large a size that the whole ring would be made up of only three or possibly four pairs! But this would be so much out of the regular order that we are fully convinced that they rest on faulty observation. So far as our specimens are concerned nothing of the kind is to be observed. On the contrary we notice faint indications of the *Archinacella* band, and hence refer the species to this genus.

Specifically *A. valida* is nearer *A.* (*Carinaropsis*) *patelliformis* Hall, from the Trenton of New York,than any other form known to us. The lateral profile especially is nearly or quite the same in the two species. The New York species, however, is smaller, has more distinct surface markings and is obtusely carinated on the back.

* In comparing this and other species with *A. patelliformis*, we refer to the Trenton form only, and, as we have not seen the original types, we are obliged to depend solely on Hall's figures and description for our conception of their characters.

Formation and locality.—Trenton group, Clitambonites bed, near Cannon Falls and Kenyon, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; Geological Department, University of Minnesota; E. O. Ulrich.

Museum Register, No. 7416.

ARCHINACELLA SEMICARINATA, *n. sp.*

PLATE LXI, FIGS. 12 and 13.

Shell small, obliquely subconical, elliptical in outline; apex submarginal, small, scarcely incurved in the cast; dorsum obtusely carinate for a short distance from the apex, lateral slopes slightly flattened; hight of shell (the posterior part especially) less than usual, equalling about two-fifths of the width, the highest point just behind the apex. Surface nearly smooth. Length 12.5 mm.; width 10 mm.; hight 4 mm. Five specimens.

The dorsal angulation allies this species to *A. patelliformis* Hall sp., but it does not extend backward so far, the apex is much smaller and less incurved, and the whole shell more depressed than in that species. It is distinguished in a similar manner from *A. valida.*

Formation and locality.—Trenton group, Clitambonites and Fusipira beds, Goodhue county, Minnesota.

Collections.—E. O. Ulrich; W. H. Scofield.

ARCHINACELLA SIMULATRIX, *n. sp.*

PLATE LXI, FIGS. 10 and 11.

Shell small, aperture horizontal, subovate, somewhat wider in front than behind; apex incurved, just above or projecting slightly beyond the anterior margin; back high, sharply rounded, the lateral slopes flattened. Surface markings obscure, concentric. Two specimens, one from Minnesota, the other from Kentucky. The dimensions of the former are as follows: length 10.5 mm.; width 8.5 mm.; greatest hight 3.4 mm.; hight of apex 1.7 mm. In the other the same measurements give 15, 12.5, 5.5 and 2.8 mm.

This species is distinguished from *A. deleta, A. valida, A. semicarinata* and *A. patelliformis* in having a less regularly elliptical outline, the anterior half being wider. In this particular it is like the much larger *A. cingulata.*

Formation and locality.—Black River group, Phylloporina bed, St. Paul, Minnesota; Trenton group, Modiolodon bed, Frankfort, Kentucky.

Collection.—E. O. Ulrich.

Archinacella subrotunda, *n. sp.*

PLATE LXI, FIGS. 26 and 27.

Shell rather small, strongly convex, broadly oval, or nearly circular, obliquely conical, with the apex obtusely pointed, not incurved, and situated close to the anterior edge; aperture slightly arched; beneath the apex, in a side view, the anterior outline is scarcely concave; backward from the apex the outline is gently convex, the highest point being about midway between the apex and the middle of the shell. Surface nearly smooth, exhibiting in the best specimens only three or four, distant, impressed concentric lines. Length 13 mm.; width 11.3 mm.; hight 5.5 mm.; hight of apex 4.5 mm.

This species is associated with *A. deleta* Sardeson sp., and *A. instabilis* var. *incurva*. From the first it is easily distinguished by its rounded (much wider) form, while in the second the apex is drawn out into a small involute projection, giving it a very different outline in the side view. The species is related probably also to *A.* (*Tryblidium*) *pileolum* Whitfield, *A.* (*Metoptoma*) *simplex* Billings, and *A.* (*Metoptoma*) *estella* Billings, but we cannot consider it identical with any of them.

Formation and locality.—Black River group, Ctenodonta bed, Goodhue county, Minnesota.
Collection.—E. O. Ulrich.

Archinacella richmondensis, *n. sp.* (*Ulrich.*)

PLATE LXI, FIGS. 6 and 7.

Comp. *Tryblidium indianense* Miller, 1891, Adv. Sh. 17th Rep. Geol. Surv. Ind., p. 85.

Shell above the medium size, subovate in outline, obliquely conical, with the apex obtusely pointed, not incurved, and situated about one-sixth of the length behind the anterior margin; in a side view the anterior slope is slightly concave, while the slope backward from the apex is correspondingly convex, with the highest point near the apex; aperture nearly or quite horizontal. Surface marked by rather distant concentric lines. Length 24 mm.; width 20 mm.; hight 6.5 mm.

This species reminds one considerably of the geologically older *A. depressa*, but the arched aperture, lesser convexity and somewhat different outline of that species are sufficient proof of their distinction. It is probably more nearly related to *A. subrotunda*, but in this case we have obvious differences in outlines and in the position of the apex. We could come to no positive conclusion respecting Miller's *Tryblidium indianense*, but if his description is reliable it is certainly distinct.

Formation and locality.—Richmond group of the Cincinnati period, Richmond, Indiana.
Collection.—E. O. Ulrich.

ARCHINACELLA RUGATINA, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 5 and 6.

This species agrees closely with *A. richmondensis* Ulrich, but may be distinguished by its more distinct and slightly incurved apex, somewhat arched aperture and stronger surface markings. The latter are coarsely lamelliform in the outer third.

Formation and locality.—Richmond group of the Cincinnati period, Middletown, Ohio.
Collection.—E. O. Ulrich.

ARCHINACELLA INSTABILIS *Billings*, var. INCURVA, *n. var.*

PLATE LXI, FIGS. 21–23.

Metoptoma instabilis BILLINGS, 1865, Pal. Fossils, vol. i, p. 251.

Original Description: "Shell small, depresed conical; apex acute, slightly incurved, situated over the anterior margin; aperture circular; surface finely striated parallel to the base. Width of an average specimen, 8 lines, height 4 lines."

A single imperfect specimen, from the Black River group of Minnesota, agrees so well with Billings' description and figures of this species, that we hesitate to give it a distinct specific name. The specimen, it is true, is smaller than the Newfoundland types and shows besides certain peculiarities that, if they could be proved to be constant, might justify a separation. The apex, for instance, is more incurved in the Minnesota specimen,—indeed it curves inward sufficiently to form a complete volution,—and the whole dorsal outline is more convex in a side view. Provisionally it may be designated as var. *incurva*, and it should be added to the list of Black River species mentioned by Billings on page 372 of his Palæozoic Fossils, vol. i, that are represented by closely allied species in divisions I, K, L, and M of the Quebec group in Newfoundland.

Formation and locality.—The types of the species are from division L, Quebec group, Table Head, Newfoundland. Var. *incurva* was collected by E. O. Ulrich near Cannon Falls, Minnesota, in the Ctenodonta bed of the Black River group.
Collection.—E. O. Ulrich.

ARCHINACELLA ROTUNDA, *n. sp.*

PLATE LXI, FIGS. 24 and 25.

Shell small, obliquely conical, moderately elevated, aperture circular, horizontal; apex situated almost directly over the anterior margin, apparently small, pointed and slightly incurved; in a side view the posterior part of the dorsal outline is very gently convex, but in nearing the apex the convexity becomes much stronger.

Beneath the apex the outline is decidedly concave. Surface of cast smooth. Muscular imprint, distinct, linear, the posterior part of the loop bending forward a little in the middle. Diameter about 7.7 mm.; hight 4.5 mm.

The specimen upon which this species is founded is important because it preserves the muscular imprint and shows that this agrees, in what we must for the present consider essential features, with the imprint found in the typical species of *Archinacella*. And it is upon the strength of this evidence that we refer all the rounded Lower Silurian patelliform shells having the apex submarginal to this genus.

Compared with related species, *A. instabilis*, *A. simplex* and *A. estella* of Billings are all higher. *A. pileolum* Whitfield sp. also is very similar, but as it belongs to a much lower horizon (Calciferous) it is fair to assume that it is distinct.

Formation and locality.—Cincinnati period, Utica horizon, near Graf, Iowa, where it was associated with *Orthoceras sociale* Hall.

Collection.—E. O. Ulrich.

Genus PALÆACMÆA, Hall and Whitfield.

Palæacmæa HALL and WHITFIELD, 1873, 23rd Rep. N. Y. Mus. Nat. Hist., p. 242. LINDSTRÖM, 1884, Gastropoda and Pteropoda of Gotland, p. 58.

For generic characters see page 821.

We propose to use this genus for all those lower Paleozoic patelliform shells having the apex subcentral and the surface marked in a concentric manner only. In the typical forms, all of which are confined to the Potsdam and Calciferous formations, the markings consist of wide (2 mm. or more) concave undulations. This is true of *P. typica* H. and W., from the Potsdam of New York, *P. irvingi* Whitfield, from the same formation in Wisconsin, and *P.* (*Metoptoma*) *quebecensis* and *P.* (*Metoptoma*) *orphyne* of Billings, from the Quebec group of Canada. In the lower Trenton species about to be described these undulations are an unsteady feature and scarcely distinguishable in casts, while in the Gotland species (Upper Silurian) they are represented by narrow ridges, separated by usually short flat, rather than concave, interspaces on which very fine concentric lines are distinguishable.

Little or nothing is known of the muscular scars of all these species except the last, *P. solarium* Lindström. In this a "wreath of muscular impressions, nearly coherent," occurs near the top of the conical cast. All that can be made out of the scars of *P. humilis* appears to agree with Lindström's observations on the Gotland species, and, as the former is featured just as we might expect an intermediate stage between *P. solarium* and the Potsdam species to be, we may provisionally assume that the scars are essentially the same in the latter as well.

Lindström places this genus with *Tecturidæ* (*Acmæidæ*, Carpenter) and perhaps justly, but, as the family is not recognized by some conchologists and as it is highly probable that the Paleozoic patelloid shells are more intimately related among themselves than to recent types, it has seemed to us the wisest to embrace them all provisionally in one broad family, the *Patellidæ*.

PALÆACMÆA HUMILIS, *n. sp.*

PLATE LXI, FIGS. 45–48.

Shell depressed conical, rather small, broadly subovate, the anterior part of the outline semicircular, the posterior slightly prolonged and more narrowly rounded centrally; apex pointed, not quite erect, leaning slightly forward and situated a short distance in front of the center. Surface marked with obscure, fine, concentric lines and usually with several strong wrinkles or undulations of growth. The latter are more or less variable and irregular, and in some cases may be wanting. On casts of the interior they are very faint or quite indistinguishable. Muscular scars not well preserved by any of the specimens seen, apparently detached and forming an oval band about the apical third of the cast. Length (small specimen) 12 mm.; width 10.7 mm.; hight 4.5 mm. In a larger specimen these dimensions are respectively 15.5, 14 and 5 mm.

The absence of radial surface markings will distinguish this species from the following forms of *Scenella*, and the subcentral position of the apex renders equally good service in separating it from the preceding species of *Archinacella*. As to *Palæacmæa*, it is certainly distinct from all other forms known to belong to the genus.

Formation and locality.—Stones River group, Vanuxemia bed, Minneapolis; Black River group Ctenodonta bed, at several localities in Goodhue connty, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 5104.

Genus SCENELLA, Billings.

Scenella, BILLINGS, 1872, Can. Nat. and Geol., vol. vi, p. 479; and Pal. Foss., vol. ii, p. 77.

For generic characters see page 822.

This genus has never been properly defined and it is perhaps impossible to do so even to-day. Still, we are convinced that, with *S. reticulata* Billings as the type, it may be made to include an easily recognizable and thoroughly natural group of patelloid shells having relations to *Palæacmæa* on the one side and to *Stenotheca* on the other. As understood by us the genus is characterized by the subcentral apex and the radial striæ. The latter vary in strength, being sometimes rather coarse, but in most cases very fine. When the radii are coarse (*S. radialis*) they show through the shell so as to be visible on the outer half of casts of the interior, but usually the casts are smooth, or exhibit only a few obscure concentric wrinkles.

The muscular scars of the typical species,—it is a Cambrian fossil,—are unknown, but in several Lower Silurian forms, which with our present light on the subject must be regarded as congeneric, they are very much as in *Palæacmæa.* Though they have not been observed very clearly, it is almost certain that they are imperfectly coherent and form a sort of wreath about the apical portion of the cast. The number of the scars is not established. Whitfield says that there are eight pairs in his *Tryblidium conicum,* a species which we believe to belong to this genus and very near *S.* (*Metoptoma*) *montrealensis* Billings. In our *S. beloitensis* the scars seem to have been divided into four sets of which the two in the posterior half appear to consist each of four almost completely coherent imprints.

When the surface markings are not preserved species of *Scenella* are distinguished from those of *Palæacmæa* by their higher conical form. In *Stenotheca* the shell is still higher and the apex curves far forward, projecting in most cases considerably beyond the anterior margin of the aperture. While these characters will suffice ordinarily in discriminating between the genera, there are still several forms of which it is difficult to decide whether they should be placed under *Scenella* or *Stenotheca* or arranged by themselves. *Metoptoma venilla* Billings, Quebec group, and *M. alta* Whitfield, Calciferous group, are examples of these doubtful species.

Scenella probably ranged through the greater part of the Paleozoic rocks, the oldest occurring in the Lower Cambrian, while the most recent known representative appears to be the Devonian species which Walcott has described from Nevada as *Metoptoma devonica.*

SCENELLA SUPERBA *Billings.*

PLATE LXI, FIG. 35.

Metoptoma superba BILLINGS, 1865, Pal. Foss., vol. i, p. 172.
? *Conchopeltis minnesotensis* WALCOTT, 1876, 28th Rep. N. Y. Mus. Nat. Hist., p. 93.

Shell large, subconical, the hight usually equalling somewhat more than half the diameter; aperture broadly ovate or circular, slightly arched in front and behind; apex subcentral or a little anterior, obtuse, inclining gently forward. Surface marked by radiating striæ, 1 mm. or less in width, and concentric lines and obscure wrinkles. In casts both sets of striæ are usually very obscure, while the radiating lines are seldom shown and then only for a short distance above the margin. Dimensions of an average example: length 64 mm.; width 58 mm.; hight 32 mm. In the largest specimen seen the aperture is nearly circular and between 85 and 90 mm. in diameter, the hight about 45 mm.

We can scarcely doubt that the Minnesota specimens above described really belong to Billings' *Metoptoma superba.* They agree exactly with his figures and description except that we see nothing of the "obscure carination" which he says "runs from the apex to the margin on one side." Perhaps it is an abnormal feature. As to *Conchopeltis minnesotensis,* Walcott's description, in the absence of figures, is too indefinite for identification.* Still we do not think it likely that his types, which we sought to see but failed, are distinct from the specimens here referred to *S. superba.* Nor do we believe that they are strictly congeneric with his *C. alternata*, the type of his proposed genus *Conchopeltis.* (See ante page 823.)

Formation and locality.—Stones River group, Cannon Falls, Minnesota. Walcott's locality for his *C. minnesotensis* is given as "four miles below Medford, Cannon River, Minn." Billings' type is from the Black River limestone at Pauquettes rapids on the Ottawa river.

Collections.—Geological and Natural History Survey of Minnesota; W H. Scofield; E O. Ulrich.

Museum Register, Nos. 3394, 7350 and 7490.

Scenella magnifica, *n. sp.*

PLATE LXXXII, FIGS. 7–9.

Of this species we have only a single specimen which was found in association with the preceding species at Cannon Falls. It seems to have had surface markings like *S. superba,* and we believe it is closely related to that species. But the hight of the shell is so much greater that we cannot do otherwise than regard it as specifically distinct. Comparing other features we find that the aperture also is more arched and the whole shell more compressed laterally so that the outline from above is decidedly elliptical instead of subcircular. Length 76 mm.; width 58 mm.; hight about 75 mm. The specimen is imperfect at the apex.

Formation and locality.—Stones River group, Vanuxemia bed, Cannon Falls, Minnesota.

Collection.—Geological and Natural History Survey of Minnesota.

Museum Register, No. 3405.

Scenella beloitensis, *n. sp.*

PLATE LXI, FIGS. 33 and 34.

Shell exceeding medium size, obtusely conical, the hight less than one-half of the smallest diameter; apex subcentral; aperture nearly or quite horizontal, somewhat irregularly subcircular. Surface of cast showing fine radiating striæ, about ten in 5 mm., over the marginal portion. Muscular imprints occupying the greater part of the inner half, apparently divided into four sets, each consisting of three or four, scarcely distinguishable, coherent scars. Length 28 mm.; width 26 mm.; hight 10.5 mm.

*Walcott's description reads as follows: "Shell obtusely conical, base slightly elliptical; apex excentric, variable in different individuals; hight one-half the greatest diameter. Shallow undulations of growth occur one-half the distance to the apex, finer lines near the margin. Substance of the shell not preserved."

This species resembles *S. superba* Billings sp., but is readily distinguished by its more depressed form, horizontal aperture and finer surface markings. The muscular imprints also are much stronger than in that species.

Formation and locality.—Stones River group, Vanuxemia bed, Beloit, Wisconsin.
Collection.—University of Wisconsin, No. 307.

SCENELLA COMPRESSA, *n. sp.*

PLATE LXI, FIGS. 38–41.

Shell small, compressed conical, the hight exceeding the longest diameter of the aperture, while the shortest diameter is to the hight as three is to five, or as two is to three; apex subcentral, laterally compressed, inclining forward slightly; back and sides of shell obscurely flattened, anterior part sharply rounded; aperture subovate, narrower in front than behind. Surface with fine radial lines, three or four in 1 mm., and somewhat irregular transverse lines and wrinkles. The shell seems to have been rather thick and the surface markings are not visible on the cast. Length 13 mm.; width about 9.5 mm.; hight 14.5 mm.

This peculiar species reminds one somewhat of the much larger *S. magnifica*, but we do not think its relations to that species are very intimate. Its affinities are probably nearer to *S. montrealensis* Billings sp., yet not enough so to render confusion between them at all likely. The narrowly rounded anterior slope and the flattening of the sides and dorsum are obvious peculiarities.

Formation and locality.—Stones River group, Vanuxemia bed, Minneapolis, Minnesota.
Collection.—E. O. Ulrich.

SCENELLA AFFINIS, *n. sp.*

PLATE LXI, FIGS. 36 and 37.

Comp. *Metoptoma montrealensis* BILLINGS, 1865, Pal. Foss., vol. i, p. 394.
Comp. *Tryblidium conicum* WHITFIELD, 1886, Bull. No. 8, Amer. Mus. Nat. Hist., p. 306.

Shell small, conical, with the apex subcentral and directed slightly forward, the anterior part compressed, especially for a short distance beneath the beak where it is almost angular; aperture somewhat irregular, subovate, narrowest in front; in a side view the anterior outline is slightly convex in the middle and correspondingly concave above to the apex; behind the latter the outline is gently convex to the margin. Surface exhibiting very fine, easily abraded, concentric and radiating striæ, and some irregular wrinkles of growth. Length 10 mm.; width 9 mm.; hight 7.5 mm.

This form is probably a variety of *S. compressa*, distinguished by its lower and wider shell and finer surface markings. It seems also to be very closely related to

Metoptoma montrealensis Billings, and *Tryblidium conicum* Whitfield, but neither of these species has the anterior slope sharply rounded as in *S. affinis* and *S. compressa.* Whitfield's species, which we regard as a true *Scenella,* seems to be more closely related to *S. superba* and *S. beloitensis* than to *S. montrealensis.* The latter, judging solely from Billings' figures and description (*op. cit.*), appears to differ from all the species mentioned in having a more attenuate apex and the whole anterior outline concave in a side view.

Besides the typical specimens of *S. affinis* we have before us six others from the geologically higher Clitambonites and Fusispira beds. In these the anterior vertical ridge is less developed and the outline of the aperture more regularly elliptical. The shell also seems to have been thinner and smoother externally. If a subordinate name is desired for this later form of the species it might be called var. *obsoleta.*

Formation and locality.—Black River group, Ctenodonta bed, and Trenton group, Clitambonites bed, Goodhue county, Minnesota; Fusispira bed, Kenyon and Wykoff, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 7487.

SCENELLA OBTUSA *Sardeson.*

PLATE LXXXII, FIG. 10.

Conchopeltis obtusa SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 336.

Having seen no specimens which we could refer to this species, we reproduce the original figure and description without expressing any positive opinion as to its validity. So far as Mr. Sardeson's figure of the specimen upon which he founds the species permits of judgment, it seems to us to be a *Scenella* in which the apex is farther removed from the center and the apical angle wider than usual.

Original description: "Shell large, patelliform, or subconical, apex excentric, apical angle 110 degrees. Aperture subcircular, about three times as wide as the shell is high. Cast marked by four or five concentric furrows and by numerous elevated radiating lines, from 15 to 20 in one centimeter."

Formation and locality.—Black River group, Rhinidictya bed, Minneapolis, Minnesota.

SCENELLA RADIALIS, *n. sp.*

PLATE LXI, FIGS. 31 and 32.

Shell large, depressed conical, hight slightly greater than one-third of the diameter; apex subcentral, obtuse; aperture almost circular, the margin apparently a little irregular though nearly horizontal. Surface with distinct lines radiating from the apex, five or six in 5 mm. These show through the outer parts of the shell and produce corresponding lines on the cast. Diameter about 55 mm.; hight about 21 mm.

This species is not nearly as high as *S. superba* and *S. magnifica*, while it differs from *S. beloitensis* in having coarser radii, and from *S. obtusa* in the more central position of the apex.

Formation and locality.—Trenton group, Clitambonites bed, St. Paul, Minnesota.

Collection.—Geological and Natural History Survey of Minnesota.

Museum Register, No. 5535.

Genus STENOTHECA, Salter.

Stenotheca, (SALTER) HICKS, 1872, Quart. Jour. Geol. Soc., vol. xxviii, p. 180.

For generic characters see page 822.

The typical species of this genus are from the Cambrian, from which horizon some ten or twelve species have been described. From these it would appear that the generic type is distinguished from *Scenella* chiefly by the curved form and stronger concentric marking. The genus seems, however, even among the Cambrian forms, to be subject to considerable variation in the matters of form and surface marking, and in such ways that we consider ourselves justified in placing the two species about to be described within its limits. Neither of the latter is greatly different from certain varieties of the Cambrian *S. rugosa* as figured by Walcott.

Stenotheca, as is the case with *Scenella* also, is often placed with the *Pteropoda*. We fail, however, to see anything in these shells to justify such a view, at any rate nothing that is not overcome by evidence favoring an alliance with the *Patellidæ*. We must admit that *Stenotheca* is not a good member of this family, but it most probably represents an offshoot from *Scenella*, which is a better example, toward certain bellerophontoids (e. g. *Cyrtolites*).

STENOTHECA EXSERTA *Sardeson.*

PLATE LXXXII, FIGS. 11–15.

Tryblidium exsertum SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 337.

Shell high, laterally compressed, curved, forming one-third or more of a volution; aperture subovate, the length and width about as three is to two, more narrowly rounded in front (beneath the apex) than behind. Surface marked with fine radiating lines, increasing in strength with the growth of the shell, with, so far as known, not less than two in the space of 1 mm. Obscure transverse markings are also present and on the basal half of a large cast several broad folds. On the specimen referred to we fail to see any signs of the radiating lines, but on the other casts, both from Minneapolis, they are faintly indicated. Muscular scars not observed.* Length of aperture 20 mm.; width of same 13.5 mm.; length of shell from apex to posterior margin 26 mm. These dimensions in a large and a very small specimen are respectively about 29, 16 and 42 mm., and 4.5, 3 and 5.5 mm. The large specimen has suffered from pressure so that the width is less than normal.

Aside from the fact that it grew to a much larger size, this species resembles *S. rugosa* var. *levis* Walcott (Tenth Ann. Rep. U. S. Geol. Surv., pl. LXXIV, figs. 5, 5*a*) more closely than it does any Lower Silurian shell known to us.

Formation and locality.—Stones River group, Vanuxemia bed. Minneapolis, Minnesota, and Beloit, Wisconsin.

Collections.—Geological and Natural History Survey of Minnesota; University of Minnesota; University of Wisconsin.

Museum Register, No. 715.

STENOTHECA UNGUIFORMIS, *n. sp.* (*Ulrich.*)

PLATE LXI, FIGS. 42–44.

Shell unguiform, acuminate-ovate from above, rounded posteriorly, narrow in front where the apex curves more or less strongly downward, sometimes nearly to the plane of the aperture and projects considerably beyond the anterior margin; aperture horizontal, ovate, usually much more broadly rounded behind than in front. Surface with distinctly elevated, regular, sublamelliform, concentric lines, from 0.2 to 0.6 mm. apart, the distance between them increasing with growth; crossing them very fine radiating lines; test rather thick; surface of cast smooth. Three specimens have the following dimensions: length of aperture 6.5, 10.2 and 11.5 mm.; width of same 5.8, 9 and 9.1 mm.; length of shell 7.7, 12.8 and 15 mm.; hight of same 3, 4.5 and 6 mm. Old specimens have thick edges and are relatively longer than medium and young examples. This is because the increase of the shell, after a certain stage, takes place principally at the posterior border. For the same reason the beak appears more strongly incurved in old shells.

This species is clearly distinct from all previously described patelloid shells. There may be some doubt about the generic position, the anterior hight being less than it should be in a true *Stenotheca*. The Cambrian *S.? elongata* Walcott, however, exceeds our species in that respect, while in its younger stages it is decidedly like some of the forms referred to *S. rugosa* by the same author. We believe, therefore, that we cannot be far wrong in placing it under *Stenotheca*.

Formation and locality.—Upper beds of the Trenton group, between Burgin and Danville, Kentucky.

Collection.—E. O. Ulrich.

* Mr. Sardeson says of the muscular scars that they "are not distinct on the cast, but there appears to be a row of about 24 passing around the shell from 2 to 5 mm. above the lip of the aperture."

Suborder BELLEROPHONTACEA.

This suborder is proposed for the reception of a type of *Gastropoda* that seems to be totally extinct. The elements to be comprised in it have heretofore been referred partly to the prosobranchiate order *Pectinibranchiata*, some to the *Heteropoda*, and others to the *Pteropoda*. They are all symmetrical shells and in this respect agree with the *Patellacea*. We believe that they are either descendants of the same unknown stock from which that suborder was derived, or that they represent an early offshoot from it, differing in the strongly involute (instead of patelliform) character of their shells. From recent *Heteropoda* they differ in having a stronger shell and in their habits, which evidently were litoral and not pelagic.

Systematists have experienced great difficulties in assigning this well-marked group of shells to its proper place in nature. Montfort, who was the first to attempt it, originally considered his *Bellerophon* as a cephalopod because he believed it to possess a number of septa pierced by a siphuncle. Although the total absence of anything like septa was soon demonstrated, Montfort's view was still maintained in the modified form necessitated by the monothalamous character of the shell. Blainville placed *Bellerophon* with the *Ophisthobranchiata*, but received very little support for his view. Not so however with the idea first advanced by Deshayes that these shells were *Heteropoda*. This view seemed to be so well established by the external resemblance of certain bellerophontids to the recent genus *Atlanta* that it became very popular. But it also has almost disappeared from modern literature.

The position to which they are now almost universally assigned is among the pectinibranchiate order of the prosobranchiate *Gastropoda*. This arrangement was inaugurated by De Koninck in 1843, when he drew attention to certain similarities existing between the shells of *Bellerophon* and *Emarginula*. His view was adopted by Pictet and Geinitz, but its general adoption was interfered with in 1866, when Meek seemed to prove that their affinities were even nearer *Pleurotomaria* and *Haliotis*. Since this date Meek's view of the natural position of this group of symmetrical involute shells has gradually gained many supporters, so that now it may be said to be the one that is generally accepted.

In our opinion the systematic position of the *Bellerophontacea* is at least approximately determined. All three of the views now current, Deshayes', De Koninck's, and Meek's, perhaps contain an element of truth; the second because *Emarginula* is either a direct descendant of the ancient type under consideration, or a reversion from the pleurotomarian type; the third because the *Pleurotomariidæ* probably sprang from the same ancestral stock; and the first because there are good reasons to believe that the *Heteropoda* have been derived from the pleurotomarian line of development. In other words the *Bellerophontacea*, *Emarginulidæ*, *Pleurotomariidæ* and *Heteropoda*, though distinguishable, are nevertheless so closely united, in one way or another, that no system of classification can afford to separate them very widely. The most natural arrangement at present suggested is to let them follow that central type of the *Gastropoda*, the *Patellacea*, in the order named. This arrangement, however, must be regarded as only provisional, since it does not take into account the grand divisional line which ought to be drawn between the symmetric and asymmetric *Gastropoda*, according to which the class may be divided into two great groups, with the *Scaphopoda*, *Pteropoda*, *Opisthobranchiata*, *Polyplacophora* and *Docoglossa* on one side, and the *Prosobranchiata*, *Heteropoda* and *Pulmonata* on the other. These two groups are distinct already in the oldest known fossiliferous rocks—so far as known then, we may say from the beginning. The members of each are determined not so much by the presence or absence of strictly bilateral symmetry of organization as by their developmental history.* A tendency to become *twisted* characterizes the whole class, but while it is a constant condition in the second group, it is never as marked and often quite absent in the first.

As regards the relation of the *Bellerophontacea* to the *Pleurotomariidæ* and so-called *Zygobranchia* in general, it is scarcely as intimate as usually supposed. So far as known both groups are equally ancient, and comparisons between the earliest types of each show that they are quite as distinct as any of the later ones. The apertural slit and slit-band which the two groups possess in common, and which is the only important feature in which they agree, became established somewhat earlier among the pleurotomarians than with the bellerophontids, from which it follows that the former is probably the more ancient instead of the younger type of the two. They may have had a common ancestor, but neither sprang from the other.

The derivation of the bellerophontids is still obscure. Of all the known and sufficiently ancient types only *Stenotheca*, which we refer to the *Patellacea*, appears at all likely to have been concerned in their evolution. In this genus the shell is more or less strongly curved, the surface frequently cancellated, and the dorsum sometimes subangular. From such a type it is not very far to *Cyrtolites*. But *Cyrtolites*, despite the fact that it is closely connected, by one species or another, to more typical members of the suborder, is very different from *Owenella*, which includes the only Cambrian bellerophontid known. Nor has the genus yet been found in rocks older than the Trenton. Although, in placing the *Bellerophontacea*

* Among recent *Gastropoda* only the *Polyplacophora* and *Ophisthobranchiata* are fundamentally symmetrical, but paleontology seems to show conclusively that the early or Paleozoic representatives of the *Docoglossa*, *Pteropoda* and *Scaphopoda* were perhaps equally so.

and *Patellacea* in the same order, we have taken the probable, yet not established, connection between *Stenotheca* and *Cyrtolites* into consideration, our principal reason for doing so lies in the fact that in both the shell is symmetrical.

During the preparation for this work we undertook as nearly a complete revision of the American species of the suborder as possible, the cabinet of one of the authors containing representatives of a large proportion of the described forms. Much time was spent also on the foreign species, though here we were obliged to rely almost entirely upon the published figures. Still, with our knowledge of the American species, the illustrations alone were in most cases sufficient for our purposes. Our comparative studies, though demonstrating the close interrelationship of the various types comprised in the suborder, still showed very clearly the actual existence of numerous natural and in most cases easily recognized groups of species which we deem of sufficient importance to rank as genera. Most of these have been already established, but, as some require sharper limitation and correction, we shall endeavor to characterize them all as fully and clearly as we can now do. Under each genus we add a list of the American species, and when desirable of the foreign as well, which we have examined and of whose affinities and position we are reasonably certain.

We recognize twenty-three genera and divide them into five families. In the following synopsis brief discussions follow the diagnosis of the genera of which no species are described by us, while the remarks on the others will be found immediately preceding the descriptions of the species of each.

Family CYRTOLITIDÆ.

Symmetrical involute shells; volutions two or three, barely in contact, sharply angular dorsally; aperture not expanded, the sinus V-shaped, never deep, sometimes wanting; no slit, and the band occurs only in *Cyrtolitina*; surface reticulate.

CYRTOLITES, Conrad. Shell coiled in the same plane, symmetrically or nearly so; volutions two or three, scarcely contiguous, the last occasionally free, enlarging gradually, carinated on the back and often on the sides, giving a subquadrate cross-section; aperture not abruptly expanding, with or without a median notch in the outer lip; no slit-band; shell thin, without callosities of any kind; surface sculpture reticulated or cancellated, consisting of straight or obliquely curved regular transverse lines connected by short oblique lines. Type, *C. ornatus* Conrad.

C. ornatus Conrad. Cincinnati period.
C. ornatus, var. *minor* U. & S. Trenton group.
C. retrorsus Ulrich. Black River, Trenton, and Utica groups.
C. retrorsus, var. *fillmorensis* U. & S. Black Riv. gr.
C. subplana Ulrich. Trenton group.
C. parvus Ulrich. Utica group.
C. carinatus Miller. Utica group.
C. disjunctus U. & S. Richmond group.
C.? dilatus U. & S. Black River group.

MICROCERAS, Hall, 1845. (Amer. Jour. Sci., vol. xlviii, p. 249.) Minute shells (1 to 4 mm. in diameter), gregarious in habit, in form like *Cyrtolites*. It is difficult to decide whether any of hundreds of specimens seen preserve the shell or not, though we are inclined to regard them as casts of the interior. They are always of a black or brownish color, with the surface perfectly smooth and generally glossy. The principal and typical species, *M. inornatus* Hall, seems to range from the Trenton to the Devonian.

The shells comprised in this somewhat doubtful genus are certainly not "embryonic volutions of bellerophontes," as supposed by Waagen, but they may be dwarfed varieties of species of *Cyrtolites* and perhaps of other genera. They usually occur associated with large numbers of *Cyclora*, another genus of minute gastropods, the species of which again may be but dwarfed forms of *Holopea* or *Cyclonema* and *Lophospira*, and with very small species of *Ctenodonta* and *Clidophorus*.

CYRTOLITINA, n. gen. (Ulrich.) (*Cyrtolites* [part.], Lindström, 1884.) Symmetrically involute, small thin shells, consisting of one and a half or two rapidly enlarging, contiguous or free volutions, with rounded sides and a more or less well developed slit-band; aperture higher than wide, sinuate dorsally and somewhat deeply emarginated in front of the slit-band; marks of growth curving strongly backward, more or less distinctly lamellose, with crenulated edges and, when distant enough, traversed by small wrinkled longitudinal riblets. Type, *Crytolites lamellifer* Lindström. In the same work (Silurian Gastropoda of Gotland, pp. 82-84) Lindström describes three more species belonging to this genus, viz.: *Crytolites pharetra*, *C. arrosus* and *C. obliquus*. In America the new genus is represented by *Crytolites nitidulus* Ulrich (Jour. Cin. Soc. Nat. Hist., vol. ii, p. 12; 1879), a species of the upper part of the Trenton group.

Family PROTOWARTHIIDÆ.

Symmetric, involute shells; aperture not abruptly expanded; outer lip and lines of growth with a broad or narrow dorsal sinus; slit and band wanting.

OWENELLA, n. gen.* Shell thin, subglobose, closely coiled; volutions compressed dorso-ventrally, moderately embracing, rounded on the back, enlarging gradually, not abruptly expanded at the aperture; umbilicus open; aperture transverse, the outer lip with a rather broad and not very deep median insinuation; slit-band wanting. So far as known the surface markings consist of transverse or growth lines only. Type, *Bellerophon antiquatus* Whitfield, Upper Cambrian, Wisconsin. *B. pettos* Koken, from Lower Silurian strata in Europe, seems to have all the essential characters of this genus.

* Named for that great pioneer in the geology of the northwestern states, Dr. David Dale Owen.

This is the oldest known representative of the suborder, but as all the essential bellerophontid characters are already well developed in it, we should look for, and may confidently expect to find, less advanced forms in the Middle and Lower Cambrian rocks.

The general expression of *O. antiquata* is such that we can scarcely doubt that it is of the type from which the *Bucaniidæ* sprang. The modifications required to reach the latter stage,—the formation of an apertural slit with its resulting dorsal band, and a not very great change in surface markings,—are quite in accordance with the developmental tendency prevailing in early Paleozoic times not only among the *Bellerophontacea* but among the *Eotomacea* as well. Further, we are satisfied that *Owenella* is the stock in which the roots of all the other types of the group, excepting the *Cyrtolitidæ*, are centered. Abundant evidence supporting this view occurs here and there through the following pages.

PROTOWARTHIA, n. gen. Aperture large but not abruptly expanded, the outer lip bilobate, with a broad and more or less deep sinus but neither a slit nor band; dorsum convex, never carinate; umbilicus closed; surface markings very fine, generally consisting of more or less obscure crowded lines of growth and delicate revolving striæ. The inner lip forms a thin granulose deposit over the dorsum of the inner end of the last whorl and extends on each side around the umbilical region. This portion is covered with interrupted or inosculating lines. Type, *Bellerophon cancellatus* Hall.

P. cassinensis Whitfield sp. Calciferous.
P. rectangularis U. & S. Stones River group.
P. pervoluta U. & S. Black Riv. and Trenton groups.
P. obesa Ulrich. Trenton group.
P. cancellata Hall sp. Trenton and Cincinnati periods.
P. granistriata Ulrich. Utica group.
P. planodorsata Ulrich. Utica group.
P. subcompressa Ulrich. Richmond group.
P. concinna U. & S. " "
P. morrowensis Miller sp. " "
P. bilobatus Sowerby sp. Low. Silur. (Probably not American.)
P. ?acutilira Hall sp. Hamilton group.

BUCANELLA, Meek.* (Not Koken.†) Back of shell distinctly trilobate, volutions enlarging rapidly, compressed dorso-ventrally, scarcely embracing; umbilicus large; aperture transverse, the outer lip sinuate; surface markings obscure, delicate, consisting apparently of both revolving and growth lines. According to Meek there is no slit-band. Type, *B. nana* Meek. The European Upper Silurian fossil, *Bellerophon trilobatus* Murchison, and our common Clinton *Bucania trilobata* Conrad, probably belong here.

Unfortunately we have not been able to secure a testiferous example of any of the three species referred to this genus.‡ Admitting the correctness of Meek's

* Proc Amer. Philos. Soc., vol. xi, p. 426; 1870.

† N. Jahrbuch f. Mineralogie, etc., Beilage Band vi, p. 389; 1889.

‡ Since this page was in type we have, through the kindness of Prof. E. W. Claypole and Mr. Aug. F. Foerste, been enabled to see specimens of *B. trilobata* Conrad sp. which retained some of the shell. This we find to be comparatively thick, and marked externally with very fine revolving lines. The lines of growth are very faint and they form a broad sinus on he central lobe of the back about as in *Protowarthia*. There is no slit-band.

description, especially the part which relates to the absence of a slit and dorsal band, we place the genus near *Owenella* and *Protowarthia*, and consider it as well distinguished from those genera by the trilobate character of its shells. Koken (*loc. cit.*) without sufficient warrant considers Meek's diagnosis as incorrect and proposes to extend the limits of the genus so that it will include, beside the species placed here by Meek and which Koken admits he has not seen, two other groups of species, one falling under our *Tetranota*, the other, having revolving surface markings, probably under *Bucanopsis*. For further discussions see remarks specially devoted to the genera named.

Family BUCANIIDÆ.

Symmetric, involute shells; whorls rather numerous, merely in contact, or embracing slightly, all visible in the umbilicus; aperture often expanded abruptly; dorsal slit-band distinct, the slit itself generally very long and narrow, sometimes represented by a row of openings; surface with transverse lamellæ or lines, usually crossed at right angles by short ribs.

TETRANOTA, n. gen. (*Bucania* [part.] of Hall and other authors; *Bucanella* [part.], Koken, not Meek.) Shell thin; aperture moderately expanded, laterally chiefly; inner lip without callosity; sinus more or less deep, terminating in a short slit; whorls generally compressed so that the transverse diameter greatly exceeds the vertical; umbilicus open, large or of moderate size; dorsal band very wide, margined on each side by a strong ridge; about midway between these ridges and the narrowly rounded or angular sides of the volutions there is another ridge on each side, making in all four constant revolving ridges; aside from these the surface markings consist of rather delicate, sublamellose, regular lines of growth, each crossed at right angles by its own set of minute ribs. The revolving ridges, the lateral ones especially, are best developed on the inner whorls and may become quite indistinguishable near the aperture. Type, *Bucania bidorsata* Hall.

T. macra U. & S.	*T. wisconsinensis* Whitfield sp.	All Lower Silurian fossils and described in this volume.
T. sexcarinata U. & S.	*T. bidorsata* Hall sp.	
T. obsoleta U. & S.		

KOKENIA, n. gen. (*Bucanella* [part.], Koken, 1889, not Meek, 1870.) Volutions depressed; slit-band wide, flat, elevated, with a broad concave space on each side; umbilicus open, rather large; aperture not expanded, lips thin, the outer one deeply emarginated. Surface with straight, uninterrupted revolving ribs, strong on the lateral parts of the dorsum, fine on the slit-band; growth lines very delicate. Type, *Bucanella esthona* Koken (Neues Jahrbuch für Mineralogie, etc., Beilageband vi, p. 389; 1889), Lower Silurian drift, Berlin. One American species, *K. costalis* U. & S.

MEGALOMPHALA, n. gen. (Ulrich.) This name is proposed for the widely umbilicated group of species which Koken has provisionally designated as the "Gruppe des *Bellerophon contortus*." The general form of the shell and volutions in these species is precisely as in the typical section of *Bucania*, as here restricted and defined. They may, however, be distinguished at once by the total absence of revolving surface sculpture. The apertural slit also appears to be much shorter, though the slit-band is well developed. In the last respect they agree with our *Tetranota*, but the expression in general is different, while the absence of the four revolving dorsal ridges, which are such a striking feature of that genus, must, for the present at least, be regarded as forbidding their reference to *Tetranota*. Again, they remind one of *Owenella*, but the presence of a distinct slit-band, which is wanting in that genus, is sufficient to distinguish them. These varied resemblances, however, probably give us a reliable clue to the developmental history of the *Bucaniidæ*. At present the line of evolution appears to be from *Owenella* to *Megalomphala* to *Bucania* to *Salpingostoma* to *Tremanotus*. *Tetranota* to *Kokenia* and *Oxydiscus* to *Conradella* are separate lines.

Eichwald's *Bellerophon contortus* may be regarded as the type of *Megalomphala*. Excepting the doubtful Chazy species which Hall in 1847 called *Bucania rotundata*, and which may belong in this connection, the genus is not known to occur in American strata. In Europe, according to Koken, it is represented by *Bellerophon contortus* Eichwald and *B. vaginati* Koken, in the Lower Silurian, by *B. taenia* Lindström, in the Upper Silurian, and by *B. macromphalus* A. Roemer, in the Devonian. That the last really belongs to *Megalomphala* requires confirmation.

BUCANIA, Hall (restricted). Shell consisting of three to five more or less depressed volutions coiled in one plane, with generally a wide umbilicus and not greatly—never abruptly—expanded aperture. Surface markings consisting of equal or unequal revolving riblets and lines of growth, together producing a more or less cancellated appearance. Revolving lines wavy or wrinkled, oblique, especially in the umbilicus, crossing from the ventral side of a whorl to the dorsal slit-band in the space of about one half a volution. Frequently they are interrupted by strong lamellæ, the wavy edges of which are parallel with the lines of growth and the apertural margin. Aperture transverse and somewhat reniform in the typical section, higher and relatively larger in the *B. nashvillensis* section. In the former the lips are thin, the outer one sinuate, and the sinus prolonged into a rather long narrow median slit; in the latter the inner lip is rather thick and the slit shorter. Slit-band distinct, raised or depressed. Type, *B. sulcatina* Emmons sp.

TYPICAL SECTION.

B. sulcatina Emmons. Chazy.
B. halli U. & S. Stones Riv. and Black Riv. grs.
B. emmonsi U. & S. Stones Riv. & Black Riv. grs.
B. minnesotensis U. & S. Stones Riv. & Blk Rv. grs.
B. sublata U. & S. Stone's River group.
B. rugatina U. & S. Black River group.
B. elliptica U. & S. Trenton group.
B. intertexta Hall. Trenton group.
? *B. punctifrons* Emmons. Trenton group.

Foreign species.—*B. ozekanowskii* Schmidt, Lower Silurian, Russia.

B. NASHVILLENSIS SECTION.

B. nashvillensis Ulrich. Trenton group.
B. lindsleyi Safford. Trenton group.
B. frankfortensis Ulrich. Trenton group.
B. subangulata Ulrich. Trenton group.
B. micronema Ulrich. Trenton group.
B. peracuta Ulrich. Trenton group.
B. singularis Ulrich. Trenton group.
B. nana Ulrich. Trenton group.
B. nana, var. *subpatula* Ulrich. Trenton group.
B. simulatrix Ulrich. Richmond group.
B. crassa Ulrich. Richmond group.

SALPINGOSTOMA, Roemer. (Leth. Geognostica, 1876.) Shell symmetrically coiled in one plane; volutions numerous, enlarging gradually, scarcely embracing, the consequence being a large open umbilicus. Aperture abruptly expanded at maturity, trumpet like; peristome thin, the outer portion slightly sinuate. Inner volutions with a slit band as in *Bucania*. This is replaced in the outer half of the last whorl by a long narrow opening or slit which, however, does not extend to the apertural expansion, but is closed some distance behind it. Surface marked with simple or sublamellose lines of growth and more or less oblique, irregular and sometimes interrupted or wavy revolving lines. Type, *S. megalostoma* Eichwald sp.

AMERICAN SPECIES.

S. buelli Whitfield sp. Stones River group.
S. buelli, var. *kentuckiensis* Ulr. Black Riv. group.
S. *expansa* Hall sp. Trenton group.
S. sculptilis U. & S. Trenton group.
S. imbricata U. & S. Richmond group.
S. richmondensis Ulr. Richmond group.
S. canadensis Billings. Hudson River group.
S. fraternus Billings. Hudson River group.

EUROPEAN SPECIES.

S. megalostoma Eichwald. Lower Silurian.
S. locator Eichwald sp. Lower Silurian.
S. compressa Eichwald sp.

TREMANOTUS, Hall.* In all respects like *Salpingostoma* excepting that an expanded aperture is developed at frequent and regular intervals, and the dorsal slit closed at corresponding periods, so that, instead of a continuous long opening, there is a series of small, elongate elliptical perforations. Type, *T. alpheus* Hall.

AMERICAN SPECIES.

T. alpheus Hall. Niagara group.
T. chicagoensis McChesney sp. Niagara group.
T. trigonostoma Hall & Whitfield. Niagara group.
T. angustata Hall sp. Niagara.
T. profunda Conrad sp. Lower Helderberg group.

FOREIGN SPECIES.

T. longitudinalis Lindström. Up. Silur., Gotland.
T. compressus Lindström. Up. Silur., Gotland.
T. maideni Etheridge, Jr. ? Triassic, New South Wales.

CONRADELLA, n. gen. (*Phragmolites*, Conrad, 1838, Ann. Geol. Rep. New York, p. 119.) Shell coiled symmetrically, general form as in *Cyrtolites* and *Oxydiscus*, the volutions enlarging gradually and being strongly keeled dorsally. Aperture oval or

*Twentieth Rep. New York St. Mus. Nat. Hist., p. 347; 1868.

subcordiform, widest in the middle or below, without callosities of any kind, nor with a sinus in the outer lip. From the aperture to a point about half around the dorsal circumference of the last volution there is a narrow open slit lying between two sharply elevated edges; behind this point the slit is closed over and forms an ordinary slit-band with distinct lunulæ. Surface with close or distant transverse imbricating lamellæ, the anterior edges of which are zigzagged and sometimes greatly spread out. Lamellæ plicated, the successive folds often arranged so as to form small revolving ridges; over all very fine lines of growth. Type, *C. obliqua* U. & S.

C. fimbriata U. & S. Stones River group.
C. triangularis U. & S. Stones River group.
C. grandis Ulrich. Stones River group.
C. obliqua U. & S. Black River group.
C. compressa Conrad sp. Trenton group.
C. similis Ulrich. Trenton group.
C. imbricata Meek & Worthen sp. Trenton gr.
C. elegans Miller. Loraine group.
C. bellula Ulrich. Loraine group.
C. dyeri Meek. Richmond group.
C. dyeri, var. *cellulosa* U. & S. Trenton.
C. pannosa Billings. Hudson River group.

OXYDISCUS, Koken.* (*Tropidodiscus*, Meek,† Waagen‡, not Steininger, 1855.) Strongly compressed, disciform shells; volutions embracing very little, expanding gradually to the aperture, sharply keeled; aperture somewhat lanceolate or subtriangular, without an inner callosity; outer lip with a deep V-shaped excision, continuing in the dorsal keel as a long and very narrow slit; behind the slit the summit of the keel may show a more or less distinct band with lunulæ, or merely a delicately bordered raised line. Surface markings consisting of growth lines only. These bend strongly backward in passing from the ventral side of the whorl to the keel. Type, *O. imitator* Koken.

AMERICAN SPECIES.

O. acutus Sowerby sp. Lower Silurian.
O. disculus Billings sp. Black Riv. and Trenton.
O. subacutus Ulrich. Trenton.
O. cristatus Safford sp. Trenton.
O. magnus Miller sp. Cincinnati.
O. curvilineatus Conr. sp. Schoharie grit and Up. Held.

According to Koken *Euomphalus strongi* Whitfield, a "Lower Magnesian" fossil, probably belongs here.

EUROPEAN SPECIES.

O. (*Euomphalus*) *planissimus* Eichwald. Low. Silur.
O. (*Porcellia*) *scutigerus* Eichw. Upper Silurian.
O. (*Cyrtolites*) *discus* Lindström. Upper Silurian.
O. (*Cyrtolites*) *orbiculus* Lindström. Up. Silurian.
O. (*Cyrtolites*) *delanonii* Œhlert. Low. Devonian.
O. imitator Koken. Middle Devonian.

Family BELLEROPHONTIIDÆ.

Symmetrically involute shells, the whorls enlarging rapidly, the mouth generally expanded laterally and ventrally, not dorsally, the umbilicus mostly small or closed. Inner lip more or less thickened, the outer sinuate and centrally emarginate,

* N. Jarhbuch f. Mineralogie, etc., Beilagebaud vi, p. 390; 1889.
† Proc. Chicago Acad. Sci., vol. i, p. 9; 1866.
‡ Pal. Indica, ser. 13, pt. 2, p. 131; 1880.

the slit short; slit-band always present. Surface with lines of growth only, or cancellated, the revolving lines straight and never oblique with respect to the longitudinal axis of the volutions.

BELLEROPHON, Montfort (as restricted by Waagen). Symmetrically involute, subglobose shells, with or without an umbilicus, the latter never very large in the typical section; volutions more or less rounded on the back; aperture generally expanded, usually with a callosity on the inner lip; outer lip with a more or less deep central emargination behind which there is a well developed slit-band or an elevated blunt keel; surface sculpture consisting of more or less strongly developed striæ of growth only. Type, *B. vasulites* Montfort.

AMERICAN SPECIES.

B. allegoricus White. Quebec gr.
B. charon Billings. Black River, Trenton.
B. troosti (d'Orbigny) Safford. Trenton.
B troosti, var. *bürginensis* Ulrich. Trenton.
B. clausus Ulrich. Trenton.
B. subglobulus Ulrich. Trenton.
B. bilineatus Ulrich. Trenton.
B. platystoma Meek & Worthen. Trenton.
B. similis U. & S. Trenton.
B. rugosus Emmons. Loraine.
B. recurvus Ulrich. Loraine.
B. capax Ulrich. Utica, Loraine.
B. mohri Miller. Richmond group.
B. subangularis Ulrich. Richmond group.
B. miser Billings. Hudson River group.
B. sp. undet. Niagara.
B. plenus Billings. Gaspé.
B. pelops Hall. Schoharie grit, Up. Held.
B. propinquus Meek. Upper Helderberg.
B. nactus Hall. Chemung.
?*B. combsi* Walcott. Devonian.
B. gibsoni White. St. Louis.
B. sublœvis Hall. St. Louis, Chester.
B. crassus M. & W. Coal Measures.
B. giganteus Worthen. Coal Measures.
B. percarinatus Conrad. Coal Measures.
B. tricarinatus Shumard. Coal Measures.

FOREIGN SPECIES.

B. fasciatus Lindström. Upper Silurian.
B. globulus Lindström. Upper Silurian.
B. sphaera Lindström Upper Silurian.
B. lineatus Goldfuss. Devonian.
B. tuberculatus d'Orbigny. Devonian.
B. vasulites Montfort. Carboniferous.
B. bicarenus Leveille. Carboniferous.
B. recticostatus De Koninck. Carboniferous.
B. scalifer De Koninck. Carboniferous.
B. martini De Koninck. Carboniferous.
B. sulcatulus De Koninck. Carboniferous.
B. ferrussaci d'Orbigny. Carboniferous.
B. sowerbyi d'Orbigny. Carboniferous.
B. canaliferus Goldfuss. Carboniferous.
B. tenuifascia Sowerb. Carboniferous.
B. hiulcus Sowerby. Carboniferous.
B. costatus Sowerby Carboniferous.
B. plicatus Ryckhold. Carboniferous.
B. tangentialis Phillips. Carboniferous.
B. jonesianus DeKoninck. Permo-Carb.
B. orientalis DeKoninck. Permo-Carb.
B affinis Waagen. Permo-Carb.
B. impressus Waagen. Permo-Carb.
B. squamatus Waagen. Permo-Carb.
B. blandfordianus Waagen. Permo-Carb.
B. triangularis Waagen. Permo-Carb.

BUCANOPSIS, n. gen. (Ulrich.) (*Bellerophon* [part.] of authors; *Bucania* [part.], Waagen, 1880, and Koken, 1889.) This name is proposed for shells agreeing in all respects with *Bellerophon* excepting that their surfaces are cancellated by regular revolving and transverse striæ. The volutions enlarge rapidly, giving a broadly expanded aperture; the umbilicus is of moderate size and may be closed entirely, while the inner lip is always somewhat thickened. The revolving lines are never oblique nor wrinkled. Type, *B. carinifera*, n. sp. (Ulrich.)

AMERICAN SPECIES.*

B. carinifera Ulrich. Trenton.
B. exigua Foerste. Clinton.

FOREIGN SPECIES.†

B. gemma Lindström. Upper Silurian.
B. latevittata Lindström. Upper Silurian.

* All, save the first, originally described under *Bellerophon*.
† The four species credited to Waagen were described under *Bucania*, all others under *Bellerophon*.

AMERICAN SPECIES.	FOREIGN SPECIES.
B. leda Hall. Hamilton.	*B. subdecussata* McCoy. Upper Silurian.
B. lineolata Hall. Hamilton.	*B. substriata* Krause. Upper Silurian.
B. lyra Hall. Hamilton.	*B. neglecta* Koken. Devonian.
B. reperta Hall. Hamilton.	*B. clathrata* d'Orbigny. Carboniferous.
B. rotalinea Hall. Hamilton.	*B. decussata* Fleming. Carboniferous.
B. textilis Hall. St. Louis.	*B. elegans* d'Orbigny. Carboniferous.
B. marcouana Geinitz. Upper Coal Meas.	*B. striata* Fleming. Carboniferous.
?*B. elliptica* McChesney. Upper Coal Meas.	*B. textilis* De Koninck (not Hall). Carboniferous.
?*B. kansasensis* Shumard. Upper Coal Meas.	*B. angustifasciata* Waagen. Permo-Carb.
?*B. meekana* Swallow. Upper Coal Meas.	*B. integra* Waagen. Permo-Carb.
	B. kattaensis Waagen. Permo-Carb.
	B. ornatissima Waagen. Permo-Carb.

The position of the last three species in the list of American species is somewhat doubtful. They should perhaps be placed with the *Bellerophon patulus* group (*Patellostium*).

PATELLOSTIUM, Waagen (emend.). (*Patellostium*, Waagen, *Phragmostoma*, Waagen [not Hall], Paleontologica Indica, ser. 13, pt. 2, p. 131; 1880.) In this group of chiefly Devonian species the characters of the shell may be said to agree in the main with *Bucanopsis*, though this agreement consists chiefly in the fact that both have revolving surface lines. Still, even these are not exactly as in *Bucanopsis*, being generally weaker (sometimes very much so) than the transverse lines and easily abraded. But the principal peculiarities lie in the greatly expanded aperture and the extent to which the inner lip is thickened and reflexed. The callosity is sometimes granulose and it may be cut out where it touches the dorsum of the preceding whorl, reminding one in both respects of *Protowarthia*. In our opinion these striking forms should be separated from *Bellerophon* and *Bucanopsis*. The only difficulty is in regard to the name by which the group may be known. Waagen distinguished his *Patellostium* from *Phragmostoma* upon what, in the absence of other differences, we cannot regard as a generic character.* The latter being the older name might be employed, only it is well known that what Waagen understood under that name is not the same as the original *Phragmostoma*, which is identical with *Carinaropsis*. *Patellostium*, on the other hand, is founded upon Roemer's *Bellerophon macrostoma*, which, unfortunately, is as yet known only from casts of the interior. Still, as it is highly probable that Roemer's species is congeneric with *B. patulus* Hall, we would suggest that *Patellostium* be so amended that it will include the following American species:

Bellerophon newberryi Meek. Upper Helderberg.	*B. rudis* Hall. Hamilton.
B. natator Hall. Hamilton.	*B. explanatus* Hall. Chemung.
B. patulus Hall. Hamilton.	*B. triliratus* Hall. Chemung.

B. montfortanus Norwood & Pratten. Coal Measures.

* In the first the inner lip is said to be entire, in the other "cut out where it touches the preceding whorl."

Euphemus, McCoy* (emend., Waagen†). Shell more or less globular or lenticular; whorls rounded, embracing so that there is no umbilicus; aperture not abruptly expanded, with the outer lip bilobed, the central insinuation moderately deep and rather wide; slit-band wide, defined on each side by a thin or thicker ridge; inner lip somewhat callous in its lateral parts, while the central portion spreads itself as a thin, longitudinally folded sheet over the inner volutions. These revolving ridges, or, as Waagen calls them, columellar folds, extend a greater or less distance beyond the aperture, in some cases reaching a point half around the last whorl. Beyond them to the outer edge of the aperture the surface usually appears smooth, but in perfectly preserved specimens it presents very fine lines of growth running parallel with the outline of the aperture. Type, *E. urii* Fleming sp.

Both McCoy and Waagen deny the existence of a slit-band, but Koken maintains (*op. cit.*, p. 393)—and, so far as the American species are concerned, we have material before us which permits us to sustain his assertion with absolute certainty—that it was always present. That it often, indeed generally, appears to be absent is due to the extreme liability of the outer or sculpture bearing layer of the shell to destruction, while on the inner volutions it is covered by the revolving columellar folds. For further remarks see under *Mogulia* (page 856.)

American species.

E. (*Bellerophon*) *carbonarius* Cox. Coal Meas. *E.* (*Bellerophon*) *modocarinatus* Hall. Coal Meas.

Foreign species.

E. (*Bellerophon*) *orbignyanus* Portlock. Carboniferous. Europe.
E. urii Fleming sp. Carboniferous. Europe.
E. indicus Waagen. Permo-Carboniferous. India.
E. apertus Waagen. Permo-Carboniferus. India.
E. laevis Waagen. Permo-Carboniferous. India.
E. lenticularis Waagen. Permo-Carboniferous. India.

Warthia, Waagen.‡ Smooth globular non-umbilicated shells, with a broad and rather deep rounded sinus in the outer lip, but without either a slit or slit-band. Inner lip only very slightly thickened, not extensive nor spreading (as in *Protowarthia*) over the umbilical regions. Aperture without lateral expansions. No revolving lines; striæ of growth very indistinct. Type, *W. polita* Waagen.

This genus is readily distinguished from *Bellerophon* by the breadth of the sinus in the outer lip and the entire absence of a slit-band. It is however singularly like the early Paleozoic group of shells for which we have created the genus *Protowarthia*. For comparisons and remarks on the probable significance of this and the preceding genus see below under *Mogulia*. So far as known *Warthia* is not represented in American strata. Waagen describes three species from the

* Synop. Carb. Foss. Ireland, p. 25; 1862.
† Pal. Indica, ser. 13, pt. 2, pp. 131, 163.
‡ Pal. Indica, ser. 13. pt. 2, pp. 131, 158; 1880.

Permo-Carboniferous of India, *W. polita*, *W. brevisinuata* and *W. lata*. To these he adds three Australian species, *Bell. undulatus* Dan., *Bell. strictus* Dan., and *Bell. micromphalus* Morr.

MOGULIA, Waagen. (Pal. Indica, ser. 13, pt. 2, pp. 131, 156; 1880.) General appearance of shell as in *Bellerophon*, from which it differs in having no slit nor slit-band, and only a shallow angular emargination in the outer lip. Surface markings consisting of lines of growth only. These are broad and strong and cross over the dorsum without further interruption than is occasioned by the sharp central bend. Only known species, *M. regularis* Waagen, Permo-Carboniferous of India.

This and the two preceding genera, *Euphemus* and *Warthia*, are of unusual interest because we believe they show that in the decline of the family it actually retraced its steps by the adoption of primitive characteristics. In other words we regard them as atavistic types in which the progressive development of the individual was arrested in the embryo, and in which, because of the failure to develop the adult features of their immediate ancestors, certain characters that under previous conditions were larval only became permanent. In the Devonian and Carboniferous *Bellerophontiidæ* the suborder obtained the hight of its development, and this was not reached until after the extinction of all the other families. The decline, which obviously was very rapid, took place during the time immediately preceding the close of the Paleozoic age. Facts like these permit us to assume that the three genera under consideration are retrograde descendants of Carboniferous *Bellerophontiidæ* and not remnants of types that flourished only in Cambrian and Lower Silurian times. Besides, this idea is entirely harmonious with laws that have been shown to operate in other branches of zoölogy, and according to which the earliest and latest representatives of a group of organisms may be more like each other than either is like intervening stages in the rise, acme and decline of the line of evolution to which they belong.

Mogulia, in the absence of a slit-band, the shape of the outer lip, the form of the aperture, and even in the strength and course of the lines of growth on the dorsum, compares closely only with *Owenella*, that most ancient of all the *Bellerophontacea*. *Warthia*, excepting that it has no spiral surface lines, nor those grano-lineate extensions of the inner lip, is precisely like that important group of Lower Silurian shells which we have called *Protowarthia*. *Euphemus*, again, in its broad and ridge-bordered slit-band, in the shape of the aperture, indeed in the form and characters of the whole shell, recalls the Lower Silurian genus *Tetranota* probably more than either *Owenella* and *Protowarthia*. But in the spiral columellar folds which spread over the umbilical regions and a large part of the dorsum of the last volution, we have an extravagant development of the delicate grano-lineate extension of the inner lip which is the principal difference between *Protowarthia* and *Warthia*.

The points brought out in the foregoing paragraph are significant and indicate, we believe, that *Owenella* and *Protowarthia*, followed by some *Tetranota*-like type, were important stages in the development of *Bellerophon*. The types named are obviously progressive. The first has no slit-band and only a very shallow sinus, the second is still without the band but has a broad and deep sinus, while the third and fourth have a narrow and very deep parallel-sided sinus or slit which with the growth of the shell causes the formation of a slit-band.

STACHELLA, Waagen. (Pal. Indica, ser. 13, pt. 2, pp. 132, 171; 1880.) Shells agreeing in all respects with *Bellerophon* excepting that they are smoother and somewhat unsymmetrically coiled, there being an umbilicus on one side and none, or at any rate a shallow one, on the other. Type, *S. bifrons* Waagen.

So far as known no shells of this type have yet been found in American deposits. Two species occur in the Permo-Carboniferous of India, and five in the Permian of the Alps. The latter are described by Stache in his monograph of the fauna of the Bellerophon limestone. Regarding the genus, it seems to mark an important departure from the ordinary types of the family. We suspect that *Stachella* may be the radical of the ophisthobranchs, but this is a mere suggestion. The Cretaceous *Bellerophina*, d'Orbigny, is a similarly unsymmetrical shell, but has no slit-band and only a shallow emargination of the outer lip.

Family CARINAROPSIDÆ.

Symmetrical, almost patelliform shells, the aperture being greatly expanded; apex small, involute, overhanging the posterior margin, consisting of no more than two volutions. Within the aperture a broad concave septum. Anterior lip with a central emargination.

This family embraces a small group of Lower Silurian shells that is readily distinguished from other bellerophontids by the internal septum. We believe that it should include also the genus *Pterotheca*, which is now almost universally referred to the *Pteropoda*. A discussion of the affinities of this genus will be found under *Carinaropsis.*

CARINAROPSIS, Hall.* (*Phragmostoma*, Hall,† not Waagen.‡) Shell consisting of little more than two volutions, the inner one very small, scarcely embraced by the outer, and shown in the umbilicus; outer volution greatly expanded, the whole shell appearing somewhat patelliform; dorsum carinate, the carina sharp on the inner

* Palæontology of New York. vol. i, p. 183; 1847.
† Fourteenth Rep. N. Y. St. Mus. Nat. Hist., p. 94; 1861.
‡ Palæontologica Indica, ser. 13, pt. 2, p. 131; 1880.

whorls but becoming less angular if not quite obsolete in nearing the apertural margin; slit-band occasionally distinguishable; outer lip of aperture thin, sinuate and notched centrally; inner lip entire where it touches the preceding volution; within the edge it is first deeply concave, then produced into a broad thick flattened plate or septum, which extends a considerable distance into the aperture; upper surface of septum with a low but well defined median ridge; inner aperture covered (always?) by a triangular flat operculum. Type, *C. carinata* Hall.

C. acuta U. & S. Black River group.
C. minima U. & S. Black River group.
C. phalera Sardeson. Black River group.
C. carinata Hall. Trenton group.
C. cunulæ Hall. Trenton group.
C. explanata Ulrich. Top of Trenton group.
C. cymbula Hall. "Hudson River group."

Genus CYRTOLITES, Conrad.

Cyrtolites, CONRAD, 1838, Ann. Rept. Nat. Hist. Surv. N. Y., p. 118.
Cyrtolites (part.), Hall, 1847, Pal. N. Y., vol. i, p. 187. MILLER, 1874, Cin. Quart. Jour. Sci., vol. i, p. 308; also 1889, N. A. Geol. and Pal., p. 401. WAAGEN, 1880, Pal. Indica, ser. 13, pt. 2, p. 132. LINDSTRÖM, 1884, Silurian Gastropoda of Gotland, p. 81.

For generic characters see page 846.

Restricting this genus to species of the type of *C. ornatus* Conrad, we have an isolated group of a shells that we find most difficult to classify satisfactorily. Despite the fact that authors have so generally agreed in uniting with the group that other peculiar type which we separate as *Conradella*, there is in reality but very little reason for considering them as related and much less as identical. In discussing that genus on a following page it is shown, we believe, to the satisfaction of every fair-minded student that *Conradella*, with its long dorsal slit and imbricated lamellæ, is nearer *Bucania*, *Salpingostoma* and *Tremanotus* than to *Cyrtolites*. Indeed, we cannot see how an unprejudiced comparison of *Conradella* and *Cyrtolites* can fail to impress the observer with the conviction that the two groups of species are not only generically distinct, but not even closely related.

Cyrtolites has been loosely employed by most authors for symmetrically involute, disciform shells, having the dorsum carinate or angular and the umbilicus broad so as to expose the inner volutions. These characters pertain to several widely distinct genera, and to use them as characteristic of a single genus is to bring together a most heterogeneous assemblage of forms. Thus we have among the species that have been referred to *Cyrtolites* several belonging to *Oxydiscus*, Koken (*Tropidiscus*, Meek), a genus that is nearer *Bucania* and *Bellerophon;* several of *Conradella*, which, as we have said, is nearer *Bucania;* and all of the species comprised in the new genus *Cyrtolitina*. Lindström and others have thought that *Porcellia*, even, is the same as *Cyrtolites*. With equal propriety we might refer to the same generic group also the recent genus *Atlanta!*

But this will not do, for it would be nothing less than ignoring most palpable facts. We must return to the original type, *C. ornatus*, and restrict the genus to species possessing essentially the same generic peculiarities. After the characters mentioned in the first sentence of the preceding paragraph, which brings us down in the identification of the genus to four or five similarly constructed types, these peculiarities consist of (1) the subquadrangular cross-section of the whorls, (2) the simple and sharp edged or minutely serrated character of the dorsal carina, (3) the total absence of a slit-band and (4) the pattern of the surface markings which, with a single exception, differs from that of all other bellerophontids. The second and third of the features is shared by *Oxydiscus*, but as the latter has more numerous and more compressed volutions, a much deeper apertural emargination and slit, and lines of growth only, there is little trouble in separating it from *Cyrtolites*. *Conradella* is distinguished by its slit-band and remarkably long apertural slit, by the rounded or cordate section of its whorls, and by its strongly imbricating and wavy surface lamellæ; *Porcellia* has a long slit like *Conradella*, rounded volutions, the inner ones unsymmetrically coiled, and different surface markings. For comparisons with *Cyrtolitina*, which of all the *Bellerophontidæ* at present seems to be the nearest, see remarks on that genus (some pages hence).

Such strong resemblances are to be traced between casts of species of *Carinaropsis* and *Cyrtolites*, that, despite our strong assertion to the contrary on a later page, we would really not be surprised if future discoveries should prove that the two genera are related genetically. At present, however, the origin of that genus is enveloped in the greatest obscurity. As to *Cyrtolites*, it may have sprung from Cambrian *Stenotheca*.

The species remaining under the genus as restricted are not many, and all (six) about which there is no doubt are illustrated in this work. Four of the six are described as new. Of the other American species that have been referred to the genus, *C. compressus* Conrad, *C. dyeri* Hall, *C. elegans* Miller, *C. imbricatus* Meek & Worthen, and *C. pannosus* Billings, belong to *Conradella; C. magnus* Miller and *C. cristatus* Safford, to *Oxydiscus; C. nitidus* Ulrich, to *Cyrtolitina; C. subcarinatus* Emmons, probably to *Carinaropsis*. *C. filosus* Emmons and *C. trentonensis* Conrad are *Cephalopoda*; while the remaining forms, *C. desideratus* Billings, *C. expansus* Hall, *C. gillanus* White & St. John, *C. sinuatus* Hall & Whitfield, and *C. sinuosus* Hall, are too little known to be placed with anything like certainty. Of European species that have been referred to *Cyrtolites* perhaps none really belong there. *C. delanouei* Œhlert, and *C. orbiculus* Lindström doubtless belong to *Oxydiscus*, to which we are inclined to refer *C. discus* Lindström as well, although it has a distinct slit-band which should not be the case in a true *Oxydiscus.* Perhaps it would be better to place the last species, together with *C. euryomphalus* Lindström, into our new genus *Cyrtolitina*, which is more especially intended for the reception of four other Gotland shells described by Dr. Lindström as *Cyrtolites lamellifer*, *C. pharetra*, *C. arrosus* and *C. obliquus.*

CYRTOLITES ORNATUS *Conrad.*

PLATE LXII, FIGS. 27–31.

Cyrtolites ornatus CONRAD, 1838, Ann. Geol. Rept. N. Y., p. 118; *Ibid.* (1839), p. 63; *Ibid.* (1841), p. 37. VANUXEM, 1842, Geol. Rept., p. 65, fig. 2. EMMONS, 1842, Geol. Rept., p. 402, fig. 2. HALL, 1847, Pal. N. Y., vol. i, p. 308, pl. LXXXIV, figs. 1*a-g*. MEEK, 1873, Pal. Ohio, vol. i, p. 148, pl. XIII, figs. 3*a*, *b*. MILLER, 1874, Cin. Quart. Jour. Sci., vol. i, p. 308. And of many other authors.

Shell varying in diameter between 12 mm. and 30 mm., with the average at about 23 mm. Volutions two or three, rapidly increasing in size, strongly and sharply carinate dorsally, rhombic subquadrate in section; sides prominent and subangular or narrowly rounded along a line about three-fifths of the hight of the volution within the dorsal carina, the dorsal slopes gently convex and distinctly undulated by strong slightly curved transverse furrows and subangular ridges, the ventral or umbilical slopes almost flat and usually without undulations; ventral side with a sharp central furrow for the reception of the dorsal carina of the preceding volution. Umbilicus well defined, wide and deep, the edge wavy. Aperture a little wider than high, the hight equalling usually a trifle more than half the greatest diameter of the shell, more or less rhombic-subquadrate, the outline often becoming a little rounded with age. Entire surface covered by a delicate network formed of raised lines running almost straight across the whorls and short connecting lines arranged alternately, the result being somewhat similar to the pitting of a thimble. In a good light the network is generally distinguishable without the aid of a magnifier, and, excepting three specimens, quite uniform in strength in different shells, there being on the outer half of the last whorl nearly always seven or eight of the transverse lines and eight or nine of the short lines in 2 mm. In the excepted specimens the network is more compact, there being over the outer part of the last whorl from ten to twelve of the transverse lines in the same space. On another, with the reticulation unusually coarse, the number averages between six or seven. On the last specimen a good magnifier brings out some very fine lines of growth running through the network. It is important to note that there is no perceptible backward curvature of the transverse lines in nearing and crossing the dorsal carina.

The above description applies to the species as it occurs in the groups of the Cincinnati period wherever these are exposed in the United States and Canada. In its typical form the species is not known to occur in the Trenton, but a variety has been found in the Clitambonites bed of the Trenton group in Minnesota. For this we propose the subordinate name *minor*, the specimens being unusually small, none exceeding 11 mm. in diameter. The volutions seem also to be narrow, the hight at the aperture in the specimens at hand exceeding the width by about one-sixth. The surface markings are precisely as in the typical form of the species excepting that the transverse striæ in crossing the dorsal carina are sometimes bent slightly backward. The variety is of consequence chiefly because it proves the existence of the *ornatus* type at quite as early a time as that in which the *C. retrorsus* lived. And this fact justifies us also in denying that *C. ornatus* was evolved from *C. retrorsus*.

Formation and locality.—The typical form is a common fossil of the Loraine and Richmond groups at numerous localities in Ohio, Indiana, Kentucky, Pennsylvania, New York and Canada. At Cincinnati the shell is often covered by a parasitic bryozoan (*Leptotrypa ornata* Ulrich) which, when carfully chipped away, generally leaves a good cast of the surface markings and not infrequently the test itself. The species has not yet been certainly identified in the Utica group, but we suspect that one or two casts collected in the lower part of this group at Covington, Kentucky, may belong to it. Variety *minor* was found by E. O. Ulrich in the Clitambonites bed of the Trenton group, near Cannon Falls, Minnesota.

CYRTOLITES RETRORSUS, *n. sp.*

PLATE LXII, FIGS. 32–37.

Shell rather small, the diameter rarely exceeding 15 mm., in one case 20 mm., in others mostly from 12 to 14 mm.; in general appearance decidedly like *C. ornatus*, the dorsal slopes being strongly undulated, and the surface distinctly reticulated. Carefully compared, however, it is found to differ in the following particulars: the keel is more prominent, the dorsal slopes are more concave, the sides sharper, the transverse section of the volutions more distinctly quadrangular, and their rate of increase greater. The most important difference is in the form of the mouth and the direction of the transverse surface lines. The mouth namely is deeply cut out and the lines instead of passing directly across the back are strongly curved backward. Finally there is a small ridge along the suture line that has not been observed in *C. ornatus*. The retral curve of the transverse lines is slightly greater than in *C. carinatus* Miller, with the typical form of which *C. retrorsus* agrees very closely so far as the inner volutions are concerned. But mature specimens of the two species cannot be confounded, the dorsal slopes in Miller's species becoming flat with maturity, while undulations are not developed except in the oldest examples. In *C. retrorsus*, on the contrary, they begin very early, while the concavity of the dorsal slopes continues through all stages.

There can be no reasonable question about the specific distinctness of this shell, nor do we doubt that it will include, if not all, at least a part of the Tennessee specimens referred to *C. ornatus* by Prof. Safford. If any are in doubt, then it is those which he obtained from his "Orthis bed," which, like the Clitambonites bed in Minnesota, we place at the base of the Trenton group. The same form occurs also in equivalent strata in Kentucky, but none of the specimens seen by us are sufficiently perfect to permit of a positive decision in the matter. So far as the form of the shell and volutions is concerned, the specimens in question certainly agree very closely with *C. retrorsus*, and, if appearances are not deceptive, they are like it also in the backward swing of the surface markings. The evidence at hand, therefore, seems to indicate that all of the Tennessee and Kentucky Trenton specimens hitherto referred to *Cyrtolites ornatus* really belong to *C. retrorsus*.

Formation and locality.—Upper part of the Trenton group between Burgin and Danville, Kentucky, and Nashville, Tennessee. Probably also in the lower part of the group near the same localities. About ten specimens, mostly casts of the interior, have been found by one of the authors in the upper part of the Trenton group and in the lower part of the Utica group at Cincinnati, Ohio, and at Covington and Newport in Kentucky.

Collections.—E. O. Ulrich; Prof. J. M. Safford.

CYRTOLITES RETRORSUS, var. FILLMORENSIS, *n. var.*

PLATE LXII, FIGS. 38 and 39.

Under this name we propose arranging provisionally a form occurring not very rarely in the shales of the Black River group at localities in Fillmore county. Unfortunately, none of the specimens before us are in a good state of preservation, all excepting three being more or less distorted casts of the interior. On two of the excepted specimens the shell is preserved on the inner volutions only, while the the third retains a few lines near the aperture. So far as can be determined, the variety differs from the typical form of the species only in having the sides of the inner volutions almost rounded, the form of the outer volution and the surface ornamentation being apparently as in *C. retrorsus*. The rounded character of the sides of the inner volutions in this, the oldest known variety of the genus, is a noteworthy feature, since it may give us a clue to the origin of the genus.

Formation and locality.—Black River group, Ctenodonta bed, Chatfield and near Fountain, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, Nos. 4051, 7535.

CYRTOLITES CARINATUS *Miller.*

PLATE LXII, FIGS. 50–52.

Cyrtolites carinatus MILLER, 1874, Cin. Quar. Jour. Sci., vol. i, p. 311, fig. 32.
Comp. *Cyrtolites conradi* HALL, 1862, Geol. Rep. Wis., p. 55. (Figured only.)

Smaller than *C. ornatus*, the size being about as in *C. retrorsus*, the average diameter about 13 mm.; in two of our specimens it exceeds 20 mm. Sides sharply carinated like the dorsum, the dorsal slopes strongly concave on the first and second whorls, nearly flat on the last, without undulations except near the aperture of the largest examples; transverse lines sweeping backward from the edge of the umbilicus, stronger than the connecting lines, the difference between the two sets increasing with age.

The original description of the species is not entirely correct, Dr. Miller claiming that the surface "never presents a cancellated appearance," but he seems to have doubted the correctness of his observations since he adds, "at least not on any specimen observed." Out of more than twenty specimens belonging to the cabinet of one of the authors several preserve the surface markings in a fairly satisfactory manner. These show that on the inner volutions the surface is minutely though distinctly cancellated. The short connecting lines are delicate, and as growth proceeds they become relatively more so, a short exposure to the weather sufficing in many cases to efface them entirely, when the specimen will appear to have transverse striæ only. Generally, however, when the stronger set of lines is preserved, more or less convincing traces of the other set also are retained.

Compared with *C. ornatus* the present species is distinguished by its sharper lateral carinæ, flatter and more concave dorsal slopes, almost total absence of surface undulations, and by the backward sweep of the lines of growth. From *C. retrorsus* it differs in being practically without dorsal undulations, in having a less prominent dorsal carina, and in the flattening of the dorsal slopes of the last volution. So far as the two species mentioned are concerned, *C. carinatus* is clearly distinct, but we cannot say as much when we compare it with *C. conradi*, a species named and figured by Hall (*loc. cit.*), without a description, as one of the fossils of the Hudson River or Maquoketa shales of Wisconsin and Iowa. Hall's illustration represents a small *Cyrtolites* very similar to *C. carinatus*, and, as the geological horizon is about the same for both, it is not unlikely that the two names apply to the same species. To establish this as a fact would in our opinion necessitate a comparison with Hall's original type of *C. conradi*, and if that is no longer possible, it would be well to drop the name entirely.

Formation and locality.—Not uncommon in the Utica group at Cincinnati, Ohio, and a number of localities in the vicinity of that city. The species occurs probably also in the lower shales of the Cincinnati period in Wisconsin and Iowa, in which case it may be looked for in southern Minnesota as well.

CYRTOLITES PARVUS, *n. sp.* (*Ulrich.*)

PLATE LXII, FIGS. 45-47.

Shell small, about 7 mm. in diameter, 6 mm. wide at the aperture, consisting of about two rapidly enlarging volutions, subquadrangular in section and somewhat wider than high; dorsum carinated, the keel not very prominent, minutely wavy in a side view; sides narrowly rounded, scarcely angular; dorsal slopes gently convex, without undulations except near the aperture where several obscure ones may be noticed. Surface with comparatively coarse lines of growth, curving strongly backward from the edge of the umbilicus to the dorsal carina which they cross without interruption. These lines are connected by more closely arranged and very delicate obliquely revolving lines, which, being lower than the transverse set, might easily be overlooked. On the last turn seven or eight of the transverse lines occur in 2 mm.

Considering the size of the shell, the surface markings are stronger than in any of the other species of the genus. From *C. carinatus* Miller, which it resembles most, it differs also in having the sides of the volutions narrowly rounded instead of sharply angular. In *C. retrorsus* and *C. ornatus* the surface ornamentation is much more distinctly reticulated, and, while the former has a much stronger keel and concave dorsal slopes, the latter is especially distinguished by the absence of a sinus in the outer lip and consequently in the more strictly transverse course of the surface markings. Internal casts of *Cyrtolitina nitida* resemble testiferous examples of this species; but if this fact is borne in mind, and further that in the former the back is flattened, the volutions more compressed laterally, and the surface markings of the cast thicker and wave-like rather than thread-like, it is almost impossible that confusion between them can ever occur.

Formation and locality.– Near top of Trenton group at Covington, Kentucky.

Collection.—E. O. Ulrich.

CYRTOLITES DISJUNCTUS, *n. sp.*

PLATE LXII, FIGS. 48 and 49.

Shell about 24 mm. in hight, consisting of about two entirely free or disjoined whorls, coiled very nearly or quite symmetrically; volutions strongly and sharply carinated dorsally, the sides somewhat narrowly rounded within the center, and strongly undulated transversely; ventral side less convex, with two abruptly elevated narrow central carinæ, forming a groove with raised edges or what is commonly called a "saddle"; hight of volutions increasing with age more rapidly than the width, the transverse section, excluding the dorsal and ventral carinæ, changing from transversely subelliptical to almost circular at the aperture of a fully grown specimen. Surface markings on the whole nearly the same as in *C. ornatus*, only the transverse ridges are not confined to the dorsal slopes but continue downward with a slight retral curve over the ventral slopes as well. The reticulation of the surface also changes with growth in a manner not observed in that species. Thus on the minute inner whorl the surface is almost smooth, only a few obscure revolving lines being visible on this part. With the beginning of the second turn the sculpture changes abruptly to the usual style of reticulation, but for some distance the transverse lines curve backward towards the dorsal carina as in *C. retrorsus* and *C. carinatus*. This retral curve, however, is soon lost so that on the greater part of the shell they pass directly over the carina as in *C. ornatus*.

The peculiarities of this beautiful shell are so obvious that comparisons are quite unnecessary. It is the only species of the genus in which the whorls are not in contact.

Formation and locality.—Richmond group of the Cincinnati period, near Spring Valley, Minnesota, where two specimens were found in association with *Orthis subquadrata* and numerous other *Brachiopoda* characterizing the horizon.

Collection.—E. O. Ulrich.

CYRTOLITES (?) DILATATUS, *n. sp.*

PLATE LXII. FIGS. 20–26.

Shell 15 to 30 mm. in hight, the inner volutions unknown, the outer expanding very rapidly in width, sharply carinated or alated on the sides, more obtusely upon the back, transversely triangular quadrate in section; dorsal slopes flat except near the prominent lateral edges where they are concave; ventral side nearly flat, with a central groove probably for the reception of the dorsal carina of the inner volutions; aperture nearly or about twice as wide as high, subtriangular, the width slightly exceeding the hight of the entire shell, the outer margin with a broad, centrally angular sinus, the inner lip with a small "saddle." Surface markings unknown; outer part of a large cast of the interior with a few faint transverse wrinkles of growth.

Of this remarkable species we have seen but two specimens, one, a large cast of the interior, belonging to the Powers' collection of the University of Wisconsin, the other a smaller testiferous example collected by E. O. Ulrich in Minnesota. The latter exhibits no signs of surface markings, but this is evidently due to lack of preservation. In the absence of any knowledge of the superficial sculpture, the generic position is somewhat doubtful. The great width of the aperture and the wing-like expansion of the lateral edges are suspicious and possibly indicate a relation to *Carinaropsis.* When fully known we believe it will be recognized as the type of a new genus intermediate in position between *Carinaropsis* and *Cyrtolites*.

Formation and locality.—Ctenodonta bed of the Black River group, Goodhue county, Minnesota The Wisconsin specimen seems to be from an equivalent horizon at Beloit.

Collections.—University of Wisconsin; E. O. Ulrich.

Genus CYRTOLITINA, n. gen.

Cyrtolites (part.), ULRICH, 1879, Jour. Cin. Soc. Nat. Hist., vol. ii, p. 12. LINDSTRÖM, 1884, Silurian Gastropoda of Gotland, pp. 82–84.

For generic characters see page 847.

The five species at present believed to have the characters of this genus were originally all referred to *Cyrtolites*. They are, however, quite distinct from the typical species (*ornatus*) of that genus, and, in certain respects at least, nearer to *Bucania* and *Conradella*. With the latter genera they agree in the surface sculpture, in having the aperture distinctly emarginated, and in possessing a slit-band, while they differ in these features from *Cyrtolites*. On the other hand the agreement with *Cyrtolites* is stronger only in the form of the volutions and in their number, the whorls being much less in number and higher than wide instead of the reverse as in *Bucania*. It is difficult to decide as to the relative merits of these agreements, and, as we are scarcely beyond the threshold of knowledge respecting the Paleozoic *Gastropoda*, we will not presume to attempt it. Still, while we pay tribute to prevailing opinions in both the selection of the new name and in referring the genus to the *Cyrtolitidæ*, it is to be understood that the arrangement is less in accordance with our views than if we had placed it among the *Bucaniidæ*. To this statement we may add the suggestion that *Cyrtolitina* may have been derived from some form of *Bucania* like *B. subangulata*.

Comparing *Cyrtolitina* with its possible relatives we find that it differs from *Cyrtolites* in having a slit-band, less carinate dorsum, an apertural emargination, higher (more compressed) volutions, and surface markings that are to be called lamellose rather than reticulated; from *Bucania* in having fewer and laterally instead of vertically compressed volutions; and from *Conradella* in having fewer and more rapidly enlarging volutions, much shorter apertural slit, no distinct dorsal keel, and the subimbricating surface lamellæ curved strongly backward on the dorsum.

CYRTOLITINA NITIDULA *Ulrich.*

PLATE LXII, FIGS. 53–55.

Cyrtolites nitidulus ULRICH, 1879, Jour. Cin. Soc. Nat. Hist., vol. ii, p. 12.

Shell small, 6 to 8 mm. in diameter; volutions about two, rapidly increasing in size, the outer embracing quite a half of the inner; dorsum blunt, thick, flattened in casts; sides gently convex to the edge of the umbilicus into which they descend at first rather abruptly, then gently, the ventral part spreading saddle-like over the inner volution. Aperture subcordate, notched below; outer lip rather broadly and deeply emarginated. Umbilicus about 3.5 mm. wide in a specimen 8 mm. in diameter, narrowly rounded at the edge. Surface of casts with distinct, subregular, retrally curved, transverse striæ, averaging about five in 2 mm. on the sides and back. The striæ continue over and are quite distinct and curved on the flattened dorsum or slit-band. On the latter some very fine revolving lines are faintly distinguishable. Somewhat oblique and stronger revolving lines, about four in 1 mm., occur on the sides of the volutions. Greatest diameter of a large specimen 8.3 mm; width of aperture 5.0 mm.; hight of same 5.0 mm.

The original description and figures are incorrect where they differ from the present work on the species. It is scarcely necessary to go into details.

Of American fossils we can compare this pretty shell only with species of *Cyrtolites* and possibly of *Bucania*. *Cyrtolites retrorsus* and *C. carinatus* are found with it, but both have more volutions, are sharply keeled and without a slit-band. The new *Cyrtolites parvus* is also associated and, because of its small size and relatively coarse markings, is more likely than any other fossil known to us to be confused with *C. nitidula*; still, they may be readily distinguished, *C. parvus* having the usual sharp dorsum and wider subquadrate aperture. Besides, it should be borne in mind that they are testiferous specimens and not casts of the interior of the species of *Cyrtolites* mentioned that look like casts of *Cyrtolitina nitidula*. Casts of *Cyrtolites* never show an imprint of the surface ornamentation, but those of the *Cyrtolitina*, on the contrary, are very distinctly marked.

Formation and locality.—Upper part of the Trenton group, in the river quarries ust west of Covington, Kentucky.

Collection.—E. O. Ulrich.

Genus PROTOWARTHIA, n. gen.

Bellerophon (part.), of numerous authors.

For generic characters see page 848.

The, chiefly Lower Silurian, group of shells for which this genus is proposed is strikingly similar to the Permo-Carboniferous species embraced in Waagen's genus *Warthia*. Indeed, there is little more than a single character, and that possibly is not always well developed, which distinguishes them. In *Protowarthia*, namely, the inner lip is prolonged as a thin grano-lineate sheet around the umbilical regions and over a greater or lesser portion of the dorsum of the posterior end of the last volution. Nothing of this kind has been observed in *Warthia*. That the surface of at least some of the forms of *Protowarthia* is delicately cancelled is not now considered of special consequence. A more significant fact is that while *Protowarthia* is almost or entirely restricted to the earlier periods of the Paleozoic, *Warthia*, if the geological record is even approximately reliable and complete, did not make its appearance till just before the close of that age. Here we have a difference in geological distribution that can be accounted for in only two ways: either the Permo-Carboniferous *Warthia* is distinct from *Protowarthia* and originated in some nearly contemporaneous (say Carboniferous) type, or we must assume that the two are the same and that the connecting species, which in that case must have existed during the Upper Silurian, Devonian, Lower Carboniferous and Coal Measures, were either destroyed or remain yet to be discovered. Considering the abundance of other bellerophontids in these strata, the latter alternative is certainly very improbable.

On page 856 we express the opinion that *Warthia* (also *Euphemus* and *Mogulia*) is a result of the decline and approaching extinction of the *Bellerophontidæ*. As stated there, such a return to primitive characters is quite in accordance with theories that are rapidly entering the realm of facts. We would have been pleased to discuss the questions involved at greater length, but the lack of space necessitates a postponement to some perhaps more appropriate future opportunity.

Compared with other bellerophontid genera *Protowarthia* is distinguished by the absence of a slit-band and the width and size of the sinus in the outer lip; *Bellerophon* has a distinct slit-band and centrally angular sinus and slit; in *Owenella* there is an umbilicus, the sinus is much shallower and centrally subangular, and the form of the shell more nearly globose; *Bucanopsis* has a slit-band, and so has *Bucania*, coupled with a large umbilicus; finally, in *Oxydiscus* the whorls are laterally compressed and sharply keeled and the shell broadly umbilicated.

Respecting the species of *Protowarthia*, they are among the most characteristic and abundant fossils of the Lower Silurian system. None are known in the Upper Silurian and only a single Devonian species. The last, moreover, is doubtfully referred to the genus.

PROTOWARTHIA RECTANGULARIS, *n. sp.*

PLATE LXIII, FIGS. 15–20.

Shell of medium size, rather closely coiled, leaving only a small umbilicus in the cast which, in the shell itself, is probably closed as in *P. cancellata;* outer volution sharply rounded dorsally, with a nearly flat or gently convex slope on each side, then turning rather abruptly into the umbilicus; aperture transverse, subtriangular, about twice as wide as high, the width but little less than the hight of the entire shell; sinus deep, the lobes not rounded but bending at almost a right angle in the middle; inner lip slightly reflexed and thickened on each side; test thin, composed apparently of two layers, the inner nacrous. Surface of specimens marked by more or less obscure lines of growth. These are usually the strongest on the dorsum, where they may be seen also on some casts of the interior. The latter, however, are in most cases quite smooth and without a trace of markings. External layer of shell not seen in good condition, so we cannot say positively, though we suspect it to be so, that it was marked near the umbilicus, as in the following species, by fine granulose striæ. Hight of shell 20.5 mm.; median hight of aperture 8.3 mm.; width of same 19 mm.; width of inner volution 7 mm.; depth of sinus 8 mm. In two other specimens, one very large, these dimensions are respectively, 24, 10, 23, 7 and 9 mm., and 30, 13.5, 27, 8 and 12 mm.

This species is often met with in collections under the name of *Bellerophon bilobatus*, but it is really quite distinct, as anyone may see by comparing the accompanying figures of that species with those of *B. rectangularis* given on plate LXIII.

A B C

Fig. 3. A and B, two views of *Protowarthia bilobata* Sowerby sp., and C, two views of *Bellerophon* (*?Oxydiscus*) *acutus* Sowerby; Caradoc sandstone, England. Copies of the original figures of these species on plate XIX of Murchison's "Silurian System," 1839.

It will be noticed that *B. bilobatus*, or *Protowarthia bilobata* as it should now be called, is a more ventricose shell, causing the back to be fuller and much more broadly rounded, while the apertural lobes, are, as usual, rounded in front instead of angular. The rectangular outline of the apertural lobes which has suggested the specific name, distinguishes *P. rectangularis* from all the other forms referred to *Protowarthia*. Indeed, it is a peculiarity that is not possessed by any other species of the whole suborder.

We have before us three specimens of a variety of this species from the Trenton limestone at Trenton Falls, New York. So far as this material at hand shows, the variety differs only in having the apertural lobes less angular than usual. We have also a number of internal casts from the Black River and Trenton shales and limestones of Minnesota which may represent other varieties of the species, but as we cannot be certain about them we prefer to leave them unclassified for the present.

Formation and locality.—Rather a common fossil of the Stones River group, at Mineral Point, Janesville and Beloit, Wisconsin, and Dixon, Illinois. In Minnesota it occurs, though not abundantly, in the Vanuxemia bed at Minneapolis, St. Paul and Cannon Falls.

Collection.—E. O. Ulrich.

PROTOWARTHIA GRANISTRIATA, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 28–30.

Shell scarcely reaching the medium size, closely coiled, leaving no umbilicus; center of dorsum raised into a low broad ridge, defined on each side by an obscure wide furrow; with age the outer boundaries of the latter increase gradually in distinctness, the back of the outer half of the last volution in the largest specimens presenting a flattened appearance; but the central ridge, though decreasing somewhat in hight, continues to the aperture. In casts of the interior there is a small umbilicus, while the central ridge is nearly as on the shelf itself. Aperture transverse, about twice as wide as high, the width generally equalling the hight of the shell; sinus wide, only moderately deep, the margin of the lobes bending rather sharply where the apertural margin is intersected by the faintly raised boundaries of the flattened dorsum. Except in the umbilical regions the test is thin. Out of nearly thirty specimens, only two preserve anything of the external layer. These show that it is marked by fine lines of growth and by very delicate revolving lines. All of the other testiferous examples preserve only the inner and middle layers, the latter appearing in every case quite smooth. Most of the specimens preserve what may be called a fourth layer. This seems to have been deposited by the inner mantle over the inner volutions, including the smaller half of the outer, while on each side it extends around the callous filling of the umbilicus. The whole of this layer is finely granulose, except the lateral extensions and these are covered by wavy revolving striæ. Hight of an average shell 19 mm.; width of aperture 19 mm.; median hight of same 9.3 mm.; width of inner volution 6 mm.; depth of sinus 5 mm.; width of same about 10 mm.

In this species the sinus is only about half as deep as in *P. rectangularis*, the apertural lobes are not rectangular, the umbilicus is closed entirely, and the volutions rounded rather than subtriangular in cross section. It is nearer *P. cancellata* Hall, but that species has a slightly deeper sinus, and a rounder back, the back never being flattened, nor is there ever a sign of the low dorsal ridge and obscure furrows characterizing *P. granistriata*.

Formation and locality.—At present this species is known certainly only from the Utica group in the vicinity of Cincinnati, Ohio.

Collection.—E. O. Ulrich.

PROTOWARTHIA PLANODORSATA, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 31–35.

Of this form we have six specimens. These show that it is of the type of *P. granistriata*,—perhaps it should be called a variety of that species,—differing in having the flattening of the back of the last volution much more decided, while the central ridge is wanting entirely, at any rate it is so for the outer volution. The dorsum of the volutions seems to be rather narrowly rounded. The surface markings are essentially the same in the two forms, as is also the form of the aperture and the dimensions, the largest specimen being about 24 mm. in hight.

The broad dorsal flattening will distinguish *P. planodorsata* at once from all other species of the genus and family known.

Formation and locality.—Utica group, Covington, Kentucky.

Collection.—E. O. Ulrich.

PROTOWARTHIA PERVOLUTA, *n. sp.*

PLATE LXIII, FIGS. 21–27.

This also may be only a variety of *P. granistriata*, but it is one well worthy of a distinct name. It is almost constantly smaller, the hight in the majority of the specimens being less than 15 mm., and in only one out of over fifty is it 20 mm. Comparing the two forms we find that *P. pervoluta* is more closely inrolled, giving a more globose form. The aperture also is relatively wider and the umbilical callosity has a columella-like twist that is not seen in *P. granistriata.* The volutions further are nearly uniformly rounded dorsally and never show anything either of a central ridge or a flattening. Though some of the specimens before us are tolerably well preserved, none of them exhibit any satisfactory evidences of external markings save the granostriate marking of the inner volution. This is more extensive, but in other respects essentially as in the two preceding species. Here and there a small patch of the external layer is retained and these sometimes exhibit faint traces of exceedingly delicate transverse and revolving lines.

Formation and locality.—In Kentucky this species occurs in the Black River group and in the lowest bed (Orthis or Modiolodon bed) of the Trenton group. In Minnesota casts of the interior are not uncommon in the Rhinidictya and Ctenodonta beds of the Black River group at St. Paul and Minneapolis. Testiferous examples are rare here, but further south near Cannon Falls and at Chatfield they are more abundant.

Collections.—E. O. Ulrich; W. H. Scofield.

PROTOWARTHIA CANCELLATA *Hall.*

PLATE LXIII, FIGS. 1–14.

Bellerophon cancellatus HALL, 1847, Pal. N. Y., vol. i, p. 307.
Compare *Bellerophon bilobatus* of Hall and other American authors, not of Sowerby.

The general form of this shell is much as in *P. rectangularis* and *P. planodorsata*, the average of characters being about intermediate between these two species. From the first it is distinguished by the more rounded back of the volutions and the rounded instead of angular outline of the apertural lobes. The sinus in the outer lip also is less V-shaped. From the second it is sufficiently distinguished by the rounded instead of broadly flattened dorsal region of the last whorl. Young specimens, especially if casts only were compared, would perhaps prove inseparable.

We refer here a large number of casts from the Black River and Trenton groups of Minnesota and elsewhere, as well as casts and testiferous specimens from the Utica, Loraine and Richmond groups of the Cincinnati region. The specimens from the Trenton period might be separated as var. *trentonensis*, as they are almost constantly a trifle more narrowly rounded dorsally than is the geologically higher typical form of the species. And yet we have specimens from the Black River group at Chatfield, Minnesota, that are, so far as it is possible to determine, precisely the same as the common variety of the species found in the lower part of the strata at Cincinnati, and which we regard as typical of the species.

Specimens preserving the shell in a satisfactory manner are everywhere rare. The outer layer which carries the transverse and revolving lines is nearly always gone, and, so far as our observation is concerned, this layer is retained, if we except two or three instances, only by specimens that have been removed from the solid limestone. These show that the perfect shell was ornamented with fine lines of growth, generally a little unequal, and even finer (just visible to the naked eye) revolving lines. The former may be obscurely visible on the inner layers of the test, but the latter are entirely superficial. Now, while most of the testiferous examples are almost entirely smooth, the greater number preserve the irregular or wavy revolving lines which surround the umbilical regions. This is true not only of this species but of the preceding forms as well, and proves that these thin extensions of the callosity of the inner lip are composed of a more durable substance than is the usual sculpture-bearing layer of the shell. So far as observed the inner whorls are not granulose dorsally as is the case in *P. granistriata*, *P. pervoluta* and *P. planodorsata*. The umbilical callosities of the inner lip are sharply defined, oblique and somewhat flattened, though always more or less excavated.

We have not seen the original type of this species which Hall sought to separate from the specimens which he regarded as *Bell. bilobatus*. But we have little or no doubt of the correctness of our identification, nor of the specific identity of a large proportion of the specimens that American authors generally and erroneously place under Sowerby's *Bellerophon bilobatus* and *P. cancellata.* The only difference between the two supposed species mentioned by Hall is that one has a cancellated surface, the other not. According to our view this difference is merely a matter of preservation, and if we are correct in this then *P. cancellata* is the commonest by far of all the Lower Silurian bellerophontids.

As to *P. bilobata* Sowerby, the original figures of which are reproduced on page 869, we have not the least doubt that it is specifically distinct from *P. cancellata*, that species being a larger and more globose form. Indeed, we doubt very much that Sowerby's species occurs in America.

Formation and locality.—Not uncommon in the Black River group, principally in the Ctenodonta bed, at Minneapolis, St. Paul, Cannon Falls, Chatfield and other localities in Minnesota. Also in Mercer county, Kentucky, and in Canada. It is very abundant in the Trenton, Utica, Loraine, and Richmond groups, in the first three especially, at numerous localities in Minnesota, Wisconsin, Iowa, Illinois, Kentucky, Ohio, Indiana, Tennessee, New York and Canada.

PROTOWARTHIA SUBCOMPRESSA, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 40—44.

Shell large, compressed-subglobose, the greatest hight and width about as six is to four; back broadly rounded, sides somewhat flattened, umbilicus closed, wanting; aperture semi-ovate, outer lip thin, inner lip moderately thick and reflexed in the umbilical regions; callosity extending over the whole front of the inner volution, apparently smooth; sinus broad and about as deep, the depth decreasing slightly with age; apertural lobes rounding very gently to the sinus where the outline makes a rather sharp curve. Surface marked by fine lines of growth and near the aperture by some obscure wrinkles. The callosity which extends over the inner volutions exhibits the usual fine irregular revolving lines in the umbilical regions. When the shell is removed, the cast shows a narrow furrow down the center of the back and several more faintly on each side. Greatest diameter 41 mm.; smallest diameter 29 mm.; width of aperture 27.5 mm.; hight of same (central) 19.5 mm.; width of inner volution 13 mm.; depth of sinus 7 or 8 mm.

This fine species, besides attaining a greater size than *P. cancellata*, differs from it in being narrower and in wanting, as far as known, the delicate revolving lines of that species. The umbilical callosity of the inner lip is also less and does not slope outwardly, the edge only being reflected. *Bellerophon morrowensis* Miller and Dyer, which also may belong to *Protowarthia*, is insufficiently known. According to the descriptions, it seems to differ in having the dorsal side sharply angular. *P. planodorsata* has a wider aperture, revolving lines, and a flat dorsum.

Formation and locality.—Richmond group of the Cincinnati period, Versailles, Indiana, and Butler county, Ohio.

Collection.—E. O. Ulrich.

PROTOWARTHIA CONCINNA, *n. sp.*

PLATE LXIII, FIGS. 36–39.

Comp. *Bellerophon morrowensis* MILLER and DYER, 1878, Contr. to Pal., no. 2, p. 8.

The specimen upon which this species is founded has, although it is much smaller, relatively nearly the same dimensions and form as *P. subcompressa.* The dorsum however is narrowly rounded instead of broadly, the aperture is triangular rather than semi-ovate, and the sinus is narrower, while the thickened base of the lip forms a small sharply defined and shallow umbilical depression which is not seen in that species. The surface of the specimen is without markings of any kind save on the small end of the visible volution where some traces of minutely granulose lines are to be detected. Greatest diameter 18 mm.; transverse diameter 13 mm.; width of aperture 11.5 mm.; central hight of same 8 mm.

It is possible that this is not distinct from the *Bellerophon morrowensis* described by Miller and Dyer from about the same horizon in Ohio. If they prove to be the same then their type specimen must be considerably crushed since it is described as "lenticular in form" and with the "dorsal side sharply angular." Under the circumstances we are obliged to consider our species as distinct.

Formation and locality.—Richmond groups of the Cincinnati period, near Spring Valley, Minnesota.

Collection.—E. O. Ulrich.

PROTOWARTHIA OBESA, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 45–47.

Shell rather large, obese, the greatest diameter between 30 mm. and 45 mm., the greatest width of the aperture usually about one-tenth less; volutions ventricose, almost uniformly rounded, the center of the dorsum just appreciably elevated; umbilicus covered by the reflexed or thickened lip, small in the cast; aperture transverse, the central hight somewhat greater than half the width; apertural lobes rounded, sinus very broad and comparatively shallow, but the depth seems to be somewhat variable; test thick. The specimens are all casts of the interior and exhibit merely obscure traces of the lines of growth. A small patch of the shell on one of the specimens shows that the growth lines are fine and unequal, and that revolving lines are wanting. Two or three broad transverse furrows cross the back of each of the five specimens before us. These furrows were produced by thickened bands upon the inner side of the shell, passing almost directly from side to side,—at any rate they are much less sinuate in the middle than is the margin of the aperture.

The ventricose volutions, shallow sinus and broad transverse furrows (on casts) are the distinctive features. Very young specimens may look much like the largest of *P. pervoluta*, but the adult form, which is all we have seen, is certainly quite distinct. *P. obesa* should be compared with the British *P. bilobata* Sowerby sp. (see fig. 3, p. 869) because it is, according to our opinion, the nearest known American representative of that much (mis-) quoted species. And still the American form is distinct if only for the reason that the apertural sinus is deeper in the *bilobata*.

Formation and locality.—Lower beds of the Trenton group, Burgin and Danville, Kentucky.
Collection.—E. O. Ulrich.

Genus TETRANOTA, n. gen.

Bucania (part.), HALL, 1847, Pal. New York, vol. i, p. 186.
Bellerophon (part.), WHITFIELD, 1874, Geol. Wis., vol. iv, p. 223.
Bucanella (part.), KOKEN, 1889, Neues Jahrbuch f. Mineralogie, etc., Beilageband vi, p. 389.

For generic characters see page 849.

Superficially examined the systematic position of this genus will probably appear to be between *Megalomphala* and *Euphemus*. The relation to the latter however is more apparent than real. Comparing the five species now referred to *Tetranota* we find that the umbilicus, though always present, is yet somewhat variable, being very large in *T. macra*, *T. sexcarinata* and *T. bidorsata*, moderate in *T. obsoleta*, and comparatively small in *T. wisconsinensis*. The vertical expansion of the aperture is extremely limited in all save the last mentioned, and in this the vertical diameter of the volutions also is greatest. The external sculpture, aside from the revolving ridges, consists chiefly of lines of growth. These are always regular and sharp, but vary in strength with the species.

While strong revolving lines like those of *Bucania* or of *Bucanopsis* do not occur, it is nevertheless a fact that in all cases of *Tetranota* preserving the external layer of the shell, or an impression of the same, we observed a row of minute prominences on each of the sublamelliform lines of growth. In a few instances we found further that these prominences were in reality the anterior terminations of very fine short striæ crossing from line to line. This style of sculpture, excepting that it is much finer, is essentially the same as that marking the *B. lindsleyi* section of *Bucania*. We attach great weight to this point and believe that it proves our association of the genus with the *Bucaniidæ* to be well founded.

The four revolving dorsal ridges, which we regard as the principal peculiarity of the genus, are always distinctly developed on the inner volutions. In *T. sexcar-*

inata they continue also over the outer volution quite to the margin of the aperture. In *T. bidorsata* and *T. wisconsinensis* the two central ones become more prominent toward the aperture, and on casts of the interior usually appear as a broad and more or less flat-topped single ridge. In the former the lateral ridges, though much less distinct, are still distinguishable in the outer half of the last whorl, but in the latter not a trace of them is to be seen on any part of the outer volution of casts of the interior, the only condition in which the species is known. The same is true of *T. obsoleta* with the addition that the double central ridge also is much less developed than in the other species.

The unusual width of the slit-band, which lies between the two central ridges and is more or less concave—never much so,—is another important characteristic, though not entirely confined to *Tetranota*.

Briefly the new genus differs from all the other genera of the suborder in the possession of four dorsal ridges. In most other respects we find that *Tetranota* agrees closely with *Bucania* and *Megalomphala.* Still there are some good additional differences. Thus, *Bucania* has a narrower slit-band and longer slit, besides stronger revolving surface sculpture, while *Megalomphala* agrees in all respects with *Bucania* excepting that it has no revolving lines. The Cambrian *Owenella*, though reminding one in a general way of *Tetranota*, is distinguished at once by the absence of a slit-band. It is scarcely necessary to extend our comparisons to such widely different types as *Bellerophon*, *Bucanopsis* and *Protowarthia.*

As to the shells of *Euphemus*, about which genus we have already (see page 856) expressed the opinion that it is an atavistic type of Carboniferous *Bellerophontidæ*, they have no umbilicus and their apertures are even less expanded. Further, they have an inner lip slightly thickened laterally and its central portion, which bears more or less numerous revolving folds, is spread as a thin sheet over the inner volutions and part of the outer. These folds may recall the ridges of *Tetranota*, but are in reality quite different, being a feature of the ventral side of the shell in the one case and of the dorsal side in the other.

Koken (*loc. cit.*) connects several Silurian and Devonian species of Europe with *T. bidorsata.* In this he has doubtless committed an error, while his proposal to use Meek's *Bucanella* for the group seems to us quite unwarranted. In the first place his *Bucanella esthona* and *B. subtriata* Krause sp. (we are not sufficiently acquainted with the others to include them in our opinion) are not congeneric with *T. bidorsata*, being without the characteristic dorsal ridges, while they have uninterrupted straight revolving lines which do not occur in a *Tetranota.* Where the *subtriata* belongs is most difficult to say just now,* but of the *esthona* we may say that it is kept out of

* We refer to this species again in our remarks on *Bucanopsis.*

Bucania by its wide slit-band and straight revolving lines, while the first character, together with its different (*Bucania*-like) aperture excludes it from *Bucanopsis.* Having to describe a similar species from Minnesota, we have concluded to establish a new genus, *Kokenia,* for their especial benefit.

The vertical range of three of the species of *Tetranota* is more extended than usual with *Bellerophontacea.* *T. obsoleta* occurs in the Vanuxemia bed of the Stones River group, in the Ctenodonta bed of the Black River group, and reappears; apparently very slightly modified, in the Utica group at Cincinnati; *T. bidorsata* occurs in the lowest division of the Stones River group of Tennessee, in the Black River group in Minnesota and Canada, and in the Trenton of Minnesota, Kentucky, Tennessee, New York and Canada; *T. sexcarinata* is found in the Vanuxemia bed in Minnesota, Wisconsin and Illinois, in the "Glade limestone" of Tennessee, and in the Fusispira bed of the Trenton in Minnesota. *T. wisconsinensis* is as yet known only from the Vanuxemia bed in Minnesota, Wisconsin and Illinois, while *T. macra* occurs in the same bed at Minneapolis.

TETRANOTA BIDORSATA *Hall.*

PLATE LXV, FIGS. 10–18.

Bucania bidorsata HALL, 1847, Pal. N. Y., vol. i, p. 186.

Shell usually about 12 mm. in hight, but the hight may exceed 20 mm., and occasionally reaches 25 mm.; volutions two and a half to three and a half, vertically compressed, sublunate in section, the width for the inner volutions or in young specimens a little greater than twice the hight; in old examples the increasing altitude of the centro-dorsal ridges causes the width just behind the aperture to be proportionally somewhat less; umbilicus large, deep, rather sharply defined, the width generally about half of the greatest diameter of the shell; the latter dimension is to the greatest width of the aperture about as three is to four. Aperture somewhat abruptly expanded laterally, the hight and width about as three is to seven; slightly indented by the preceding whorl; lips thin, the outer one with a moderately deep emargination, taking up between one-fourth and one-third of the anterior outline; depth of the same about one-fifth less than its width. Dorsum with four strong revolving ridges, the two central ones nearer each other than to the lateral ones, and higher, the altitude also increasing gradually to the aperture; between them lies the broad slit-band which is more distinctly concave on the shell than on internal casts, the double ridge in the latter, particularly near the aperture, often appearing as a broad and more or less flat-topped single ridge; on each side of the central ridges there is first a broad groove, then an obtusely angular ridge, and finally a narrower groove which slopes down to the angular or sharply rounded side of the volution. While the central pair of ridges increases in prominence, the lateral pair becomes more and more indistinct on the last volution, till at the apertural margin they are scarcely distinguishable,—at any rate this is true of casts. The transverse surface markings are prominent, regular, visible to the unassisted eye, about three in 1 mm.; the course of the striæ from the umbilicus is at first nearly straight across, and it is only in the centro-lateral grooves that they curve backward very strongly. When the characters of the external layer are preserved, these very fine short lines are to be seen crossing the transverse lines rectangularly.

Variety MINOR, *n. var.*

(Not figured.)

This subordinate name is proposed for a small variety of the species which we have found in the Black River shales of Minnesota. The largest specimen seen is less than 10 mm. in hight. All four of the dorsal ridges retain their prominence to the apertural margin, and in this respect the variety is like *T. sexcarinata.* The edge of the umbilicus, however, is not angular, but narrowly rounded, while the transverse striæ are much finer, eight or ten occurring in the space of 1 mm. On the best specimen each of the transverse lines carries a row of very minute prominences.

Although we have not seen the original types of this species, we are still reasonably confident that the specimens above described are of the form to which the name *bidorsata* should be restricted. That authors and collectors have included under this name more than one species is clear from published lists, they having no doubt viewed the dorsal ridges as a specific feature, while we regard them as of generic importance.

Formation and locality.—Stones River group (Central limestone), Murfreesboro, Tennessee; Black River group (Ctenodonta bed,—var. *minor*), Minneapolis, St. Paul, Cannon Falls, and near Fountain, Minnesota; Trenton group (Clitambonites and ?Fusispira beds), St. Paul, Cannon Falls, and near Fountain, Minnesota. In Canada Billings catalogues it as a Black River and Trenton fossil; in Kentucky and Tennessee it occurs in the same groups. Hall's original types are from the lower beds of the Trenton at Middleville and Watertown, New York. Testiferous examples are very rare in Minnesota, but casts are rather common in the Clitambonites bed at several points in Goodhue county.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, Nos. 7382, 7435, 7439, 7456, 7513, 7522.

TETRANOTA SEXCARINATA, *n. sp.*

PLATE LXV, FIGS. 3–9.

This species grew to a larger size than Hall's *T. bidorsata,* the average hight being from 25 mm. to 30 mm. The volutions also are somewhat wider, the hight and width being respectively as two is to five. The dorsal ridges differ in this that the centro-lateral pair continues in full strength almost or quite to the apertural margin. There is besides a lateral pair of ridges, not so strong as the others though still quite distinct, making in all six revolving ridges. This outermost pair may occasionally appear to be represented in *T. bidorsata*, though never so distinctly; yet when carefully compared it will be noticed that *T. sexcarinata* really has an extra pair, since the ones which in Hall's species form the extreme lateral boundaries of the volutions, and at the same time the edge of the umbilicus, are present also in *T. sexcarinata*. The umbilicus is of about the same size and character in the two species, but the mouth and surface markings are different. The sinus in the outer lip, namely, is deeper and much wider, the backward sweep of the lines of growth beginning already between the edge of the umbilicus and the outer ridge instead of at the centro-lateral ridge. Furthermore, the lines are much farther apart and coarser, the distance from line to line averaging about 1 mm. Finally, the lines of growth are, though more or less obscurely, reproduced on casts of the interior, while no trace of them is observable on casts of the other species.

With the differences mentioned there can be no reasonable doubt about the specific distinctness of *T. sexcarinata* and *T. bidorsata*; and the others are still farther removed. Good adult specimens cannot be confused, only the young being sufficiently alike to render separation difficult.

Formation and locality.—Stones River group (Vanuxemia bed), Minneapolis, St. Paul and Cannon Falls, Minnesota; Beloit and Janesville, Wisconsin; Dixon, Ill.: Lebanon and Lavergne, Tennessee. Trenton group (Fusispira bed), Fillmore county, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, Nos. 5064, 7530.

TETRANOTA MACRA, *n. sp.*

PLATE LXV, FIGS. 1 and 2.

This species reminds one in its markings of *T. sexcarinata*, but has only four dorsal ridges. The lines of growth also are stronger, showing distinctly on casts. The umbilicus is relatively larger than in any of the other species of the genus and the sides of the volutions more sharply angular. Corresponding differences occur in the form of the aperture.

Formation and locality.—Vanuxemia bed, Stones River group, Minneapolis, Minnesota.

Collection.—E. O. Ulrich.

TETRANOTA OBSOLETA, *n. sp.*

PLATE LXV, FIGS. 19–23.

This species differs from *T. bidorsata* in several obvious respects. Chief among these is the fact that the revolving ridges are much less developed, especially on the last volution, the centro-lateral pair being quite obsolete except on the inner volutions, while even the central pair does no more than to merely maintain the same strength relatively that it held in earlier stages. Interior casts of mature shells exhibit a broad, comparatively low and more or less distinctly grooved central ridge, beyond which the surface is first shallowly excavated and then gently convex to the lateral boundaries of the volutions, which again are not angular but narrowly rounded. The exterior of the shell looks the same, only the ridges bordering the slit-band appear thinner and sharper. Continuing our comparisons with *T. bidorsata* we find that the umbilicus is smaller and less abrupt, and the volutions more rounded on each side and therefore elongate-reniform in cross-section.

The form of the aperture and the surface markings seem to be very nearly the same in the two species. The latter were easily abraded, and on only a single specimen,—it is from the Utica group at Cincinnati and doubtfully referred to the species,—have we been able to make them out at all. In this specimen they are imperfectly preserved near the aperture. Here they appear to be somewhat finer than in *T. bidorsata* and each seems to have borne a row of minute prominences.

It is scarcely likely that any one will ever find it difficult to separate *T. obsoleta* from *T. sexcarinata*, the apertural sinus being deeper and the revolving ridges even more prominent and constant in that species than in *T. bidorsata*.

The largest specimens of *T. obsoleta* occur in the Vanuxemia bed of the Stones River group at Minneapolis. One of these has a hight of nearly 30 mm. The others range from this size down to about 15 mm. The average hight of the specimens from the Black River and Trenton groups is less, being only about 15 mm., while in the largest it did not exceed 20 mm. In the Utica group however the average was increased again to almost 20 mm.

Formation and locality.—Stones River group (Vanuxemia bed), Minneapolis and St. Paul, Minnesota; Janesville, Wisconsin. Black River group, Mercer county, Kentucky; (in Ctenodonta bed) Chatfield and six miles south of Cannon Falls, Minnesota. Trenton group (Fusispira bed), Goodhue couty, Minnesota. Utica group at Cincinnati, Ohio, and localities in the vicinity of that city.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, Nos. 510, 5109, 7294, 7465.

TETRANOTA WISCONSINENSIS *Whitfield.*

PLATE LXV, FIGS. 26–29.

Bellerophon wisconsinensis WHITFIELD, 1878, Ann. Rept. Geol. Surv. Wis., p. 76; also 1882, Geol. Surv. Wis., vol. iv, p. 223, pl. VI, figs. 15, 16.

Greatest hight of shell varying in the material before us from 8 mm. to 37 mm.; closely coiled for the genus, subglobular in form when young, but becoming strongly bilobed, with the last volution less inrolled and the lips greatly expanded laterally and somewhat also above (yet not materially thickened) in the adult form; in the latter the outer lip is deeply notched in the middle, the notch spreading anteriorly more slowly than usual, the lobes on each side rounded-triangular in outline. Dorsal periphery of casts with a broad, revolving band, the top of which may be slightly convex, flat or concave, the whole increasing in elevation with age; on each side of the central band the inner volutions (as seen in fractured specimens) have first a concave space and then a ridge, but these pertain chiefly to the exterior side of the shell, being only in rare cases, and always with difficulty, distinguishable on casts; inner volutions elongate-reniform in section, outer volution more triangular; umbilicus comparatively small, the width only about one-fifth of the greatest diameter of the shell. Surface markings not fully determined, apparently as in *T. obsoleta* and *T. bidorsata.*

The essential generic characters (i. e., the revolving ridges) were overlooked by Prof. Whitfield. Still he noticed the resemblance to the adult form of *T. bidorsata*, which species he regarded as a *Bucania*, while his *wisconsinensis* he held to be "a true *Bellerophon*, as is readily seen by the closed or nearly closed umbilicus." But differences in the size of the umbilicus, when other characters agree, are now considered as of small importance. In this case certainly it is not of material consequence. Besides, the umbilicus is not by any means closed, there having been no axial thickening which might have filled the not very small cavity seen in casts.

Young specimens showing the inner volutions of *T. wisconsinensis* closely resemble those of *T. obsoleta*, the only difference observable in casts being that the umbilicus is slightly smaller and the volutions more ventricose in the present form. Adult specimens of the two species cannot be confounded, the last volution being higher, with flattened slopes, and less inrolled in *T. wisconsinensis*, the whole producing a very differently shaped aperture. *T. bidorsata* and *T. sexcarinata* have more compressed whorls, much larger umbilicus, and a wider as well as otherwise differently shaped mouth, while for both the lateral ridges are conspicuous features of casts, which is not at all the case in *T. wisconsinensis.*

Formation and locality.—Stones River group, Beloit and Janesville, Wisconsin; Minneapolis and St. Paul, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; University of Wisconsin; E. O. Ulrich.

Museum Register, Nos. 665, 5108, 7297, 7316, 7284.

Genus KOKENIA, n. gen.

Bucanella, KOKEN, 1889, N. Jahrbuch f. Mineralogie, etc., Beilageband vi, p. 389. (Not Meek.)

For generic diagnosis see page 848. For remarks see the following specific description and under *Tetranota* and *Bucanopsis*.

KOKENIA COSTALIS, *n. sp.*

PLATE LXIV, FIGS. 46–49.

Shell small, about 10 mm. in hight; volutions enlarging (apparently) gradually to the aperture, depressed, somewhat reniform in section, the hight and width respectively as four is to six and a half; slit-band wide, flat, sharply defined, somewhat elevated; on each side the surface descends first into a broad concavity, beyond which the slope continues, now with increasing convexity, to the sharply rounded or subangular edge of the umbilicus; the latter is deep, and about one-third as wide as the greatest diameter of the shell. Surface with seven straight revolving lines on each side between the edge of the umbilicus and the slit-band; the first on each side of the latter weaker than the others. The slit-band show faint evidence of having borne four or five very fine longitudinal lines. Transverse lines very fine, about eight in 1 mm., running, with little curvature, obliquely backward from the sides of the volutions to the slit-band, joining the same at an angle of something like 45 degrees.

We have seen but a single imperfect specimen of this species, and were it not that it belongs to a very interesting and easily recognized type, we would scarcely be justified in describing it. We regard it as closely related to Koken's species *esthona*, which he, as we have already stated (pp. 849, 876), erroneously places with Hall's *Bucania bidorsata*, in the genus *Bucanella*, Meek. Since Koken's species is not a *Bucanella* and the *bidorsata* is the type of our *Tetranota*, the question arises, can the *esthona* also be included in that genus? We will admit at once that they are related forms, yet we think the answer must be in the negative, and for two reasons: first, the aperture is much less expanded laterally in the species *esthona* and *costalis* than it should be in *Tetranota;* second, the revolving surface lines continue to the aperture and are too numerous to be considered as equivalent to the four constant dorsal ridges of *T. bidorsata*. As there is no other genus in which the two species might be placed, we propose a new one with the name *Kokenia*.

Specifically, *K. costalis* differs from *K. esthona* in the lesser prominence of the slit-band. A careless or inexperienced observer might confuse it with the associated *Tetranota bidorsata*, yet any one accustomed to the work of discriminating between fossils can scarcely fail in separating them at once.

Formation and locality.– Clitambonites bed of the Trenton group, near Cannon Falls, Minnesota.
Collection.—E. O. Ulrich.

Genus BUCANIA, Hall.

Bucania (part.), HALL, 1847, Pal. New York, vol. i, p. 32. WAAGEN, 1880, Pal. Indica, ser. 13, pt. 2, pp. 130–150. KOKEN, 1889, N. Jahrbuch f. Mineralogie, etc., Beilageband vi, p. 379.

For generic characters see page 850.

As originally defined by Hall, this genus was to include bellerophontid shells having a large umbilicus. For many years the genus was regarded as of very doubtful value, paleontologists having learned that the relative size of the umbilicus was not of itself sufficient ground for a separate genus. The fact that the original types of *Bucania* had revolving lines was not considered of consequence by Hall in 1847, nor by any other paleontologist who had occasion to refer to the bellerophontids previous to 1880. In this year an important work on these symmetrically involute shells was published by Waagen (*op. cit.*). This author proposed to apply the name *Bucania* to all bellerophontids possessing revolving striæ, and he redefined the genus in accordance with his view.

While it is not to be denied that Waagen's proposal was a decided improvement upon previous attempts, it is still evident that his arrangement is artificial. His definition is too broad since it includes a variety of types that, while agreeing with the originals of *Bucania* in having spiral lines, are nevertheless widely removed from them genetically and readily distinguished by other characters. Lines of one kind or another, having a spiral direction, occur not only in species of the type of *Bucania sulcatina*, but in *Salpingostoma* and *Tremanotus* and in the new genera *Cyrtolitina*, *Conradella* and *Tetranota*. Then they occur in the very best development in a large group of species, ranging in time from the Trenton group to the close of the Paleozoic age, which we have decided to separate as a new genus under the name of *Bucanopsis*.

The trouble with *Bucania* has been that its real peculiarities have never been appreciated. Hall, as stated, regarded the large open umbilicus as distinctive for the genus. His description says also that the mouth is abruptly expanded, but in this doubtless he was influenced by his *B. expansa*, which now is not a *Bucania* but a *Salpingostoma*. The name of the genus was most probably inspired by the same species, and if it had been customary at that time to designate the type of a genus his choice would, we believe, have fallen upon the *expansa*,—and it would have made a good type of a good genus. But, since Roemer has described a genus that will include the *expansa*, and both Waagen and Koken take *B. sulcatina*, the first species following Hall's description of the genus, as the type,—a course that is fully justified,—it would not be good policy, and only add to confusion where there is too much already, if we were to revert to what evidently was Hall's original intention. Nor can we blame either Roemer or Waagen for overlooking or ignoring his intention, since in the absence of a more complete knowledge of *B. expansa* than was furnished by Hall, they would not have been justified in departing from the rule which, when the type is not designated, gives that rank to the first species following the generic description.

As we are all agreed to adopt *B. sulcatina* as the type and to restrict the genus to species having essentially the same characters as that species, the first thing to do is to determine exactly which are the essential peculiarities and which are not. This may not have been possible for either Waagen or Koken, and we are probably the first having sufficient material, both in the way of species and individuals, to do it in an approximately satisfactory manner.

The amended description of *Bucania* given on page 850 rests on no less than twenty Lower Silurian species. These show that the umbilicus is nearly always large, certainly never small. The outer lip has a broad V-shaped sinus and a central slit, the slit-band is narrow and slightly elevated, flat, or channel-like. The surface markings run in two directions, transversely and spirally, and both sets cross the volutions obliquely from the umbilicus to the slit-band, the degree of obliquity of the spiral lines depending upon the rate of increase in size of the volutions, being greatest in those in which the expansion is the most rapid. The transverse (growth) lines are oblique because they curve in directions parallel with the margin of the aperture. But the feature of the surface sculpture that deserves the most attention, and this applies to the *Bucaniidæ* as a whole, is that the intersections of the two sets of lines are nearly always rectangular.

According to the remaining characters, the species fall into two groups, the first or typical section, containing the type of the genus and seven other species, being characterized by a thin shell, very broad umbilicus, slowly and gradually enlarging depressed volutions, relatively wide yet not expanded aperture, thin lips, and long slit. In the second or *B. lindsleyi* section the shell is thicker, the umbilicus smaller, the volutions enlarge more rapidly and are higher, the inner lip is thicker and slightly reflected on each side, and the slit shorter. These differences will be better understood after a comparison of figures 1-12 with the remaining figures on plate LXVI.

Concerning the slit, perhaps not one specimen in a thousand of the *B. sulcatina* section preserves it entirely. As a rule the delicate apertural portion of the shell is broken away quite to the posterior end of the slit. In the other section a complete aperture is a much more frequent occurrence, both because the slit is shorter and the shell stronger.

It will be noticed that the characters brought out in the foregoing paragraphs are different from those pertaining to much the greater part of the genus as defined by Waagen and Koken. They derived their ideas of the genus chiefly from Upper Silurian, Devonian and Carboniferous spirally ribbed species, which with few exceptions (none of them true *Bucania*) will fall into the genus that we propose to call *Bucanopsis*. It is to be noted; however, that Koken with his usual acumen draws attention (*op. cit.*, p. 380) to differences in the aperture and surface sculpture between the "*Sulcatina*-typus" and the Devonian and Carboniferous species. Unfortunately he did not, or for want of material could not, carry his comparisons to their logical conclusion.

According to our opinion *Bucania*, as here restricted, is (1) strictly a Silurian genus and possibly not even represented in the Upper Silurian, (2) it is the stock from which *Salpingostoma*, and later *Tremanotus*, was derived, and (3) it is not genetically related to *Bucanopsis*. In support of the first statement we have the fact that while the twenty known Lower Silurian species fit closely together, not one of the succeeding forms could be included without materially altering the generic diagnosis. The truth of the second statement is but too apparent to those who are obliged to discriminate between imperfect specimens of associated species of *Salpingostoma* and *Bucania*. Casts of the former from which the abruptly expanded aperture has been broken away, and on which the dorsal fissure is not clearly represented, are most difficult, if indeed it is at all possible, to separate from casts of *Bucania*. The important agreement, however, lies in the surface sculpture which in all essential respects is the same in the two genera. But it is scarcely necessary to discuss the relation of *Bucania* to *Salpingostoma* here since we shall do so quite fully some pages hence in our remarks on that genus. The third statement refers to *Bucanopsis*. This genus was evolved, we think, not from *Bucania* but from *Bellerophon*. No better description of the genus could be given than that which says that it includes species agreeing in all respects with *Bellerophon* excepting that they have revolving striæ which, with the transverse lines, produce a cancellated sculpture. Without the revolving lines *Bucanopsis* would be nothing more or less than *Bellerophon*. Not so, however, with *Bucania*, since that genus would still be distinguishable. Again the spiral lines are not the same in *Bucania* and *Bucanopsis*, being straight in the latter and not oblique nor wrinkled nor ever interrupted as in the former.

Among the species of the *B. lindsleyi* section it is common to find that the obliquely revolving lines are sharply interrupted by the regular development of lamellæ whose wavy anterior edges are decidedly elevated and parallel with the margin of the aperture, of which indeed they represent previous stages. The effect is considerably as in the otherwise widely different genera *Conradella* and *Cyrtolitina*. The surface sculpture of *Tetranota* also, though of a finer pattern, is essentially of the same type.

Of the species originally referred to *Bucania* by Hall,* *B. sulcatina* and *B. intexta* are typical of the genus; *B. punctifrons* Emmons sp., though provisionally retained in the genus, is a peculiar form having a reticulated surface sculpture very much like that of *Cyrtolites ornatus*; *B. rotundata*, if correctly described, belongs to *Megalomphala; B. bidorsata* is the type of our new genus *Tetranota*; and *B. expansa* belongs to *Salpingostoma*.

Bucania halli, *n. sp.*

PLATE LXVI, FIGS. 4–8.

Shell 20 to 30 mm. in hight, consisting of about three and a half depressed volutions; volutions increasing in size gradually to the aperture, gently convex on the back, subangular at the sides, slightly concave in the middle third of the ventral part, acutely subelliptical in section, and about twice as wide as high; umbilicus large, deep, well defined, with flattened slopes, and equalling nearly two-thirds of the greatest diameter of the shell. Aperture transverse, the hight usually not exceeding half of the width, acutely subelliptical, angular and narrow at the lateral extremities, and slightly indented below by the preceding volution; outer lip very broadly sinuate, medium slit not fully seen, probably a half volution in length. Surface with subequal revolving wrinkled ribs, averaging about seven in 5 mm.; the total number increasing with age by bifurcation and interpolation; in the umbilicus, especially behind the anterior half of the last volution, the ribs are decidedly oblique, but on the back of the volutions they are nearly longitudinal; at intervals of 2 or 3 mm. they are interrupted by more or less distinct transverse lamellæ, running obliquely backward from the edge of the umbilicus to the slit-band which they join at an angle of about 65°. Slit-band narrow, in some specimens appearing as slightly elevated; in others the center is excavated. Casts of the interior are quite smooth. A small specimen is 20 mm. in hight; the aperture is 15.5 mm. wide and 7.5 mm. high; the greatest width of the inner volution (at edge of inner lip) 5.5 mm. The surface markings are not perfectly retained by any of our specimens.

* Pal. New York, vol. i, 1847.

One seems to show obscure traces of very fine spiral lines between the stronger ones, and it is possible that such lines will be found on the perfect shell.

B. halli is closely related to *B. sulcatina*, but that species has wider volutions, and, although they do not enlarge any more rapidly, the proportional width of the aperture is greater, being quite equal to the hight of the shell, which is not the case in the present species. The whole form of that shell is also more globose. *B. intexta* is a smaller and narrower shell, and has more closely arranged revolving ribs and less depressed volutions.

We have four fragmentary casts of the interior, collected in the Fusispira bed of Goodhue and Fillmore counties, that may belong to this species.

Formation and locality.—Stones River group, Cannon Falls, Minnesota (six specimens); Black River group, Mercer county, Kentucky (eight specimens).

Collections.—E. O. Ulrich; W. H. Scofield.

BUCANIA MINNESOTENSIS, *n. sp.*

PLATE LXVI, FIGS. 9 and 10.

This is associated with and probably closely related to *B. halli*. Still there should be no difficulty in distinguishing the two forms since this grows to much greater size and yet has the same number of volutions. The last whorl especially enlarges rapidly, though relatively more in hight than in width. The sutures are deeper and the slope of the umbilicus, taken as a whole, is not so flat. Still the flatness of the slope increases with growth until on the last third of the outer whorl it has become decidedly concave; causing the sutural portion to appear swollen. The surface markings seem to be about the same in the two species.

Formation and locality.—Vanuxemia bed of the Stones River group, Goodhue county, Minnesota.

Collection.—E. O. Ulrich.

BUCANIA EMMONSI, *n. sp.*

PLATE LXVI. FIGS. 1–3.

This species differs from *B. halli*, which it resembles closely, in being smaller and in having on the whole narrower yet more speading volutions. The volutions are more rounded in the umbilicus, causing the suture line to be deeper. The latter is peculiar in being deepened at regular intervals by the development of short, wave-like dents in the ventral side of the volutions. Similar dents are to be seen also on the sides of the volution in the Fountain specimens, but they cannot be seen on the even better preserved Tennessee shell. These sutural indentations distinguish the species not only from *B. halli* but from the even nearer *B. intexta* and all the other species now known of the genus. In a specimen 18 mm. high, the width of the last volution increases from 5 mm. to about 17.5 mm. The hight of the aperture is about 10 mm.

Formation and locality.—"Central limestone" of the Stones River group, near Murfreesboro, Tennessee. Vanuxemia bed, Cannon Falls, Minnesota. Black River group (?Ctenodonta bed), near Fountain, Minnesota.

Collection.—E. O. Ulrich.

BUCANIA ELLIPTICA, *n. sp.*

PLATE LXVI. FIGS. 11 and 12.

Of this species we have only three casts of the interior, and all are more or less incomplete. The best is figured on plate LXVI. In this, as in the others, the apertural portion is broken away quite to the posterior end of the slit. In the figured example the last volution appears as though it had been free and possibly expanded at the aperture, in which case we would have to call it a *Salpingostoma.* But the slight expansion shown by the specimen is most probably the result of crushing. The volutions, as far a sobserved, are elliptical in cross section and enlarge slowly, the last in width from 6 mm. to 14 mm. On the whole the cast of the interior resembles *B. halli* U. & S., *B. emmonsi* U. & S., and *B. intexta* Hall, the last in particular, but a distinct species is indicated by the rounded instead of angular sides of the whorls. Detailed comparisons with the species named will bring out several other differences.

In the Kentucky specimens the volutions are less convex in the back than the Minnesota type of the species, and it is possible that more perfect material will prove them to belong to a distinct species.

Formation and locality.—Lower part of Fusispira bed, Trenton group, three miles south of Cannon Falls, Minnesota; base of Trenton or top of Black River group, Mercer county, Kentucky.

Collection.—E. O. Ulrich.

BUCANIA SUBLATA, *n. sp.*

PLATE LXVI, FIGS. 16–19.

This is a small subglobose shell, with wide volutions, broadly rounded on the back, flatly sloping in the umbilicus; and sharply angular on the sides. The umbilicus is sharply defined and deep, but comparatively small, its greatest diameter equalling only about half of the hight of the shell. The volutions increase gradually in size to the aperture, are acutely subelliptical in section, about twice as wide as high, and two and a half or three in number; the width of the aperture equals the hight of the shell. The surface markings are preserved on only a very small part of the shell. As near as can be determined they appear to have been about as in *B. halli.* The slit-band lies between two thin elevated lines and is a trifle wider, and the slit shorter, than usual. Hight of shell 12 mm.; width of aperture 12 mm.; hight of same about 6 mm.; width of umbilicus 6.5 mm.; width of inner end of last volution about 4.7 mm.

The form is more globose and the umbilicus relatively smaller than in any of the preceding species of the genus. In both of these aspects it reminds one strongly of *B. sulcatina*, of which it is probably a dwarfed descendant.

Formation and locality.—The types are from the upper part of the Trenton group, near Burgin, Ky. A cast of the interior, agreeing in every respect with the type, was found in the Ctenodonta bed of the Black River group, near Fountain, Minnesota; another (fig. 19) is from the Stones River group, at Minneapolis. A very small specimen, presumably of the same species, occurred in the Fusispira bed at Wykoff.

Collection.—E. O. Ulrich.

BUCANIA LINDSLEYI *Safford.*

PLATE LXVI, FIGS. 24 and 25.

Bellerophon lindsleyi SAFFORD, 1869, Geol. of Tenn., pl. G, figs. 3*a*, *b*, *d* and *e*. (3*c* doubtful.) Not described.

Shell 30 mm. to 40 mm. in hight, the width of the aperture slightly less than the greatest hight of shell; volutions about three, embracing less than a fourth of the next within, rounded on the back, somewhat semi-circular in cross-section, narrowly rounded beneath the middle line of the sides; umbilicus moderately steep, of large size considering the rapid expansion of the volutions, its greatest width equalling about one-third of the hight of the shell; aperture somewhat expanded in the lower part, semi-elliptical in outline, the lateral angles narrowly rounded and scarcely reflected, the center of the lower outline very slightly indented by the preceding whorl; lower lip entire, thickened inwardly; upper or outer lip thin, the margin sweeping backward to form a broad shallow sinus, the center continuing backward as a narrow slit, the latter having a length of at least 10 mm. in a specimen 38 mm. in hight. Surface coarsely lamellose, the lamellæ, which indicate the margin of the aperture at previous stages, occurring at intervals on the back of the last volution varying from less than 2 mm. to 4 mm. or more, the average being about 3 mm. Usually the lamellæ are crossed approximately at right angles by more or less unequal and irregular ribs, seven to ten in the space of 5 mm., and these again by fine lines of growth. Often the ribs are irregularly broken up and sometimes they combine to form an obscure network reminding one of the surface sculpture of *B. punctifrons* Emmons. (See pl. LXVII, fig. 44). Slit-band distinct, slightly concave, margined on each side by a sharply elevated, thin line; lunulæ somewhat unequal but always clearly defined, rather crowded.

This fine shell is readily distinguished from all of the preceding species of the genus by the rapid expansion of its whorls.

Formation and locality.—Trenton group (Middle Nashville), DeKalb county, Tennessee. A small imperfect specimen, possibly of this or the next species, occurred in the Clitambonites bed near Cannon Falls, Minnesota.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

BUCANIA RUGATINA, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 13–15.

Resembles *B. lindsleyi* closely, but is smaller, the hight of what appears to be a full-grown individual being a trifle less than 20 mm. Of other differences we may mention that the whorls are more tightly enrolled, causing the umbilicus to be appreciably smaller, the transverse markings are relatively stronger, more equidistant, closer, averaging 1 mm. apart and appear more like waves or wrinkles than overlapping plates. A slight groove on each side of the slit-band occurs on the specimen illustrated. The other specimens are not in condition to permit us to decide whether these grooves are characteristic of the species or not. At any rate nothing of the kind has been observed on good specimens of *B. lindsleyi.*

Formation and locality.—Upper part of Trenton group, near Burgin, Kentucky,

Collection.—E. O. Ulrich.

BUCANIA NASHVILLENSIS, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 36–40.

This species is based on six specimens received from Prof. J. M. Safford and supposed by him to belong to his species *lindsleyi.* A careful comparison with the original type of that species, good figures of which are given on plate LXVI, proves that they represent a closely related yet distinct species. In the first place the volutions expand more rapidly, two and a half turns making as large a shell as three whorls in the *lindsleyi.* Next the umbilicus is smaller and more abrupt, the sides of the volutions being more sharply rounded. Again the dorsum is more prominent along the central line, causing a more or less decided flattening of the dorso-lateral slopes. The slit-band also, instead of being sunken, is slightly raised. Finally, as regards the surface markings, the transverse lines are much less regular, and crowded rather than distant, while as a rule they would scarcely be described as lamellose. They are also much less distinct except near the aperture of large specimens where they are strengthened and emphasized, as usual with old shells, by irregular wrinkles. The oblique revolving lines also are little more than half as strong, while in the umbilical cavities, where these lines are usually very conspicuous in Safford's species, they are scarcely distinguishable. After adding to these differences that the shell of *B. nashvillensis* is thicker, we believe we have given ample reasons for the creation of a new species.

Formation and locality.—Trenton group, De Kalb county, and Nashville, Tennessee.
Collections.—Prof. J. M. Safford; E. O. Ulrich.

BUCANIA FRANKFORTENSIS, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 30–33.

This species is related to both *B. lindsleyi* and *B. nashvillensis*, but is distinguished from both by its subtriangular aperture, thicker inner lip and coarser surface sculpture. The volutions are also narrower and the hight of the shell, as compared to the width, relatively greater. While it is scarcely possible that any one will confound it with the first named, such an occurence is not improbable with the second, since in both the dorsum is obtusely angular. Still, where good ventral views can be compared (see plate LXVI, figs. 32 and 37), showing their different mouths and the more rapid lateral expansion of the outer volution of *B. nashvillensis*, a glance should suffice to separate them.

Formation and locality.—Near top of Trenton group, Frankfort, Kentucky.
Collection.—E. O. Ulrich.

BUCANIA SUBANGULATA, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 20–23.

In this well marked species the dorsum is obtusely angular, the slope of the surface from the slit-band to the edge of the umbilicus somewhat flattened, and the sides sharply rounded or subangular, these features imparting a widely triangular, perhaps it would be better to say rhomboidal, section to the volutions, which of itself is sufficient to distinguish the species from the associated *B. rugatina.* Continuing our comparisons with that species, we find that the surface markings, though similar in pattern and strength, are not so regular, and the umbilicus is a little larger and better defined, while the slit-band forms the flat summit of a low keel instead of a smooth groove. Both *B. frankfortensis* and *B. nashvillensis* are probably closely related, though readily distinguished by their greater size, relatively smaller umbilicus, and more rapidly enlarging volutions. At maturity, however, the ventro-lateral angles are more abruptly expanded in *B. subangulata,* giving the aperture a more broadly triangular form than is the case in either of the larger species. It is to be borne in mind, further, that these large shells require no more turns to attain their full growth than do specimens of the present species less than half their size.

In the largest of eight specimens the hight is about 23 mm., the width of the aperture about 25 mm., the hight of same (in a side view) 17 mm. In a small specimen the same measurements resulted respectively in 9 mm., 9 mm., and 5 mm., showing that the aperture is relatively larger in adult examples. The small specimen, which is one of several, was at first believed to be distinct, but a careful comparison of the whole series resulted in the conviction that the small examples were merely immature.

Formation and locality.—Upper part of Trenton group, Mercer and Boyle counties, Kentucky.
Collection.—E. O. Ulrich.

BUCANIA MICRONEMA, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 26–29.

Of this form we have but a single example. Although closely resembling *B. sublata*, *B. lindsleyi* and *B. rugatina*, in one or another feature, we are fully persuaded of its specific distinctness. The specimen, which has the appearance of being mature, is so much smaller than the second of the species mentioned that further comparisons with it are probably unnecessary. As to *B. sublata*, the present shell has it volutions narrowly rounded on the sides instead of sharply angular, its aperture is relatively larger, and its surface markings, which are not visible to the unassisted eye, are much finer. Compared with *B. rugatina*, with which it was found, its volutions expand more rapidly, giving a wider aperture, and its surface markings are much finer. Besides the transverse lines are much less distinct and not wave-like, while the lines running in the opposite direction, of which there are about five instead of two in 1 mm., are not only finer but more continuous, appearing like irregular wavy, knotted lines, running obliquely forward from the umbilicus to the slit-band.

Formation and locality.—Near top of Trenton group, Danville, Kentucky.
Collection.—E. O. Ulrich.

BUCANIA SIMULATRIX, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 48 and 49; PLATE LXVII, FIG. 45.

Shell large, known from casts of the interior only. These consist of three or four comparatively slender and loosely coiled volutions, leaving a large umbilicus in which all the inner whorls are clearly exposed. Volutions somewhat reniform in section, narrowly rounded in the ventral third of the sides, the ventral surface gently concave, the dorsal part of the section nearly semi-circular. Last volution obtusely carinated, with the dorso-ventral diameter increasing toward the aperture more rapidly than is the case with the inner volutions, the hight and width of the whorl just behind the aperture being about equal, while at the smaller end the two dimensions are respectively about as three is to five. Aperture somewhat triangular-ovate, wide below, the expansion taking place chiefly at the lower part of the sides. In the cast the expansion appears very abrupt, but doubtless it is much less so in the shell itself. Inner lip slightly reflexed at the sides, thick centrally; outer lip broadly and deeply sinuate. Surface markings unknown; slit long. The best specimen seen has the following dimensions: entire hight 46 mm.; hight of aperture 29 mm.; greatest width of same 33 mm.; width and hight of last volution just behind the aperture about 23 mm.; hight and width of inner end of same 5 and 8.5 mm. respectively; greatest diameter of umbilicus about 23 mm.; length of slit about 31 mm.

The hight in this species is relatively greater than in *B. frankfortensis*, which we consider as more closely related than any of the other species. The aperture also is less nearly triangular, the apertural margin, as seen in a side view, less uniformly curved, the umbilicus larger, and the volutions more evenly rounded on the back. The next species, *B. crassa*, is a more closely coiled and heavier shell, having, therefore, also a smaller umbilicus. The form of the mouth and sinus is also different. Casts of *B. simulatrix* resemble those of the associated *Salpingostoma richmondensis* in a remarkable degree. For comparisons see description of that species.

Formation and locality.—Richmond group of the Cincinnati period, Richmond, Indiana.

Collection.—E. O. Ulrich.

Bucania crassa, *n. sp.* (*Ulrich.*)

PLATE LXVII, FIGS. 46–48.

This species, though closely resembling *B. frankfortensis* and *B. nashvillensis* in many respects, will be distinguished almost at a glance by its uniformly convex instead of subangular dorsum. This difference, in conjunction with a greater relative width of the whorls, causes the aperture to be proportionally wider. The lower lip also, though strong, has a longer slope and its surface is less convex. The umbilicus is somewhat smaller and more abrupt than in *B. frankfortensis*, and the shell more globose.

The specimen figured has suffered considerably from maceration, the slit-band and all, excepting the strongest of the surface markings, being quite obliterated. On two other specimens, neither as complete as the one illustrated, there is a low, yet well defined, rounded dorsal ridge, and in one this is accompanied on each side by a faint furrow, while anteriorly it terminates in an open slit about 17 mm. long. Whether this dorsal ridge was originally flat or concave on the summit, and bore lunulæ, we are unable to say. Still, it is to be expected that such a condition obtained on the perfect shell. As to the surface markings, what remains of them indicates a sculpture similar to that shown in our figures of *B. lindsleyi* and *B. nashvillensis*. (See plate LXVI.)

The shell in this and the species with which we have compared it is unusually thick for the genus, especially on the ventral side of the volutions, and casts of the interior must look very different from the shells themselves. We have not, however, seen any casts which seemed at all likely to belong to either.

Formation and locality.—From the uppermost beds of the Richmond group, near Richmond, Indiana.

Collection.—E. O. Ulrich.

BUCANIA SINGULARIS, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIG. 47.

This species is remarkable for the prominence of the transverse lamellæ and for the unusual length of the intervals between them. They appear to be especially thick and prominent on the lateral portions of the back. The slit-band is elevated and, like the lamellæ, shows rather distinctly on the cast of the interior. Aside from the lamellæ the whorls are rather broadly rounded on the back, and narrowly rounded on the sides, leaving an umbilicus, the greatest width of which equals about one-third of the entire hight of the shell. The mouth is transverse and somewhat elliptical in outline, the inner lip thick, cut out in the middle and with a comparatively narrow prominence immediately above the excision, the outer lip with a very wide angular sinus and a narrow open slit at least 15 mm. long in a specimen 30 mm. in hight. The surface markings are obscured by a delicate bryozoan which we failed to remove satisfactorily. As near as we can make them out they appear to consist of (1) lines of growth, and (2) of elevated points arranged in decussating series or of lines running rectangularly across the spaces between the elevated edges of the lamellæ. Similar variations of sculpture have been observed in *B. lindsleyi.*

Though clearly a *Bucania*, we are in doubt about the specific alliances of this shell. Selecting from the species described in this work, *B. crassa* and *B. lindsleyi* (Safford) appear to be the nearest. Still, the differences are so manifest that comparisons are deemed quite unnecessary.

Formation and locality.—Upper beds of Trenton group, Nashville, Tenn.

Collection.—E. O. Ulrich.

BUCANIA PUNCTIFRONS *Emmons.*

PLATE LXVII, FIGS. 41–44.

Bellerophon punctifrons EMMONS, 1842, Geol. Rept. 2nd Dist. New York, p. 392.
Bucania punctifrons HALL, 1847, Pal. New York, vol. i, p. 187.

Shell rather small, probably not exceeding 20 mm. in hight. Volutions three or three and a half, rounded on the back, subangular on the sides; umbilicus large, its width somewhat greater than half the hight of shell; aperture slightly wider than high, subpentagonal. In a transverse section the volutions are semicircular in the dorsal half, with the umbilical slopes almost straight and the ventral side broadly indented by the preceding whorl. The width of the last volution expands from 6 mm. to 12 mm. in a specimen 18 mm. high. In the same specimen the slit has a length of 16.5 mm., and a width of about 0.7 mm. The slit-band is concave, bordered on each side by a delicate line, and crossed by numerous fine lunulæ. On each side of the slit and band the whole exposed surface is covered by a strong and very sharply defined network, the deep meshes of which are so arranged that they form rows running in two directions, one almost directly across the volutions, the other obliquely forward and outward from the band. Finally, in certain lights, a third arrangement of the meshes will be observed, namely, in series passing obliquely forward from the sides to the slit-band. The last direction is approximately at right angles to certain more or less distinct lines or varices of growth which interrupt the regularity of the network on old examples. (See figs. 43 and 44).

Excepting the surface markings, *B. punctifrons* agrees very well with the typical section of the genus. Even the retiform character of the sculpture is not entirely foreign to *Bucania*, since a kind of reticulation is frequently observed in the *B. lindsleyi* section that would not require a very great modification to produce the ornamental sculpture of the species under consideration. Still, we have no suspicion that *B. punctifrons* is closely related to any of the *B. lindsleyi* section. For the present we consider it as a species standing entirely alone.

Formation and locality.—Trenton group, at several localities in New York and Canada. The specimens upon which the above description is based were found in the lower part of the group ("Orthis bed") near Nashville, Tennessee, by Prof. Jas. M. Safford.

Bucania nana, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 41—44.

Shell small, 10 mm. or less in hight, volutions two and a half or three, each embracing more than half of the preceding turn, expanding gradually and with moderate rapidity quite to the aperture, reniform in cross-section, broadly rounded on the dorsum and rather narrowly where the surface descends into the umbilicus; the latter is small, equalling only about one-fourth of the greatest diameter of the shell; aperture rounded when perfect, usually appearing more or less reniform, scarcely expanded, its width equalling about four-fifths of the hight of the shell; lips thin, the outer one with a central slit probably less than 2 mm. in length, the sinus also being unusually shallow, the inner lip prolonged slightly on each side and forming a very thin callosity over the back of the preceding whorl. Surface sculpture consisting of sharp, regular, rather closely arranged and but very little curved striæ of growth, and exceedingly fine, obliquely revolving lines, the latter obscure on even the best specimens. Slit-band raised, distinct, narrow, concave, bordered on each side by a sharply elevated thin line; lunulæ not very distinct. Out of eleven specimens the largest is about 10 mm. high, the smallest about 5 mm. In an average shell the hight is 7.0 mm.; the diameter at right angles to the hight 5.2 mm.; the width of the aperture 5.5 mm.; its hight about 5.0 mm.; greatest width of umbilicus about 2.0 mm.

Variety SUBPATULA, *n. var.* (*Ulrich.*)

PLATE LXVI. FIGS. 45 and 46.

Under this subordinate name we propose to classify provisionally three specimens found in association with *B. nana,* but differing in several respects from the typical form of the species. Thus, the aperture is wider, its width fully equalling the greatest diameter of the shell. Then the umbilicus is narrower, being almost closed. On one of the specimens the surface is in good condition, but we failed to notice any evidence of the delicate revolving lines occurring on no better preserved examples of *B. nana.* If it could be shown that these lines are always absent, then we would favor a removal of the supposed variety to the genus *Bellerophon,* in which case the varietal name should be promoted to the specified rank. We may add that we have before us three casts of the interior from the lowest beds at Cincinnati, Ohio, that look very much as if they might belong to this variety.

We are not satisfied that either the variety or the species is a true *Bucania.* The umbilicus is too small and the sculpture not what it should be. The markings of *B. nana* are considerably like those found on *Tetranota bidorsata,* but the *nana* is most certainly not a *Tetranota.* We suspect that the species and variety are close relatives of two Clinton group shells described by Foerste as *Bellerophon* or *Bucania exigua* and *fiscello-striata.* In the surface markings, the last reminds one also of *Bucania punctifrons.* All five of these forms require further study before their positions can be established.

Formation and locality.—Upper part of Trenton group, Mercer county, and Covington, Kentucky.
Collection.—E. O. Ulrich.

BUCANIA PERACUTA, *n. sp.* (*Ulrich.*)

PLATE LXVI, FIGS. 34 and 35.

Of this remarkable shell we have seen only a single imperfect specimen which was collected by Prof. J. M. Safford and kindly sent to one of the authors for description. When entire it must have looked like a gigantic *Cyrtolites*, and we were at first inclined to place it in that genus. Closer investigation, however, showed that the surface markings were in reality different and the shell too thick for a *Cyrtolites*, while in both respects it proved to correspond with some of the *Bucania lindsleyi* group of species. The curving transverse folds of the flattened dorsal slopes are represented in other species of *Bucania* by the salient edges of the imbricating lamellæ, while the fine obliquely revolving lines in the depressed interspaces are commonly present in the genus. The volutions expand very rapidly, and in this particular, as well as in the dorsal angulations, the species corresponds perhaps best with *B. nashvillensis*, figured on the same plate. A view of the aperture of the specimen therefore agrees rather closely, in its lower part, with figure 37 of the plate. But the umbilicus is larger and much more sharply defined than in that species, the sides of the volutions being compressed into knotted keels. These lateral keels are nearly central on the inner whorls in a side view, but as growth proceeded its position became more ventral, the umbilical slope becoming at the same time more abrupt. For the same reason the transverse section of the whorls changes from rhomboidal to triangular. Only a small portion of the slit-band remains. This is slightly elevated and flat. Seven or eight of the revolving lines, which as usual are irregularly wrinkled, occur in 4 mm.

Formation and locality.—Upper part of the Trenton group, DeKalb county, Tennessee.

Genus SALPINGOSTOMA, F. Roemer.

Salpingostoma, F. Roemer, 1876, Lethæa Geognostica.
Bucania (part.), Hall, 1847, Pal. New York, vol. i.
Bellerophon (part.), Eichwald.
Bucania (?*Tremanotus*), Whitfield, 1882, Geol. of Wis., vol. iv, p. 224.

This genus will include a number of species that most American paleontologists have considered as typical of the genus *Bucania*. However, in discussing the latter genus (see page 883) we have given our reasons for restricting its use to species conforming strictly with the type *B. sulcatina*, and for placing those of the type of Hall's *B. expansa* in *Salpingostoma*. It is therefore unnecessary to again take up this part of the subject.

Salpingostoma, as understood by us, will include shells whose inner volutions correspond in nearly every respect with the whole shell of the most typical species of *Bucania*, and it is only in fully grown entire examples that the peculiarities of the genus are apparent. These consist in the abrupt development of a thick and greatly expanded aperture and in the anterior closing of the long dorsal apertural slit. A dorsal slit, equivalent to that of *Salpingostoma*, was present in the middle of the apertural sinus in all *Bellerophontacea* having a slit-band. In some it was very long (*Bucania* and *Conradella*), but in the majority it was comparatively short; and in all cases it is the feature that gave rise to the slit-band, the posterior end of the slit having been pushed forward in proportion with the growth of the shell.

In only two genera of the suborder, however, *Salpingostoma* and *Tremanotus*, was the slit closed in front. In both of these genera the aperture is enormously expanded, not only laterally and ventrally, but dorsally as well, and it is the last peculiarity, one in which these genera stand practically alone, that we consider as the most important. The anterior closing of the slit was, we think, merely incidental to this expansion of the aperture, and perhaps dominated entirely by the necessity of overcoming the extreme liability to fracture to which the aperture would have been subject had the slit been allowed to continue to its outer margin.

Regarding the dorsal slit of *Salpingostoma*, it is questionable if the entire length of it that is represented by a ridge on casts of the interior was open. There is some reason to believe that a portion of the posterior end was covered by a thin film of shell. The greater portion of it, however, seems to have been permanently open. While there may be some doubt about the covering of the posterior end, there is none when we come to the anterior end. Here, from the beginning of the apertural expansion, backward for a distance equalling about one-half of the transverse diameter of the volution, the slit is undoubtedly closed, though continuing in some specimens as a gradually diminishing furrow on the inner side of the shell. In other specimens, of the same species even, there is a broad internal thickening, leaving a furrow instead of a ridge on casts of the interior. Behind the slit there is a distinct band with lunulæ, precisely as in *Bucania* and *Bellerophon*.

The surface markings of *Salpingostoma* are practically the same as in *Bucania*. Beneath the apertural expansion they consist of more or less oblique and wavy, wrinkled, revolving striæ, interrupted at subregular intervals by lines of growth. The former may be represented, as in *S. buelli*, by small, partially disconnected knots, which are arranged in series in such a manner that when viewed with the light coming from different directions the predominent element of the markings is changed from the oblique to the longitudinal. In *S. sculptilis* the revolving lines are zigzag and unite with the transverse lines in producing a network in which the pattern is complicated by an extra thread running obliquely through the alternating meshes. In nearing the mouth and continuing over the expansion the revolving lines usually become the most conspicuous element of the surface ornamentation, but they seem never to lose their irregularly wavy character entirely. As a rule the transverse lines predominate in the umbilical regions, and occasionally also on the dorsal part of the apertural expansion. The inner side of the aperture is always smooth.

Regarding the expanded aperture, we believe that it was developed only once during the life of the animal, and that it marks the fully matured condition. Two facts lead us to this opinion: first, the uniform size (in each species) of the specimens in which it is developed or preserved; and second, the thickness, as of age, to which the expanded rim may attain. As demonstrating the first we will give the results of measurements of two species. In ten average specimens of *S. richmondensis* the hight of the shell, excluding the apertural expansion, is 45 mm. in the smallest and only 50 mm. in the largest; in five specimens of *S. buelli* the same measurement varied between 35 and 37 mm. Herein lies the principal difference between *Salpingostoma* and *Tremanotus*, and it at the same time explains the development of a row of small openings in the latter instead of a single long slit.

In *Tremanotus*, namely, the expanded aperture is a periodic development, a new one being formed at frequent intervals. There is, therefore, no narrow limit to the size of the specimen. The expansion is also always very thin, and the old ones were either broken away or reabsorbed, the latter being in our opinion more likely. As in *Salpingostoma*, the development of each expansion was preceded or accompanied by the anterior closing of the apertural slit, continued growth at last producing a row of openings instead of a continuous fissure. The number of these openings remaining uncovered varied probably according to their sizes and with the species. The only evidence on this point now available is furnished by casts of the interior. These seemed to show that they remained open for a distance equalling about a third of a volution. In this distance, which slightly exceeds the average length of the slit in *Salpingostoma*, different species of *Tremanotus* show from four to about ten openings.

The surface markings of *Tremanotus longitudinalis* Lindström, the only species of the genus on which they have been observed in a thoroughly satisfactory manner, are on the whole more like those of *Bucania* than *Salpingostoma*, but as they are practically of the same type in all three genera, they are of but little assistance in referring a shell to its proper genus.*

Finally, we wish to state emphatically our conviction that *Bucania*, *Salpingostoma* and *Tremanotus* stand in close generic relationship to each other. The

*Koken draws some fine distinctions between the different surface sculpturings of a number of European and one American species belonging in this connection, yet, if his observations on the others are not much nearer the truth than those which pertain to *Tremanotus*, they are certainly of little value. But we are perhaps more severe here than we intend, since in our opinion Dr. Koken has given us a most praiseworthy and valuable work. Because of the general minuteness and correctness of his observations, an error so palpable as the one he has fallen into with respect to *Tremanotus* is to be regretted more than condemned. Where he got the idea that the inner side of the aperture in *Tremanotus* is radially folded, and that "the folds are restricted to the inner side and in no wise dependent upon the outer side," is beyond our comprehension. It is simply not a fact.

development was progressive from one to the other in the order named. In the first the aperture is never greatly expanded, in the second it flares abruptly at maturity, while in the third an expanded mouth is developed at more or less frequent intervals. The second type was probably evolved in times preceding the Trenton period, but the evolution of the third seems to have been postponed till after the close of the Lower Silurian.

SALPINGOSTOMA BUELLI *Whitfield.*

PLATE LXVII, FIGS. 34–37 and ?38.

Bucania buelli WHITFIELD, 1878, Ann. Rept. Geol. Surv. Wis. for 1877, p. 76.
Bucania (*Tremanotus?*) *buelli* WHITFIELD, 1882, Geol. of Wis., vol. iv., p. 224.

Shell of medium size, consisting of about three and a half volutions. The greatest diameter of the shell, just before the development of the expanded aperture, varies usually between 35 mm. and 36 mm., while the width of the last volution at the same point is about 20.5 mm., and its hight one or two mm. less. Volutions appressed, subreniform in section, the hight of the inner ones just a little more than half the width; dorsum broadly convex, the sides narrowly rounded or subangular, the ventral surface slightly concave where it is in contact with the preceding whorl. Umbilicus large, exposing all the inner whorls, with the sutural line deep. Aperture abruptly expanded, nearly horizontal, slightly raised and gently sinuate in front, broadly ovate or subcircular in outline with the hight and width nearly equal, the latter usually a little the greater; average hight about 35 mm. Transverse surface markings (behind the apertural expansion) consisting of fine sharp lines, three or four in 1 mm., and at intervals increasing with growth from 1 to 2 mm., of a stronger wrinkle-like set; both sets sweep backward with very little curvature between the sides of the volutions and the slit, joining the latter at an angle of about 60°; the transverse striæ are crossed by nodular revolving lines, the nodes being arranged in such a manner that by changing the direction of the light a diagonal arrangement will become more prominent than the longitudinal. Toward and on the apertural expansion the revolving lines increase gradually in strength, assuming at the same time a radial disposition, while the interpolation of a smaller set produces a distinct alternation in size at the margin. Inner surface of aperture perfectly smooth or exhibiting a few obscure concentric lines.

Dorsal slit about 24 mm. long, its edges raised, represented by a narrow rough ridge on casts. Behind the slit an ordinary band, appearing raised because bordered on each side by a narrow groove. In front of it to the beginning of the expansion a similar band; this continues as a gradually diminishing small ridge to the sinus in the lip.

The lateral view of a cast of this species given by Whitfield (*op. cit.*, pl. VI, fig. 13) does not agree with our specimens, the outer third of the last volution being much fuller in the figure, and represented as convex or straight almost to the edge of the aperture instead of deeply concave. Still, we cannot for a moment doubt that we have really described the species intended by Prof. Whitfield, since the majority of them are from the locality which furnished the original types, and all are precisely like specimens in the museum of the University of Wisconsin labelled in Prof. Whitfield's hand as *Bucania buelli.* That the figure objected to may not be true to nature is indicated by the fact that it does not agree with his fig. 12 which is stated to be of the same specimen. It may be that the specimen is in part a cast of the exterior, which would account also for the presence of the radiating ribs. Not a trace of the latter is visible on any specimen seen by us that is truly a cast of the interior.

The surface sculpture of *S. expansa* Hall sp., of the Trenton of New York, is not well known, but casts of the interior are readily distinguished from those of this species, the volutions being less depressed, and subtriangular in section instead of subreniform. We have several fragments of a variety or closely related species from the Black River limestone of Kentucky, differing from the typical form of *S. buelli*, so far as the imperfect material will admit of judgment, in having a thicker shell, coarser surface markings, and smaller inner volutions when compared with the expanded aperture which is fully as large as *S. buelli.* The aperture also is not so abruptly turned outward dorsally. In the last feature it is more like *S. expansa* but the specimens are too small for that species and the volutions rounded on the back instead of subangular. Since the form is close to *S. buelli* we may designate it provisionally as var. *kentuckyensis.*

The specimen represented by fig. 38 on plate LXVII is considerably smaller than any other of the species seen. The radiating ribs on the apertural expansion also are stronger than they should be in *S. buelli.* If these differences prove constant in other specimens they should be distinguished as a variety at least.

Formation and locality.—In Minnesota *S. buelli* is a rare fossil and so far known only from the limestones of the Stones River group, at Minneapolis, Cannon Falls and Old Concord. In Wisconsin, however, it is not uncommon and continues into the overlying limestones of the Black River group; Beloit and Janesville are the principal localities. In Illinois it occurs at Rockton and Dixon.

Collections.—Geological and Natural History Survey of Minnesota; University of Wisconsin; Charles Schuchert; E. O. Ulrich; W. H. Scofield.

Museum Register, Nos. 7293, 7318, ?5544.

SALPINGOSTOMA SCULPTILIS, *n. sp.*

PLATE LXXXII, FIGS. 16—20.

Shell scarcely attaining medium hight, consisting of at least three and one-half volutions, the hight, including apertural expansion, about 40 mm. Inner volutions enlarging very slowly, somewhat rhomboidal in section, obtusely angular on the dorsum and more narrowly angular on the sides, the hight and width respectively as six is to ten. Aperture expanding abruptly till it measures at least 30 mm. in width and 28 mm. in hight; anterior sinus very shallow. Umbilicus large, exposing all the whorls. Surface markings forming a coarse network of alternating hexagonal meshes; an extra thread passes in an obliquely forward and inward direction through each mesh. In the umbilicus the oblique thread is the most conspicuous. About six rows of meshes occur on the small part of the outer volution on each side between the slit-band and the lateral edges. On the apertural expansion the markings increase in strength, though numerous longitudinal threads are interpolated as the space to be covered grows larger. Dorsal fissure about 17 mm. long.

This species may be related to *S. expansa* Hall sp., but it is readily distinguished by its smaller size and by the angularity of the back of its inner volutions, these being more rounded in that species (*i. e.* elliptical or reniform in section). The dorso-ventral diameter of the aperture also is relatively less in that species. The surface ornamentation of *S. expansa* being as yet unknown, we cannot say how it compares with that of *S. sculptilis*. Compared with *S. buelli* Whitfield, it will be found that *S. sculptilis* is smaller, has different surface markings, and volutions that are not only narrower but rhomboidal instead of reniform in section.

Formation and locality.—Four specimens, all from the Fusispira bed of the Trenton group, three from different localities in Goodhue county, and one from Ollie Hansen's farm near Fountain, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 7462.

SALPINGOSTOMA IMBRICATA, *n. sp.*

PLATE LXXXII, FIGS. 21 and 22.

Of this species we have but a single imperfect cast, the greater part of the expanded aperture being broken away. In the remaining parts it resembles *S. sculptilis* but the whorls are even narrower, the hight being to the width as five is to six and the section broadly subelliptical. The back of the volutions is broadly convex, the sides narrowly rounded or subangular, and the umbilical or ventral slope slightly flattened. The dorsal slit seems to have been at least 30 mm. in length. The shell is entirely gone except in the umbilicus, where, in the suture lines especially, there are remains of very regularly recurring, salient, thin, transverse, imbricating lamellæ, seven or eight in a distance of 5 mm. On the dorsal parts of the shell these lamellæ must be much farther apart. Revolving lines are faintly indicated on the back. There is something so suggestive of *Tremanotus* about this species that it is to be hoped that better specimens may soon be discovered.

Formation and locality.—Richmond group of the Cincinnati period, near Spring Valley, Minnesota.
Collection.—E. O. Ulrich.

SALPINGOSTOMA RICHMONDENSIS, *n. sp.* (*Ulrich.*)

PLATE LXVII, FIGS. 39 and 40.

Shell slightly exceeding medium size, the hight, including apertural expansion, 50 to 55 mm.; known from casts of the interior chiefly. These consist of about three strong volutions, the inner ones wide, depressed, sharply rounded on the sides, broadly and evenly convex on the back, less convex and with a very slight central cavity on the ventral side, the whole giving a transversely elongate subelliptical cross-section, whose width is a little more than twice the hight. Dorso-ventral diameter of last volution increasing very rapidly in the outer half, while the transverse diameter enlarges very slowly. Just behind the apertural expansion, where the volution is more or less distinctly compressed laterally, the dimensions in three specimens (casts) are as follows: width 22, 23 and 24 mm.; hight 26, 27 and 27 mm. At the opposite side of the shell the volution is about 15 mm. wide and 7 mm. high in all three specimens. The umbilicus is of the usual size for the inner volutions, but for the entire shell it is comparatively small. This is because the angular or narrowly rounded boundary moves gradually toward the ventral side of the volutions, causing the wall of the umbilicus to become more and more abrupt. Just behind the aperture it is nearly or quite perpendicular, the ventral surface of the volution being almost flat. Apertural expansion abrupt, apparently not very wide, with recurved edges, broadly ovate in outline, slightly narrower above than below. Dorsal slit about 20 mm. in length, beginning the same distance or somewhat more behind the apertural expansion. The slit is represented by a rough (fractured) ridge on casts. Behind it the cast is smooth, but in front of it there is a more or less distinct broad furrow.

The surface markings have been observed only on the back of the second volution. Here they consist of about seven irregular revolving ribs on each side of a very narrow elevated slit-band. At intervals of about 1.5 mm. the ribs are interrupted by transverse lamellæ. Where they are shown the volution has a width of 7 mm.

Collectors have heretofore identified this species with Hall's *Bucania expansa* from the Trenton of New York,* but a comparison proves it quite distinct. In the first place, though of about the same size, there is one volution less. Next, the last volution is relatively narrower and higher just behind the aperture, and the latter very differently outlined. Finally, the last volution is nowhere triangular as is the case in the Trenton species. Compared with *S. buelli* and *S. sculptilis* the outer volution will be found much larger especially as regards the dorso-ventral diameter.

In practice the most difficult perhaps to separate from this species is the associated *Bucania simulatrix*. Though of widely different affinities, casts of these two species, especially when, as is usually the case, the aperture is imperfect, are very apt to be confused. Still, after familiarizing one's self with certain differences, they may be distinguished almost at a glance. In the first place the volutions of the *Bucania* are more slender. This difference is particularly striking in an apertural view, the small end of the outer volution, in specimens of the same hight, being at least a fourth wider in the *Salpingostoma*. In the *Bucania* again the width of the last volution continues to increase quite uniformly instead of being almost constricted near the aperture. When the latter is preserved the difficulties have vanished, for this part is readily distinguishable.

Formation and locality.—Richmond group of the Cincinnati period, at Richmond, Indiana, where casts of it occur rather abundantly. Good specimens, however, are anything but common.

Collection.—E. O. Ulrich.

Genus CONRADELLA, n. gen.

Phragmolites, CONRAD, 1838, Ann. Geol. Rep. New York, p. 119.
Cyrtolites (part.), HALL, 1847 and 1871. MEEK and WORTHEN, 1868. MEEK, 1873. S. A. MILLER, 1874 and 1892.

For generic characters and list of species see pages 851, 852.

It is strange that this sharply defined genus of shells has been so uniformly confused with *Cyrtolites*. Aside from the fact that the whorls are similarly coiled in the two groups, there is not a single character in which they are identical. While the typical forms of *Cyrtolites* have no slit-band and in some cases not even a sinus in the outer lip, *Conradella* has not only a sharply defined raised band, but an unusually long apertural slit as well. The form of the volutions also is different, the transverse section in the former being more or less rhomboidal, while in the latter it is ovate or obcordate. Finally, the surface markings are not at all similar,

* The erroneous identification of this and a number of other Trenton fossils in the upper member of the Cincinnati period, is responsible for the commonly prevailing yet groundless idea that the fauna of the "Cincinnati group" is a sort of mixture of "Trenton and Hudson River types." The sooner paleontologists will come to realize that a careful comparison of the fossils themselves is one of the first necessities in a successful identification or discrimination, the better it will be for stratigraphical geology. Mistakes are always possible, but time and care will avert most of them.

Cyrtolites having fine thread-like lines arranged in a reticulate manner, while in *Conradella* the surface is covered by strongly imbricating transverse lamellæ, the raised edges of which are serrated.

It seems to us that *Conradella* is in reality nearer *Bucania* than *Cyrtolites*. A careful comparison brings out what we conceive to be important agreements. Thus, in *Bucania* there is a rather long apertural slit, a large umbilicus and the whorls increase somewhat slowly in size, while the surface sculpture, though differing in detail, is of the same type. Of course, we do not wish to be understood to say that *Bucania* and *Conradella* are closely related, nor that there is any difficulty in keeping the two genera separate, the strong dorsal keel, less depressed and more slowly enlarging volutions, and the directness of the transverse imbrications in the latter being very obvious peculiarities. Yet, when we consider the general sameness of the types, we cannot escape the conviction that they were derived from the same stock. The great development of the lamellæ, each of which must at first have been abrupt apertural expansions, is corroborative evidence for this view, since it is a feature recurring in even greater development in *Tremanotus*, a genus that doubtless was derived from *Salpingostoma* and *Bucania*.

In the new genus *Cyrtolitina* (see pages 847, 856), the surface markings are somewhat similar, but the lines of growth sweep backward on nearing the dorsum, causing a sinus in the outer lip, the apertural slit is much shorter, and the volutions fewer in number and much more rapidly enlarging. The long slit and the general form of the shell of *Conradella* remind one greatly of the Devonian and Carboniferous genus *Porcellia*, Leveille, yet it is more than doubtful if there is any true relationship between them. In *Porcellia* the surface markings are of a different type, while the innermost volutions are unsymmetrically coiled, showing that it was derived from a pleurotomarid rather than a bellerophontid stock, the symmetric coiling of the later whorls probably indicating partial atavism.

Respecting the name of this genus, we would have been glad to restore Conrad's *Phragmolites* (partitioned stone) were it not objectionable because it gives an incorrect idea of the fossil. Conrad believed his *P. compressus* to be a chambered shell. This, however, was soon learned to be an error, and as Hall placed the species unreservedly into *Cyrtolites*, which was proposed by Conrad at the same time, all subsequent paleontologists have followed in ranking *Phragmolites* as a synonym under *Cyrtolites*. Had the name ever attained currency, we would feel ourselves bound to revive it, on the score of priority, despite its inappropriateness, but as no one, so far as we can learn, ever adopted it, we thought it best to view the name as one that has failed of being established because of incorrect and insufficient definition. Yet we think it but justice to Mr. Conrad, who was a better paleontologist than he is usually credited with having been, that his name should be connected with the genus. Hence the name *Conradella*.

CONRADELLA OBLIQUA, *n. sp.*

PLATE LXVII, FIGS. 1–6.

Shell discoid, small, commonly from 10 mm. to 15 mm., and not known to exceed 20 mm., in diameter. Whorls three or four, enrolled so that the keel of each is partly imbedded in the base of the next; transverse section of whorls subcircular, or transversely elliptical, the dorsum (excepting the keel) sometimes slightly flattened. Keel sharply elevated, narrow, nearly 1 mm. high in the largest specimens, the summit with distant subimbricating lunulæ bordered on each side by a delicate raised line. Slit long, extending backward from the aperture almost half a whorl, having a length of fully 20 mm. in a specimen 14 mm. in diameter; borders of slit raised, though not as prominently as the keel farther back. Transverse, serrated surface imbrications crossing the whorls obliquely, seeming to sweep strongly backward from the umbilicus, without however forming a sinus on the back. Serrated edges moderately prominent, the elevation in no case exceeding 1.0 mm., being in most cases less than 0.5 mm.; behind each sinus a rib, dying out before it reaches the preceding lamina.

On the inner volutions the transverse imbrications are crowded, but on the last the distance between them is increased so that the average at the keel equals about one-third of the width of the volution. Between the serrated edges the surface is very finely cancellated, the longitudinal lines being somewhat less distinct than the transverse.

This species is readily distinguished from *C. compressa* Conrad, *C. pannosa* Billings and *C. dyeri* Hall by the obliquity of the transverse imbrications, and the greater width of the volutions.

Formation and locality.—Not uncommon in the Rhinidictya and Ctenodonta beds of the Black River group, at St. Paul, Minneapolis, Cannon Falls, Chatfield and Fountain, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, Nos. 4051, 6853, 7536.

CONRADELLA SIMILIS, *n. sp.* (*Ulrich.*)

(Not figured.)

This species is closely related to *C. obliqua* differing from it chiefly in the transverse section of the whorls. In that species the section is almost circular, but in the form which we propose to call *C. similis* it is broadly obcordate. This difference causes the keel to appear as less abruptly elevated, the slope on each side of it more gentle, and the edge of the umbilicus more narrowly rounded. The ventral side of the volutions being flatter, the umbilicus therefore is not only more abrupt at its circumference, but also a little smaller. The transverse imbrications, though not quite so oblique, are similarly disposed, but the serrations are broader and fewer in number, there being on each side only six or seven, to ten or eleven in *C. obliqua*. In *C. compressa* Conrad the transverse imbrications are but little, if at all, oblique, and the dorso-ventral diameter of the whorls the greater, while for *C. similis* the opposite is true.

Formation and locality.—Upper part of the Black River group, in Mercer and Boyle counties, Kentucky.

Collection.—E. O. Ulrich.

CONRADELLA FIMBRIATA, *n. sp.*

PLATE LXII, FIG. 66; PLATE LXVII, FIGS. 7–10.

Shell discoid, from 18 mm. to 25 mm. in diameter. Volutions about three, enlarging more rapidly than usual for the genus, very strongly and rather abruptly carinate, broadly subcordate in section, wider than high, narrowly rounded in the lower part of the sides; umbilicus comparatively small, equalling two-fifths of the diameter of the shell; slit extending nearly a half-volution posterior to the apertural margin. Aperture abruptly expanded at frequent intervals, the expansion left behind forming transverse, imbricating, folded lamellæ, the anterior edges of which are strongly serrated and project, collar-like, 3 or 4 mm. forward and outward from the surface of the last volution. Each expansion has seven folds, the lower one faint, the upper ones strong. Occasionally a smaller one is developed between each pair of the latter. The entire surface covered by very fine longitudinal and transverse lines. All the transverse markings cross the volutions obliquely. When, as is generally the case, the projecting lamellæ are broken away, the surface presents two or three more or less obscure revolving ribs on each side of the prominent keel. Greatest width of last volution, without the apertural expansion, in a specimen 25 mm. in diameter, about 12 mm.; with the expansion about 18 mm.; hight of aperture about 15 mm. Intervals between imbrications varying on the outer whorls between 1 and 2 mm.

When the apertural expansions are broken away this shell reminds one greatly of *C. similis*, the only difference being that the whorls enlarge more rapidly. But the perfect shell cannot be confused with any other, the great extent of the overlapping expansions giving it a very striking appearance.

Formation and locality.—Stones River group (Vanuxemia bed), Minneapolis, Minnesota, and Dixon, Illinois.

Collections.—Geological and Natural History Survey of Minnesota (about 22 specimens); E. O. Ulrich (6 specimens).

Museum Register, Nos. 653, 5110, 8724.

CONRADELLA TRIANGULARIS, *n. sp.*

PLATE LXVII, FIGS. 19–22.

Shell usually from 15 to 18 mm. in diameter, compressed discoid, consisting of about three volutions; whorls carinate, slightly higher than wide, triangular-obcordate in section, gently convex on the sides, widest and angular below where the surface sinks abruptly into the umbilicus. Surface very rough, the zigzag or serrated lamellæ crossing the whorls almost directly, from 0.5 to 1 mm. apart, each with eight or nine folds between the dorsal keel and the edge of the umbilicus; at the latter the lamellæ generally turn somewhat abruptly forward. Usually the folds are arranged so as to present obscurely the appearances of revolving ridges. At other times they may alternate in adjacent series. The angularity of the ventral part of the sides of the volutions varies somewhat, the margin of the umbilicus being in many cases very sharp, while in others it would be more truly described as abruptly rounded. In casts of the interior, of course, the angle is never so distinct as in the shell itself.

Most collectors of northwestern fossils have identified this species with the New York Trenton *C. compressa* Conrad, sp. They are, however, quite distinct, the whorls in the New York shell being wider and more uniformly convex on the sides, the umbilicus not at all sharply defined, and the transverse imbrications more distant. Compared with all the known species of the genus, excepting the next, which see, none seems to us so near as *C. dyeri* Hall sp., a variety of which occurs in the Trenton of Minnesota. Still, *C. triangularis* is distinguished readily enough from that species, as well as from all the others, by the more distinctly angular character of the umbilical edge. Besides *C. dyeri* is a smaller shell, with rounder volutions, and more sharply raised keel, while the transverse imbrications are more crowded and the appearance of revolving ridges much stronger.

Formation and locality.—Vanuxemia bed of the Stones River group, Minneapolis, Minnesota, Janesville and Beloit, Wisconsin, and Dixon, Illinois; also at Lebanon, Tennessee.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, Nos. 7292, 7309.

CONRADELLA GRANDIS, *n. sp.* (*Ulrich.*)

PLATE LXII, FIG. 67; PLATE LXVII, FIGS. 16–18.

This species is closely related to *C. triangularis* but reaches a much greater size, the greatest diameter of one of the specimens being fully 30 mm. Then the transverse section of the whorls, which also increase more rapidly in size, is a little different, the dorsal slopes being more convex, the sides less angular, and the transverse diameter relatively greater, the latter exceeding the vertical diameter by one-sixth, whereas the two dimensions are equal, or the hight the greater, in *C. triangularis*. Furthermore, the folds of the surface imbrications are fewer in number, there being only five or six on each of the dorsal slopes to eight or nine in that species. Then the revolving ridges are more distinct, and the keel is more abrupt, especially on interior casts of *C. grandis*, the latter exhibiting distinctly a broad furrow on each side of the keel. The slit extends quite half around the last whorl.

Formation and locality.—"Glade limestone" of the Stones River group, Lebanon, Tennessee, where the types (three specimens) were collected by Prof. J. M. Safford, and sent to one of the authors for description.

CONRADELLA DYERI *Hall.*

PLATE LXVII, FIGS. 30–33.

Cyrtolites dyeri HALL, 1871, Advance sheets, 24th Rept. Regents N. Y. St. Cab., and reissue of same. 1872, p. 230, pl. VIII, figs. 7, 8. MEEK, 1873, Pal. Ohio, vol. i, p. 149, pl. XIII, figs. 2*a*, *b*, *c*, (not 2*d* and *e*, these representing *C. elegans* Miller). MILLER, 1874, Cincinnati Quart. Jour. Sci., vol. i. p. 309.

Shell small, 10 to 13 mm. in diameter, laterally compressed, consisting of two and a half or three volutions, the outer embracing the next within for about one-third of its hight. Whorls cordiform in section, broadest and sharply rounded below, sharply and abruptly carinate dorsally, rounded on the sides the curvature increasing downward from the keel; hight and width of volutions, including the carina, about equal, or the former slightly the greater. Umbilicus about equalling the dorso-ventral diameter of the last turn at the aperture. Surface marked by numerous closely and regularly arranged transverse lamellæ, the raised edges of which are curved abruptly backward at regular intervals and have a general retral direction from the umbilicus to the keel. The recurved intervals being more prominent than the longer straight portions, and occurring at regular intervals, they cause the surface to appear as having revolving ribs. On the ventral half of the volutions the lower sides of the loops sometimes coalesce and form really continuous revolving lines. Ten of the loops on each side is the usual number for the last whorl, but two extra ones are sometimes distinguishable near the aperture of larger examples. Of the transverse lamellæ the average number on the back of the last volution in 2 mm. is seven or eight. The keel is prominent, rounded on the summit, and, so far as observed, without a trace of lunulæ, although some of the specimens before us are in a beautiful state of preservation. The slit has the usual length (i. e., nearly a half volution).

We have two specimens of a variety or a closely related species from the Trenton of Minnesota which we propose provisionally to designate as

Variety CELLULOSA, *n. var.*

PLATE LXVII, FIGS. 27–29.

They are both only about 9 mm. in diameter, and differ from the typical form of the species in having much less of a keel and in the peculiar modification of the surface markings. The lamellæ, namely, generally unite with each other in such a manner that a cellular rather than striated surface results. When slightly weathered the connected sides of the successive loops may appear like delicate longitudinal plates. It seems to be a rule that the loops are oblique and joined to each other only on one side, the other being open. Again it may appear that the longitudinal line is independent and runs directly through the loops. The transverse lamellæ are unusually crowded, the average on the last volution being from eight to ten in 2 mm.

The surface markings of *C. dyeri* have never been correctly illustrated. On the accompanying plates we show that the "revolving ridges" are as a rule not ridges at all, but only an appearance due to the elevation and longitudinal arrangement of the closely following loops of the transverse lamellæ. When continuous revolving lines are formed it is only through coalescence of one or both sides of the loops of succeeding lamellæ.

Compared with the preceding species *C. dyeri* is distinguished at once by its smaller size and unusually crowded surface markings.

Formation and locality.—The typical form occurs in the Richmond group at Richmond and Versailles, Indiana; Oxford, Clarksville, Freeport and Waynesville, Ohio; near Maysville, Kentucky, and Spring Valley, Minnesota. Variety *cellulosa* was found in the Clitambonites bed of the Trenton group at St. Paul and Cannon Falls, Minnesota.

Collection.—E. O. Ulrich.

CONRADELLA BELLULA, *n. sp.* (*Ulrich.*)

PLATE LXVII, FIGS. 23–26.

This species in most respects occupies an intermediate position between *C. dyeri* Hall and *C. elegans* Miller. From the former it is distinguished by its lesser thickness (compare figures 24 and 31 on plate LXVII) less crowded lamellæ, and by having numerous well marked lunulæ on the slit-band. From *C. elegans* it differs in having more slender whorls and less coarsely marked surface.

The specimen figured seems to be complete. If this is the case, then we have another feature in which *C. bellula* differs from both of the species with which we have compared it. Namely, a slit extending only about a fourth, instead of half around the circumference of the last turn.

Formation and locality.—Lower half of the Loraine group, Covington, Kentucky.

Collection.—E. O. Ulrich.

CONRADELLA ELEGANS *Miller*.

PLATE LXVII, FIGS. 12–15.

Cyrtolites dyeri (part.), MEEK, 1873, Pal. Ohio, vol. i, p. 149, plate XIII, figs. 2*d*, 2*e*.
Cyrtolites elegans, MILLER, 1874, Cincinnati Quart. Jour. Sci., vol. i, p. 310.

This species is closely related to and about of the same size as *C. dyeri* Hall, but we cannot say that we ever found it difficult to distinguish. In the first place the transverse lamellæ are less crowded—sometimes they are more than twice as far apart as in that species; next the undulations or loops of each are not so deep and fewer, there being only five or six to a side as against ten in *C. dyeri;* then it is only in rare instances that even the most obscure appearance of revolving ridges is observable; finally, the whorls are a trifle higher, while the slit-band bears distinct and closely arranged lunulæ. The last is probably to be regarded as the most important of the differences mentioned. The *C. triangularis* of the Stones River group, though of a similar type, is readily distinguished by its larger size, rougher surface, oftener and more deeply undulated lamellæ, and angular umbilical edges. *C. grandis* is perhaps nearer than any other, but it grows so much larger that there is little danger of confusion between them. For comparisons with *C. bellula* see that description.

Formation and locality.—As yet this pretty shell is known only from the shaly limestones of the Loraine group, at Cincinnati, Ohio and localities in the immediate vicinity of that city.

Collection.—E. O. Ulrich.

CONRADELLA IMBRICATA *Meek* and *Worthen*.

PLATE LXVII, FIG. 11.

Cyrtolites imbricatus MEEK and WORTHEN, 1868, Geol. Surv. Ill., vol. iii, p. 340, pl. IV, fig. 12.

A good figure of this species has not yet been published, and as it is an interesting form and one that may be expected to occur in Minnesota, we have decided to illustrate a specimen that a careful comparison with the original type proves to belong to the same species. This specimen is from the same locality as the type and differs from it only in being smaller. The greatest diameter of the type is about 22 mm.; in our specimen 15.5 mm.

The chief peculiarity of *C. imbricata* lies in the fact that the sides of the whorls are the most prominent and somewhat angularly bent just beneath the middle and flattened in the umbilicus, giving a subrhomboidal or *Cyrtolites*-like transverse section instead of the rounded or cordiform section prevailing among the other species of the genus. In all other respects the species agrees very well with *C. triangularis* U. & S. and *C. elegans* Miller. Still, the transverse lamellæ are more irregularly undulating and wider apart than in either of those forms.

Meek and Worthen make a statement to which we must object. Namely, that the inner volutions are "nearly half embraced by the last turn." This is true of only the anterior part of the last volution of their type, and we are inclined to believe that it is due to oblique pressure to which the specimen has been subjected. On the rest of the type, as in the whole of the specimen now illustrated, the embracing extends only to the base of the carina.

Formation and locality.—In strata regarded as belonging to the Trenton group, Alexander county, Illinois. The same layers contain *Rhynchotrema inæquivalvis* Castelnau (*R. increbescens* Hall) and *Nematopora delicatula* Ulrich.

Collections.—Illinois State Museum; E O. Ulrich.

Genus OXYDISCUS, Koken.

Bellerophon, *Cyrtolites*, *Porcellia* and *Euomphalus* (part.) of authors.
Tropidodiscus of MEEK, 1866, and WAAGEN, 1880, not Steininger, 1855.
Oxydiscus, KOKEN, 1889, N. Jahrb. f. Mineralogie, etc., Beilageband vi, p. 390.

For generic characters see page 852.

This group recommends itself to us as not only a convenient but a natural generic division of the *Bellerophontacea*. Sowerby, Billings and Conrad placed three of the species under *Bellerophon*, from which they are distinguished by their lenticular form, compressed and sharply carinate volutions, scarcely, if at all, expanded aperture, and by their thin lips and the total absence of any callosity. Lindström and Miller placed four of the species with *Cyrtolites*, a genus that is widely different in all respects excepting the general form. As to *Porcellia*, Koken has shown, and we can bear evidence for the general correctness of his observations, that that genus represents a totally different type of structure. Finally, the reference of two of the species to *Euomphalus* rests probably upon nothing more than an error of observation and judgment.

Koken excludes all those species from the genus in which even a suspicion of a slit-band occurs. This we think is drawing the line too close and somewhat inconsequent. He admits into *Bellerophon* (sens. strict.) species in which the slit-band is represented by a single keel only. And he is probably correct in this, since in not only closely related species but in one and the same species (e. g., *B. troosti* Safford) a true slit-band may occur occasionally, while the usual form has merely a keel.

Besides the species listed on page 852 there are three more American, or rather Canadian, species that may belong to *Oxydiscus*. These were described by Billings as *Bellerophon macer*, *B. palinurus*, and *B. argo*, the first from the Calciferous formation, the second from the Quebec group, the third from the Black River group. Of the three forms, the first is the most likely to belong here, but in the absence of any positive knowledge respecting their essential generic features, it is best to leave them provisionally where they are placed by Mr. Billings.

Respecting the systematic position of *Oxydiscus*, we are somewhat in doubt. The absence of any sort of revolving lines is against the inclusion of the genus with the *Bucaniidæ*. On the other hand such a position is strongly indicated by the absence of labial callosities and more particularly by the large umbilicus and long apertural slit. The latter occurs most certainly in the Lower Silurian species next described, and as these species agree verly closely in all respects with the Upper Silurian and Devonian types of the genus, we have assumed that the slit is one of the prime characteristics of the genus. Now, if this view proves to be correct we cannot be far wrong in placing *Oxydiscus* in the immediate vicinity of *Conradella*. The only difference of any consequence between these genera are that, while the surface of the volutions of the latter are crossed by imbricating, wavy lamellæ, which are not turned backward on the dorsum to form an angular sinus where they meet at the keel, the whorls of the former are crossed simply by fine lines of growth, turning backward very strongly in nearing the dorsal keel, their junction here indicating a narrow, V-shaped excision in the outer lip.

OXYDISCUS SUBACUTUS, *n. sp.* (*Ulrich.*)

PLATE LXII, FIGS. 62–65; PLATE LXXXII, FIGS. 23–25.

Shell lenticular; dorsum acutely carinated; greatest diameter from 15 mm. to 28 mm.; greatest thickness or width nearly one-half the diameter. Volutions three and one-half to four and one-half, thickest near the umbilicus, from which the surface ascends first with a gently convex, then with a concave slope to the sharp periphery; each volution embracing between one-third and one-half of the preceding one; umbilicus exposing all the whorls; its width somewhat less than one-third of the diameter of the shell; edge of umbilicus abrupt, subangular; aperture obcordate, indented below by the sharp dorsum of the preceding whorl; margin of aperture thin, in a side view with a strong backward sweep; slit long, very narrow. Surface marked by fine and rather indistinct lines of growth.

This species agrees perhaps as well as any with the Devonian types of the genus. Of Silurian forms only *O. cristatus* Safford and *O. disculus* Billings need be compared. The Candian species will be found to be more compressed, and to have the edge of the umbilicus less abrupt. For comparisons with Safford's species see next description.

Formation and locality.—Upper beds of the Trenton group near Danville, Kentucky, where more than twenty specimens were obtained. We have reason to believe that the same species occurs also in Tennessee and in the Fusispira bed in Minnesota.

Collection.—E. O. Ulrich.

OXYDISCUS CRISTATUS *Safford.*

PLATE LXXXII, FIGS. 26—28.

Cyrtolites cristatus SAFFORD, 1869, Geol. of Tenn., p. 289.

Through the kindness of Prof. J. M. Safford we have before us the types of his *Cyrtolites cristatus.* These show conclusively that the species is an *Oxydiscus*, closely related to *O. subacutus* Ulrich, yet not strictly identical. The Tennessee species is uniformly larger, the greatest diameter in four specimens varying between 30 and 38 mm. More important differences are (1) that the whorls are one less in number in mature examples, (2) that they increase more rapidly in size, (3) that they embrace each other in a lesser degree, the amount being in no case more than a sixth of the hight of a whorl, while the last may become entirely free, without, however, any appreciable diminution in the depth of the sharp furrow, which, farther inward, receives the keel of the preceding whorl. In consequence of the peculiarities mentioned, the umbilicus is relatively somewhat larger. Finally, the shell substance is comparatively thicker on the ventral side, and the keel more distinct than in the Kentucky species. Taken all in all, we do not see how we can do otherwise than regard *O. subacutus* as distinct from *O. cristatus.*

Formation and locality.—From Safford's "Middle Nashville," which we regard as representing an upper member of the Trenton group, at Nashville and in Jackson county, Tennessee.

Collections.—J. M. Safford; E. O. Ulrich.

Genus BELLEROPHON, Montfort.

Bellerophon, MONTFORT, 1808, Conchiliologie Systematique, vol. i, p. 51. WAAGEN, 1880, Pal. Indica, ser. 13, pt. 2, pp. 130 and 133.
Bellerophon (part.), HALL, LINDSTRÖM, and most authors prior to 1880.
Waagenia, de Koninck, 1882, Ann. Soc. Geol. de Belgique, p. 14.
Waageniella, BAYLE, 1883. Proposed instead of WAAGENIA which was preoccupied.

For generic characters and list of species see page 853.

Adopting this genus in the restricted sense proposed by Waagen, we have an easily recognized and still large group of Paleozoic shells. The numerous species are of a remarkably uniform type, distinguished at once from *Protowarthia* by its slit-band and different apertural emargination; from *Bucania* and allied genera by the total absence of revolving surface lines. Within its own family, the *Bellerophontidæ*, *Bellerophon* has not the revolving sculpture of *Bucanopsis*, nor the extremely expanded aperture of *Patellostium*, nor the revolving folds of the inner lip which characterize *Euphemus*, while neither *Mogulia* nor *Warthia* have a distinct slit-band.

The principal distinctive features of the genus are: (1) the absence of all kinds of sculpture save the more or less strongly developed lines of growth, (2) the small or entirely closed umbilicus, (3) the moderate expansion of the aperture, (4) a more or less strong callosity on the inner lip, and (5) a well developed, generally raised, slit-band terminating anteriorly in a short median emargination or slit in the outer lip.

The genus might be divided into several subordinate groups none of them, however, seeming of more than doubtful utility. One, *Waagenella*, including a few Carboniferous species, is distinguished by a definite callosity in the umbilical region. Regarding the *Bellerophon contortus* group of Koken, we have already distinguished it as a separate genus under the new name *Megalomphala* (see p. 850), this type belonging in our opinion to the *Bucaniidæ* rather than the *Bellerophontidæ*.

Ten of the fifteen American Lower Silurian species retained as true bellerophons are figured and described in this report, giving a very good idea of the genus as represented in this part of the Paleozoic rocks. Most of them are described for the first time and all are more or less closely and obviously related.

Bellerophon troosti (*D'Orbigny*) *Safford.*

PLATE LXIV, FIGS. 1–5.

Bellerophon troosti D'Orbigny, 1840, Cephalopoda, p. 206; as figured by Safford, 1869, Geol. of Tenn., pl. G, figs. 4*a*—4*d*.

Shell beneath the medium size, rarely exceeding 17 mm. in diameter; somewhat transverse, the width of the aperture being greater than the hight; whorls rather broad, inflated, though somewhat depressed on each side of the prominent dorsal carina; on the sides they are strongly convex, rounding into the small but deep and constantly developed umbilicus. In the adult shell the carina is rounded, but in young specimens the summit is flat or slightly excavated, forming a distinct slit-band on which lunulæ are either not preserved or were originally very faint. Aperture greatly expanded laterally, outer lip sharp and thin, with a deep and rather narrow subrectangular central emargination; inner lip thickened and much expanded laterally and horizontally, the inner edge forming a thick low biconcave ridge with a rounded central prominence; the latter constricted within the mouth and continuing inwardly as a distinct ridge; latero-ventral angles turned backward, in some cases partly overhanging the umbilicus. Surface marked by growth lines only. They are more or less distinct, though on the whole fine. They are also somewhat irregular, being generally arranged in bundles, which, especially near the aperture of adult shells, may produce obscure undulations of the surface. The course of the striæ from the umbilicus to the dorsal carina is very little curved and nearly at right angles with the carina. However, just before joining the latter, they bend sharply backward. Hight of one of the largest of the Kentucky specimens 16 mm.; greatest width of the aperture 19 mm.; width of whorl just in front of edge of inner lip 7 mm. In Tennessee the species often attains a hight of 20 mm.

We have before us an excellent series of silicified shells of this species and can testify to the unusual constancy of its specific characters. Considering this persistence we might be justified in separating the following form as a distinct species, but after considerable reflection we have concluded that such a course would not now be warranted. We propose then that it be known as

Variety BURGINENSIS, *n. var.* (*Ulrich.*)

PLATE LXIV, FIG. 6.

This variety grew to be a litttle larger than the typical form (22 mm. in hight), has a proportionally less expanded mouth (the greatest diameter of the shell is about the same as the width of the aperture), more slowly enlarging volutions, and a larger umbilicus. On the best specimen the dorsal carina besides has the characters of a true slit-band and near the aperture it exhibits distinct lunulæ.

B. troosti is one of a number of closely related Lower Silurian species. The group is well represented in the Trenton of Minnesota, but that *B. troosti* itself occurs here is as yet very doubtful. *B. similis* is very much like it, and before we found specimens showing the mouth and lines of growth, we unhesitatingly referred the casts of the interior to this species. Still, it is possible that *B. troosti* is really represented among the casts now assigned to *B. similis.*

Formation and locality.—The typical form is not uncommon in the Trenton group at Nashville and Hartsville, Tennessee, and Danville, Frankfort and other localities in central Kentucky. Var. *burginensis* occurs with the typical form near Burgin and Danville, Kentucky. The species is limited to a vertical range of a few feet in the upper half of the group.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

BELLEROPHON CLAUSUS, *n. sp.* (*Ulrich.*)

PLATE LXIV, FIGS. 7–10.

In the general form of the shell and the course of the lines of growth, this species resembles *B. troosti* very closely. Carefully compared we find that the new species differs in several important respects. First the umbilicus is entirely closed, next the lines of growth are more regular and sharper, then the slit-band is more truly a band though on the whole less prominent, while the lunulæ are sharply defined. Finally, the inner lip is scarcely as broad though its inner margin is heavier, while the prominence of the central boss is emphasized by a deep and large depression on each side of it. We know of no other species with which *B. clausus* need be compared, excepting two or three of those next described.

Formation and locality.—Trenton group, Frankfort, Kentucky, and near Nashville, Tennessee.
Collection.—E. O. Ulrich.

BELLEROPHON BILINEATUS, *n. sp.* (*Ulrich.*)

PLATE LXIV, FIGS. 19–21.

Very much like *B. troosti*, only smaller, narrower across the aperture, with fine and sharper, as well as more regular, lines of growth, and much less prominent slit-band. The latter is concave, lies between two sharp lines and is crossed by rather distinct lunulæ. The posterior curve of the lines of growth on the dorsum also is broader, while the inner portion of the lower lip is much less thickened. The last difference is even more conspicuous when we compare the species with *B. clausus*, and this, coupled with the fact that the umbilicus is closed in that species and rather large in *B. bilineatus*, renders confusion with that form quite improbable.

Formation and locality.—Upper portion of the Trenton group, near Danville, Kentucky.
Collection.—E. O. Ulrich.

BELLEROPHON SUBGLOBULUS, *n. sp.* (*Ulrich.*)

PLATE LXIV, FIGS. 17 and 18.

This also resembles *B. troosti* very closely, but good testiferous examples may be distinguished without much trouble. The surface striæ, though their direction with respect to the dorsal keel is nearly the same as in *B. troosti* (the retral curve on the back is somewhat wider), are more regular, sharper and thread-like. Comparing other characters it is found that the volutions are more ventricose and more uniformly rounded, causing the shell as a whole to be more globular, the keel is less prominent and thinner, the aperture is more rounded and less expanded transversely, and the callosity of the inner lip not so great—probably much less. (In all of our specimens of this species the mouth is obscured by an incrustation of siliceous material so that we cannot tell exactly about the callosity of the inner lip.) *B. subglobulus* is distinguished from *B. clausus* by similar differences, while the presence of a small umbilicus adds another, the umbilicus being closed in that species. In *B. bilineatus* the umbilicus is larger and the slit-band concave instead of rounded.

Formation and locality.—Black River limestone, Mercer county, Kentucky.

Collection.—E. O. Ulrich.

BELLEROPHON PLATYSTOMA *Meek* and *Worthen*.

PLATE LXIV, FIGS. 22–30.

Bellerophon (Bucania?) platystoma M. & W., 1868, Geol. Surv. Ill., vol. iii, p. 312, pl. III, figs. 8*a*, *b*.

Shell exceeding medium size for the genus, composed of about three volutions, which increase rather slowly in size until near the aperture where the last one is suddenly and greatly expanded laterally; whorls embracing very little, subtriangular in cross-section, with the dorsum strongly carinate; surface descending on each side from the keel, first with a concave then a nearly flat slope, toward the edge of the umbilicus into which it turns very abruptly; umbilicus open, rather large, about one-fourth as wide as the greatest diameter of the shell; aperture somewhat triangular-reniform, the hight a little greater than half the width, the width exceeding by nearly a fifth the greatest diameter of the shell; outer lip thin, broadly sinuate, the center of bottom of sinus prolonged into a narrow slit; inner lip apparently with but a very little developed callosity. Lines of growth sharp, rather regular, curving backward gently between the umbilicus and carina. The latter, on which we have not observed any well defined slit-band, is very prominent and almost sharp on casts of the exterior, but on casts of the interior it is not distinguishable from the general regularity of the dorsum.

We are quite confident of the specific identity of the Minnesota shells above described and the original types of *B. platystoma*, the latter having been examined by us. In Minnesota we have two varieties of the species, one, agreeing exactly with Meek and Worthen types, occurring in the Fusispira bed, the other, which is much smaller, its greatest diameter but rarely exceeding 20 mm., being a common fossil of the Clitambonites bed.

B. platystoma is closely related to *B. similis*, but may be distinguished readily enough by the different transverse section of its volutions, this being subtriangular while in the new species it is semicircular rather than triangular. When, as is often the case, the expanded aperture is broken away, the remaining whorls of *B. platystoma* remind one greatly of *Crytolites*. Similarly imperfect examples of *B. similis*, however, are scarcely distinguishable from *B. troosti*. None of the other species known are closely related, nor have we experienced any difficulty in separating *B. platystoma* from them.

Formation and locality.—The original types are from the Trenton (Galena) group at Galena and Dixon, Illinois. In Minnesota the small form is common in the Clitambonites bed at localities in Goodhue county, while the larger or typical form is not rare in the Fusispira bed at Kenyon, Holden P. O., Wykoff, Weisbachs' dam, and other localites.

Collections.—Geological and Natural History Survey of Minnesota; W. H. Scofield; E. O. Ulrich; Dr. C. H. Robbins.

Museum Register, Nos. 6765, 7399, 7449, 7463.

BELLEROPHON SIMILIS, *n. sp.*

PLATE LXIV. FIGS. 31–39.

This species is represented by about thirty casts of the interior and exterior, showing a decided constancy in its specific peculiarities. The form of the carinated volutions, indeed the general aspect of the whole shell in its usual state of preservation, is so much as in *B. troosti* that at first sight it may seem to be identical with that Kentucky and Tennessee species. A closer examination and better specimens, however, will soon prove them to be quite distinct. In the first place, the surface striations, instead of passing from each side almost straight across the back of the volutions to the carina, curve strongly backward, thereby forming a deep though wide-angled sinus in the outer lip. Next the striæ are coarser, sublamellose, more regular and not arranged in bundles as in *B. troosti*. Further, the keel grows more prominent toward the aperture and the umbilicus is larger, though this is probably due entirely to the lesser thickness of the test. Finally, the aperture is of a different shape, less expanded laterally and less contracted by the callosity of the inner lip. The callosity is much less and forms no transverse ridge at the inner part of the lip.

B. similis occupies an intermediate position between *B. troosti* and *B. platystoma* Meek and Worthen, the section of the volutions being as in the former, while all the other characters are more nearly like those of the latter. With ordinary care good specimens of *B. similis* and *B. platystoma* are not difficult to separate. *B. similis* has more rapidly enlarging and relatively fuller volutions, the dorsal part of the transverse section, if we exclude the carina, being almost semicircular, while in *B. platystoma* the slope on each side of the prominent keel is decidedly flattened. This difference in the transverse sections of the whorls we have found to be very reliable and of itself sufficient for the separation of the two forms excepting in a few cases in which the specimens were either poorly preserved or badly crushed.

It remains to be mentioned that several specimens show very faintly a number of wide revolving bands. Whether these are structural or merely accidental has not been determined. Possibly they indicate color bands.

Formation and locality.—Clitambonites and Fusispira beds of the Trenton group, Wykoff, Kenyon, and various localities in Goodhue county, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 8725.

BELLEROPHON RECURVUS, *n. sp.* (*Ulrich.*)

PLATE LXIV. FIGS. 11–13.

This species is closely related to and in some respects intermediate in position between *B. clausus* and *B. similis.* The lines of growth curve backward as in the latter, while the umbilicus is entirely closed as in the former. Compared with *B. clausus* we find that the lines of growth curve backward much more strongly in approaching the dorsal carina, and the outer lip consequently has a much deeper sinus, while the callosity of the inner lip is not so great. The aperture, as nearly as we can make it out, must be very much as in *B. troosti* (pl. LXIV, fig. 3), not so much expanded laterally perhaps. The absence of an umbilicus will distinguish the species at once from *B. similis.* None of the other known Lower Silurian species of the genus are as closely related as the two with which we have compared *B. recurvus.* Further remarks are, therefore, unnecessary, particularly since it is our wish that the student should rely chiefly upon the illustrations in seeking to identify the species of this difficult group of fossils.

Formation and locality.—So far known only from the Loraine group at Cincinnati, Ohio, where a few specimens were found near the tops of the hills.

Collection.—E. O. Ulrich.

BELLEROPHON SUBANGULARIS, *n. sp.* (*Ulrich.*)

PLATE LXIV. FIGS. 14–16.

Having no umbilicus, this species is related to *B. clausus* and *B. recurvus,* but it is distinguished at once from both by its subangular dorsum, and relatively narrower and somewhat triangular aperture. Its surface markings are rather distinct and regular; on the dorsal slopes they sweep backward gently to the carina.

Formation and locality.—Richmond group, Richmond, Indiana.

Collection.—E. O. Ulrich.

BELLEROPHON MOHRI *Miller.*

PLATE LXIV, FIGS. 44 and 45.

Shell large, last volution with the aperture abruptly and greatly expanded laterally; inner volutions of moderate size, appearing rather closely involute, having only a small umbilicus, with the slope on each side of the carinated dorsum slightly flattened; aperture somewhat semicircular in outline, much wider than high, its width comparing with the hight of the entire shell about as seven to ten; outer lip thin, the small V-shaped central emargination prolonged backward into a rather long narrow slit, which as growth continues forms the slit-band; inner lip thick, greatly expanded, extending below almost to the periphery of the outer volution; concave on each side of the latter, the inner edge thick and with a rounded central swelling which continues inwardly as a rounded ridge; inner aperture subtriangular, the inner or lateral angles rather sharp, the outer more obtuse. Surface marked by strong, regular, thread-like lines of growth, of which, on an average specimen, twelve to fourteen occur in 5 mm. The course of the striæ from the umbilicus to the slit-band is gently curved in the central half, but more strongly at each end. Slit-band very rarely preserved; when perfect it surmounts a low ridge, is of moderate width, concave, bordered on each side by a thin sharp line, and covered by more or less unequal lunulæ. In casts of the interior the umbilicus is much larger, sharply defined and very abrupt, the ventral side of the volutions appearing to be almost flat and the section of the outer one triangular.

This fine species is related to *B. platystoma* and *B. similis*, but has a thicker shell than either of the Trenton species. This shows itself especially in the much stronger development of the inner lip, and in the smaller umbilicus. As casts of the interior, in which condition all three of these species are most commonly met with, *B. mohri* may be distinguished from the others by the impression of the callosity of the inner lip which causes the umbilical cavity to appear as drawn out narrowly above. The volutions besides enlarge more rapidly, and the umbilicus, especially when compared with *B. similis*, is deeper and much more sharply defined.

Good testiferous specimens are very rare, many being distorted by pressure, and in most of them the greater part of the aperture is broken away, and the surface markings obscured by weathering or maceration. The majority, however, preserve a large part of the expanded inner lip.

Formation and locality.– Not uncommon in the upper part of the Richmond group of the Cincinnati period at Richmond, Indiana. We have it also from Lincoln county, Kentucky.

Collection.—E. O. Ulrich.

Bellerophon capax, *n. sp.* (*Ulrich.*)

PLATE LXIII, FIGS. 50 and 51; PLATE LXIV, FIGS. 40-43.

This species agrees closely with *B. mohri*, but on comparison proves to differ in a greater or lesser degree in nearly every feature. First, the volutions enlarge more rapidly, second, they are more ventricose, third, the umbilicus in casts is a trifle smaller and more rounded at the edge, fourth, the outline of the aperture is less narrowly rounded on the sides, and fifth, the cross-section of the outer volution of casts is nearer semicircular than triangular. The shell is larger, the volutions increase in size much faster, the umbilicus is smaller, and the inner lip much heavier than in *B. platystoma* and *B. similis*. When the aperture is imperfect, specimens of this species sometimes look very much as though they might be a larger variety of *Protowarthia granostriata.* Yet this is most certainly not the case, since the species possesses a slit-band and the aperture of a true *Bellerophon.* When neither of these features is preserved, then it is distinguished from the *Protowarthia* by its open umbilicus and larger size.

Formation and locality.—Lower part of the Loraine group and upper part of the Utica group at several localities in the vicinity of Cincinnati, Ohio.

Collection.—E. O. Ulrich (7 specimens).

Genus BUCANOPSIS, n. gen.

Bellerophon (part.), HALL, MEEK, DE KONINCK, MCCOY, D'ORBIGNY, and other authors prior to 1880. LINDSTRÖM, 1884, Silurian Gastropoda of Gotland.
Bucania (part.), WAAGEN, 1880, Palæontologica Indica, ser. 13, pt. 2, pp. 130 and 150. KOKEN, 1889, N. Jahrbuch f. Mineralogie, etc., Beilageband vi, p. 379.
?*Euphemus* (part.), MCCOY, 1844, Synopsis Carb. Foss. Ireland, p. 25.

For generic characters see page 853.

The greater part of the species which we propose to classify under this generic name were originally described as of *Bellerophon*, an arrangement that was quite satisfactory to paleontologists till 1880 when Waagen proposed to separate them on account of their spiral surface sculpture. In this we think he was fully justified, because extensive studies of the *Bellerophontacea* prove conclusively that the surface markings deserve a high rank among the characters that are available to the systematist who seeks to subdivide the group into natural and convenient generic sections. But, as we shall show in discussing that genus, both he and Koken, who adopts Waagen's proposition, are wrong in extending the application of Hall's *Bucania* to all the spirally striated bellerophontids. *Bucania* must be restricted to species of the type of *B. sulcatina*, which is quite different in other respects from the Devonian and later Paleozoic shells that make up the bulk of the species referred by them to Hall's genus. The surface markings even are not exactly the same in the two groups, they being straight and parallel with the direction of the whorls in *Bucanopsis* while in true *Bucania* they are wrinkled, interrupted and more or less oblique in direction.

It seems very clear to us that *Bucanopsis* was developed from *Bellerophon* and not from *Bucania.* Every character of the genus. excepting the revolving lines, corresponds with the former and is more or less different from the latter. A comparison of the figures of species described in this work alone can scarcely fail to convince students that this is really a fact, and the same must continue to grow more obvious when they extend their comparisons to Upper Silurian, Devonian and Carboniferous *Bellerophontidæ*.

Bucanopsis, if we include in it, as we must provisionally do, all the Paleozoic spirally striated shells which agree in other respects with *Bellerophon,* may not be an entirely natural genus. By this we mean that many of the later forms are probably not descended from the Trenton type of the genus. We think it possible that *Bucanopsis*-like species were evolved from *Bellerophon* not only in Lower Silurian times but at later periods as well. Again it is not unreasonable to suppose that certain developmental lines, originating in some period preceding the Trenton, may have resulted in forms that we cannot now separate satisfactorily from *Bucanopsis.*

The last possibility is suggested by Koken's remarks on the development of the shells which he erroneously places into Meek's genus *Bucanella* (see this work pages 849, 876 and 882). If he is correct in regarding *Bellerophon substriatus* Krause, and several Devonian species mentioned by him, as having descended from his Lower Silurian *B. esthona,* then the possibility is strengthened into probability; for *B. esthona* most certainly came from quite a different stock than that which produced *Bucanopsis carinifera,* while the supposed Devonian descendants are scarcely distinguishable from *Bucanopsis,* and only by the slightly greater width of their slit-bands. However, we are strongly inclined to doubt that Koken's views on the question under consideration are justified by the facts. In our opinion, *B. esthona,* as well as a corresponding American form, is quite distinct from most if not all of the others with which he connects it, and it probably represents an undescribed genus with relations nearer *Tetranota* and *Bucania* than *Bucanopsis.** On a preceding page we propose the name *Kokenia* for this new genus, and on plate LXIV figure the only known American species of this type (*K. costalis,* page 882).

B. substriatus Krause strikes us as a form that may have been developed from a species of *Tetranota* like *T. wisconsinensis.* The characters known, it is true, are insufficient to establish its affinities, yet if it could be proved that the inner whorls retain only a trace of latero-dorsal ridges, we would overlook its somewhat different surface markings and place the species with little or no hesitation under *Tetranota.* But to show the difficulty of correctly estimating the generic affinities of many of the bellerophontids from figures and descriptions above, we may say that so far nothing has been published of *B. substriata* that might be considered as thoroughly antagonistic to the view that would consider it as a modification of the Lower Silurian *Protowarthia,* in which delicate revolving lines are also often present. The broad apertural sinus reminds one strongly of *Protowarthia,* and when it comes to the tripartite character of the shell, which character in connection with another about to be considered led Koken to place these species with *Bucanella, B. substriatus*

*It is to be mentioned that Koken very properly places *B. esthona* in the immediate vicinity of *Bucania* or, as we call it, *Tetranota bidorsata.*

resembles *Protowarthia granistriata* more closely in this respect than either *Bucanella trilobata* Conrad sp., or *Kokenia esthona*.

The longitudinal striation, unusual width and elevation of the slit-band, the last feature producing an obscure tripartite character to the shell, seem to be the principal characters upon which Koken bases his conception of *Bucanella* as distinct from *Bucania*, which with him included *Bucanopsis*. These features he finds in his *B. esthona*, Krause's *B. substriatus* and in several other Silurian and Devonian shells which he assumes to be related to species upon which Meek founded *Bucanella*. This assumption, however, is totally unwarranted, and in the absence of sufficient evidence to prove his point Koken should not have charged Meek with an incorrect description.

The elevation of the slit-band in the group of species under consideration is probably not of much consequence, though usually present. Its unusual width, however, may be of importance but we see no way of utilizing it at present. The extension of the revolving lines over the slit-band also seems to us to be of little value. We came to this conclusion because they may be present in one and absent in the other of two closely related species. For instance, in *Bucanopsis textilis* Hall (not De Koninck sp.), of the Warsaw or St. Louis group, the slit-band seems always to be without revolving lines, but in an undescribed form recurring in the Chester group of Kentucky, and which can scarcely be distinguished, such lines are clearly present. We find them also in *B. leda* Hall, while they are absent in the closely related *B. lyra* Hall. Then they are developed again in some of the Carboniferous species, notably *B. marcouiana* Geinitz, *B. ellipticus* McChesney, and *B. montfortianus* Norwood and Pratten, the last belonging to the *Bellerophon patulus* group of species. It seems to us, therefore, unreasonable to accord any more than specific importance to the presence or absence of these lines.

There is another assertion made by Koken to which we must take exception. He says that *B. esthona* is "obviously a combination of the characters of the so-called *Euphemus* and *Bucania*." This observation is so totally at variance with our own opinion that we are almost at a loss to answer it except with a simple contradiction. He is most assuredly far from the truth if he means to imply that the revolving ridges of *Euphemus*, which we cannot for a moment doubt are really folds of an extension of the inner lip, are in any way comparable with the spirally ribbed external surface sculpture of *Bucania* and *Bucanopsis*.

BUCANOPSIS CARINIFERA, *n. sp.* (*Ulrich.*)

PLATE LXII, FIGS. 56–61.

Shell less than medium size, the hight varying in thirty-five specimens between 7 mm. and 15 mm.; width of aperture nearly or quite equal to the hight. Volutions two or two and one-half, rather closely coiled, embracing to a little more than one-half, with a strong, prominent, flat-topped dorsal keel, from which the surface descends in a wide concave slope; sides rounding somewhat narrowly into the small open umbilicus; section of volutions broadly cordate. Aperture broad, somewhat triangular-ovate in outline; outer lip thin, with a moderately deep V-shaped central emargination; inner lip thick, very wide, reflected laterally, extending downward over the preceding volution whose keel shows through very distinctly. Surface with fine straight revolving striæ, alternating somewhat in strength; transverse or growth lines, excepting an occasional wrinkle, usually very faint, but on the larger specimens they become much stronger and incline to be irregular. Slit-band flat, smooth so far as known.

This, the type and only known Lower Silurian representative of the proposed genus *Bucanopsis*, reminds one somewhat of the European *B. substriatus* Krauss, but the dorsal carina is much more prominent and the slit-band narrower than in that rather doubtful Upper Silurian species. None of the Gotland species of the genus have the dorsum carinated. Of Lower Silurian *Bellerophontidæ*, *Bellerophon troosti* and *B. platystoma* are somewhat similar, but as the former has more rounded volutions and the latter quite a differently shaped aperture, there is little likelihood of confusion between them even as casts. Being true bellerophons they have of course no revolving lines, while the carina is never so prominent as in *Bucanopsis carinifera.*

We have about fifty specimens of what we take to be the same species from the Loraine group at Cincinnati, Ohio. They are, however, smaller than the Trenton form, the hight being in most cases less than 7 mm. and in only one as much as 10 mm. Not one of them exhibits even a trace of surface markings although preserving the shell, or rather a replacement of the same in crystalline calcite. But the absence of surface markings on these specimens should not be considered as proof that they were originally without them, since they are wanting also on all the other *Gastropoda* occurring in association with them. Among these other forms are well known species of *Lophospira* and *Cyrtolites ornatus,* the surfaces of which under more favorable conditions are always distinctly sculptured.

Formation and locality.—Upper part of Trenton group, near Danville, Kentucky; Loraine group of the Cincinnati period, Cincinnati, Ohio.

Collection.—E. O. Ulrich.

Genus CARINAROPSIS, Hall.

Carinaropsis, HALL, 1847, Pal. New York, vol. i, p. 183.
Phragmostoma, HALL, 1861, Fourteenth Rept. N. Y. St. Cab. Nat. Hist., p. 94; not Waagen, 1880, Pal. Indica, ser. 13, pt. 2, p. 131.

For generic characters see page 857.

This is a well-marked genus, and one that we find it difficult to place satisfactorily in our scheme of classification. Taking the small inner volution alone, we are reminded sometimes of *Cyrtolites*, at other times of *Oxydicus*, but the whole shell with its greatly expanded and peculiarly constructed aperture, is so widely different from these genera that, with our present knowledge, we cannot think even for a moment of seriously comparing them. There are perhaps better reasons for bringing the genus into connection with *Bellerophon*, there being in reality scarcely a single—if indeed any—feature of *Carinaropsis* that is not also present in some form or other in species of that genus. Thus, picking out the more essential characters of *Carinaropsis*, an expanded aperture is frequently present in *Bellerophon*, though the inner volution or volutions are never minute as in *Carinaropsis*, the inner lip is often thickened within into a blunt ridge (e. g. *B. troosti*) but the ridge is never developed into a projecting wide plate; then the volutions are often carinated, though but rarely, if ever, so distinctly as the smaller volution of *Carinaropsis*. Finally, the shells of both genera have a slit-band and a sinus in the outer lip. Though their features on the whole are the same in kind, they still differ so greatly in development that, especially when resemblances in very different directions are considered, we are more than satisfied that *Carinaropsis* represents a distinct family.

We have already alluded (see page 857) to certain striking agreements in structure existing between *Carinaropsis* and *Pterotheca*, a genus of Silurian shells that all authorities now place with the *Pteropoda*. In both of these genera the aperture is broadly expanded, a septum is developed, and the back is carinated, in each case more strongly in *Pterotheca* than in *Carinaropsis*. But while in the latter the shell forms as much as two volutions, in the former it is merely arcuate, the curvature in no case amounting to a single volution. Though the differences between the two genera are doubtless important, are we not so far justified in claiming that *Pterotheca* is not farther removed from *Carinaropsis* than this genus is from *Bellerophon?* We say "so far" because *Pterotheca* possesses one character that is not represented in *Carinaropsis* nor in any true member of the *Bellerophontacea*. Namely the apical extremity of *Pterotheca* is divided by two small vertical septa into three portions of which the central one is longer and somewhat wider than the lateral ones.

Granting for the present that *Pterotheca* is a pteropod, we look in vain among the other types of that sub-class of shells for anything corresponding to the trifid apex of *Pterotheca.* We conclude, therefore, that the peculiarity is of generic importance only, and consequently not a serious objection to an arrangement which, in following the suggestion of the other characters, would bring *Carinaropsis* and *Pterotheca* within the limits of the same order and family. According to our opinion this family will prove to belong to the *Docoglossa* and not to the *Pteropoda.*

CARINAROPSIS CUNULÆ *Hall.*

PLATE LXII, FIGS. 10–13.

Carinaropsis (*Phragmostoma*) *cunulæ* HALL, 1861, Fourteenth Rept. N. Y. St. Cab. Nat. Hist., p. 94.

Shell 20 mm. to 25 mm. in width, the length of the largest specimens about 20 mm., the hight of the same about 10 mm.; consisting of two or two and one-half volutions, the last abruptly expanded. Dorsum angular, or slightly carinated on the small volution, the angle becoming gradually more and more obtuse toward the deeply emarginated anterior edge, where it may be quite obsolete and in some specimens replaced by a broad flattened slit-band. Umbilicus small but distinct and deep. Aperture broadly subovate, insinuated in front and somewhat truncated behind; posterior lip reflected. Septum broad, extending about two-fifths across the aperture from the edge of the posterior lip, nearly twice as wide as long, its anterior edge somewhat thickened and slightly arched; behind the edge, which is nearer the plane of the apertural margin than usual, the outer surface is moderately concave. Inner surface of septum distinctly carinate, with a slight continuation of the same feature on the outer side. Inner aperture subtriangular or semi-elliptical, closed by a nearly flat operculum. Surface marked by fine lines and more or less obscure varices of growth.

This species differs from *C. cymbula* Hall in having the first volutions larger and projecting farther beyond the posterior lip, which again is more abruptly deflected, but the best difference lies in the septum whose outer surface is much less excavated in this species.

Formation and locality.—Upper part of Trenton group, Nashville, Tennessee, and Boyle county, Kentucky.

Collection.—E. O. Ulrich.

CARINAROPSIS CYMBULA *Hall.*

PLATE LXII, FIGS. 1–4.

Carinaropsis (*Phragmostoma*) *cymbula* HALL, 1861, Fourteenth Rept. N. Y. St. Cab. Nat. Hist., p. 94.
Phragmostoma natator (in error for *cymbula*) HALL, 1862, Fifteenth Rept. idem., pl. VI, figs. 12–14.

Volutions one and a half or two, the first very minute; posterior margin of aperture not reflected, causing an unusual depth between the lip and the edge of the septum; edge of septum scarcely thickened, the whole outer surface of septum nearly smooth. In other respects like *C. cunulæ*. The great excavation of the septum is the principal peculiarity of the species.

Formation and locality.—Top of the Trenton group, near Danville, Kentucky. The original types of the species are said to have come from the Hudson River group, but this is probably an error.

Collection.—E. O. Ulrich.

CARINAROPSIS PHALERA *Sardeson.*

PLATE LXII, FIGS. 14–18.

Carinaropsis (or *Bellerophon*) *phalera* SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, no. 3, p. 336.

This form is very near *C. cunulæ* Hall, the only differences that we can now see being the apertural margin which is less reflected and scarcely truncated posteriorly, giving a more nearly circular outline and greater depth to the concavity of the septum. Mr. Sardeson mentions "indistinct radiating folds on the dorsal surface" of one of his specimens (a cast), but we have failed to notice anything of the kind.

Formation and locality.—Black River group, Rhinidictya and Ctenodonta beds, St. Paul, Minneapolis Chatfield, Minnesota.

Collections.—E. O. Ulrich; original types in the cabinet of the geological department of the University of Minnesota.

CARINAROPSIS ACUTA, *n. sp.*

PLATE LXII, FIGS. 6–9.

Shell very delicate, the largest about 27 mm. in length, but the majority of the specimens before us, perhaps because of imperfection, are only from 3 to 11 mm. in length. Volutions about three, the inner ones very small, greatly compressed, and very sharp on the dorsum, the last expanding very rapidly. As the dorsal angle becomes gradually less acute and the rate of expansion of the volutions increases, the aperture changes from triangular to subcircular. Septum comparatively short, the edge much within the plane of the apertural margins. Posterior lip not reflected. Surface, so far as observed, quite smooth.

This differs from the preceding species in the greater compression and much sharper dorsal angulation of the inner whorls, and in the much shorter septum.

Formation and locality.—Black River shales, Rhinidictya and Ctenodonta beds, Cannon Falls, and near Fountain, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 7534.

CARINAROPSIS MINIMA, *n. sp.*

PLATE LXII, FIG. 19.

Shell very small for the genus, the width of the aperture about 8 mm. in a specimen having a length of 6 mm. and a concavity of about 4.3 mm. Dorsum only moderately acute at first and becoming gradually quite obtuse. Surface with several comparatively strong lines or wrinkles of growth.

Of this species we have seen only the small specimen figured on plate LXII. At first we thought it might be an immature example of *C. phalera*, but a more careful comparison proved conclusively that so great an expansion of the aperture could not have occurred in the young of that species. Indeed, the expansion of the aperture is a sign of maturity in this genus, and that this condition has been reached by the specimen in question is further indicated by the strength of the lines of growth which mark its surface where the latter is in good preservation. If these indications are trustworthy then the species will be distinguished very readily from all the others known of the genus by its small size.

Formation and locality.—Black River group (Ctenodonta bed) near Cannon Falls, Minnesota.
Collection.—E. O. Ulrich.

CARINAROPSIS EXPLANATA, *n. sp.* (*Ulrich.*)

PLATE LXII, FIG. 5.

Shell large, volutions apparently less than two, the first very small, the next greatly expanded; hight only about one-third of the width; umbilicus very small; dorsum angular. Aperture not well preserved, apparently transversely subelliptical, and somewhat broadly sinuate in front; posterior lip little if at all reflected. Septum large, curved inward, the inner edge about 18 mm. long in a specimen 38 mm. wide. Surface of casts with obscure varices of growth.

The width is relatively greater than in any of the other species. The outer surface of the septum is less deeply concave and its anterior edge farther within the plane of the apertural margin than in *C. cymbula*, which it resembles perhaps more closely than the others.

Formation and locality.—Upper part of the Trenton group, Covington, Kentucky.
Collection.—E. O. Ulrich.

Subclass PROSOBRANCHIATA.

Order PECTINIBRANCHIATA.

Suborder EOTOMACEA.

This proposed suborder is made up chiefly of four families of shells that are perhaps the most important of all to the paleontologist, namely, the *Raphistomidæ*, *Pleurotomariidæ*, *Euomphalidæ* and *Trochidæ*. Besides these it should include other families, as for instance the *Fissurellidæ* and *Haliotidæ*, which were most probably derived from the *Pleurotomariidæ*, provisionally also the *Maclureidæ* because of their evident relations to the *Euomphalidæ*. Then we include also the *Turbinidæ* because their early Paleozoic prototypes can be shown to have very close relations with unquestionable members of the group, while of their recent representatives it is well known that they are not greatly different from the *Trochidæ*.

We find it most difficult to designate the characters of the shell which may fairly be said to be peculiarly characteristic of the group. Perhaps such characters do not exist,—at any rate we shall not now attempt to point them out. For the present it must suffice to say that the suborder rests principally upon observations which we regard as proving the common origin of the four families first mentioned. These observations will appear in the course of our remarks on the families known to have representatives in the Lower Silurian rocks of Minnesota.

Family RAPHISTOMIDÆ, n. fam.

This family includes shells which we regard as the best known representatives of the original stock from which the *Euomphalidæ*, *Pleurotomariidæ* and *Trochidæ* were almost simultaneously evolved. The position of the majority of the forms is intermediate between the first two families, leaning toward the second rather than the first, while the rest compare better with types that we place as early representatives of the last family, particularly with certain of the Upper Silurian shells which Lindström refers to the recent genus *Trochus*.

The most persistent character of the *Raphistomidæ* is one that at first may seem almost trivial, but because of its persistency it is justly entitled to rank as important. Namely, the lines of growth on the upper side of the whorls, which of course correspond in direction with the outline of the upper lip of the aperture, though directed on the whole backward, are curved sigmoidally, thus causing a usually very slight sinus in the outer part. The curvature is never strong and is perhaps best developed in *Raphistoma* in which the point at which the change in direction of the curve occurs is usually marked by a slight seam-like line or interruption. In *Raphistomina* and *Euomphalopterus* the sigmoid character of the curve is always distinguishable but there is no intermediate interruption.

A true slit-band does not occur in any of the *Raphistomidæ*, yet it would be quite reasonable to consider the angular or lamellar periphery of the whorls as its representative. Or it may be that the slightly sinuate outer parts of the lines of growth on the upper side of the whorls are homologous with the lunulæ crossing the band of true *Pleurotomariidæ*. Still, the evidence at hand is insufficient to establish either view. For the present then we have two well marked differences between the shells of the two families that may be utilized even should the suggested homologies admit of demonstration. The first of these differences lies in the absence of an apertural slit and the resulting slit-band, while the second may be expressed by saying that the retral sweep of the lines of growth in the *Pleurotomariidæ* is never diminished but, on the contrary, is nearly always increased just before reaching the band, while in the *Raphistomidæ* it is decreased and often overcome entirely on the peripheral carina. In cases like *Euomphalopterus alatus*, in which the carina is extremely developed, the second curve is again overcome by a third which is strongly retral. The last, it seems to us, has no further significance than the preservation from injury of the anterior outer angle of the carina which would have been exceedingly liable to breakage if the second curve had continued.

We place here in all five genera. The position of the first three we regard as unquestionable, the fourth, *Omospira*, differs very decidedly from the rest in the rounded form of its volutions and relatively high spire, while the fifth, *Scalites*, is doubtful because there is yet much to learn respecting its most important characteristics. If the last should prove to have the really essential features of the family then its systematic position would most likely be between *Raphistoma* and *Omospira*. All of these genera have heretofore been placed with the *Pleurotomariidæ*. For general remarks on them, farther than those about to follow, the reader is referred to our discussion of that family on a subsequent page.

RAPHISTOMA, Hall, 1847.* Shell sublenticular or plano-convex, the spire flat, the sutures close; volutions triangular in section, sharply angular and generally thin at the periphery; there is neither a slit nor a band; umbilicus varying in size but nearly always present; aperture turned backward slightly so as to form a shallow notch at the outer angle; lines of growth only; on the flattened upper surface these are slightly sigmoid and usually interrupted by a raised line between the two

* Pal. New York, vol. i, p. 28.

curves; passing over the acute edge they turn strongly forward and finally back again into the umbilicus. Types, *R. staminea* and *planistriata* Hall.

RAPHISTOMINA, n. gen. Shell lenticular to depressed conical, umbilicated; volutions sharply angular and carinate at the periphery, the carina projecting over the but slightly impressed sutures; aperture very little oblique, subrhomboidal; upper lip directed backward with a gently sigmoid curve, the sutural half convex, the outer half concave, the extreme outer angle slightly hooked; outline of lower lip varying from concave to convex, in the latter being almost parallel with the upper; lines of growth moderately distinct, not interrupted on the upper side of the whorls. Type, *Raphistoma lapicida* Salter.

EUOMPHALOPTERUS, F. Roemer, 1876.* Shell trochoid or subturbinate, broadly umbilicated, consisting of six or seven volutions rounded in section internally; carina thin, very wide, placed between the middle and the base of the whorls, enclosing numerous small tubular spaces running obliquely forward and outward and somewhat at variance with the lines of growth, and opening along its outer edge; aperture rounded, very oblique, the lower lip deeply and broadly sinuate; the lines of growth make a sigmoid curve between the umbilicus and the outer edge of the carina, the extent of the outer curve varying with the species and depending upon the width of the carina; on the upper side of the whorls they are curved less strongly and on the inner part in an opposite direction from that observed on the base, the result being that in a species like *E. undulans* Lindström sp., in which the carina is comparatively narrow, the anterior edge of the aperture, as viewed from above, is a gentle sigmoid, while in a widely carinated form like *E. alatus* the edge is biconvex, being recurved at the outer extremity. Type, *E. alatus* Wahlenberg sp.

OMOSPIRA, n. gen. Shell somewhat elongate turbinate, subturriculate; volutions seven or eight, ventricose, obliquely flattened in the upper part by an obtuse shoulder-like angulation; the latter, which may or may not constitute the periphery of the whorls, forms the outer margin of a wide band-like space in which the lines of growth, which first curve strongly backward in their course from the suture line, are turned in the opposite direction; a short distance before reaching the angle the curve is sharpened; as in *Raphistoma* the junction between the two curves is marked by a thin line, while beneath the outer angle the lines of growth are turned somewhat gently forward. Aperture somewhat quadrate-triangular, its hight slightly greater than the width, narrowly rounded but not effuse below; columellar lip rather straight, not thick, usually reflexed so as to hide a minute umbilical perforation. Surface markings consisting of fine lines of growth only. Type, *O. laticincta*, n. sp. (Ulrich.)

* Leth. Geogn., Ed. 4, pt. 1. pl. xiv, fig 9.

?SCALITES, Emmons. Shell turbinate, spire only moderately high; whorls flat above rising step-like one above the other, sharply angular at the periphery, produced below; no umbilicus; aperture subtriangular, apparently drawn out below; columellar lip rather thick, slightly twisted. Surface markings and form of outer lip unknown; probably as in *Omospira* and *Raphistoma*. Type, *S. angulatus* Emmons.

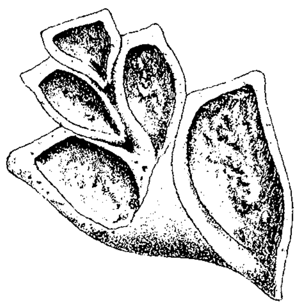

FIG. 4.—*Scalites angulatus* Emmons, Chazy limestone, Chazy, New York. View of a weathered specimen, imbedded in stone, showing part of the upper whorls in section and the umbilical region and slightly twisted columellar lip. Received from Prof. H. M. Seeley and now in the collection of E. O. Ulrich.

The accompanying figure shows nearly all we could learn of this genus and species. The general form reminds one of certain species of *Lophospira*, but we are certain that the angular periphery of the whorls does not carry a band as in that genus. Unfortunately, neither the original types nor, so far as known, any of the specimens discovered since, afford any positive knowledge concerning the form of the outer lip and surface markings. Although we believe that these characters will prove to be essentially as in the preceding genera of this family, we must admit that the question is complicated by the marked resemblance which *S. angulatus* bears to *Holopea supraplana*. For the present then the name *Scalites* should be restricted to the species to which it was originally applied.

Of these five genera *Euomphalopterus* is the most recent, being perhaps entirely an Upper Silurian type. The others with a few doubtful exceptions, are confined to Lower Silurian deposits. *Raphistoma* begins with several species in the Chazy and continues to the top of the Cincinnati period; *Raphistomina* is known in the Trenton, Black River and Calciferous formations, and we have reason to believe that the type reaches as far back as the Cambrian; while *Omospira* comprises Black River and Trenton species and perhaps a single Upper Silurian form. *Raphistomina* strikes us as the most primitive of the four Lower Silurian types and we feel reasonably satisfied that the others were evolved from it. *Raphistoma* was produced by flattening the spire, and by the anterior prolongation of the central portion of the lower lip, the latter modification causing the hook of *Raphistomina* to be replaced by a notch in the upper side of the outer angle of the aperture. *Euomphalopterus* differs chiefly in its more rounded volutions, and excessively developed carina. The lower lip also has become more strongly and constantly sinuate, causing a more oblique aperture. The evolutional modifications, it will be noticed, are almost exactly opposite in the two cases. As to *Omospira*, it was most probably derived from *Raphistoma*, or from some unknown allied type. The relations and differences existing between *Raphistoma*, *Raphistomina* and *Euomphalopterus* are clearly shown by the figures in the accompanying cut:

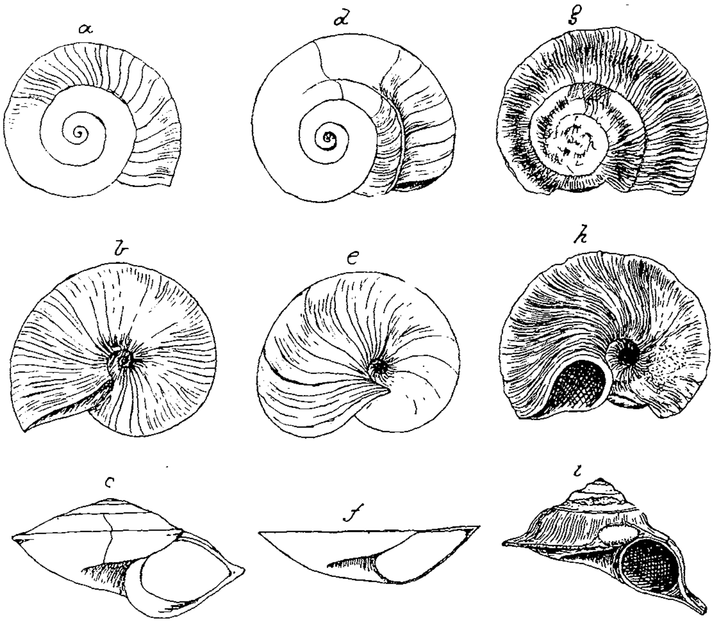

FIG. 5.—Sketches illustrating the character of *Raphistomina*, *Raphistoma* and *Euomphalopterus*. *a*, *b*, *c*, three views of *Raphistomina lapicida* Salter sp.; *d*, *e*, *f*, similar views, × 2, of *Raphistoma peracutum*, a depressed but otherwise very typical species of the genus; *g*, *h*, *i*, similar views of *Euomphalopterus alatus* var. *obsoletus*, n. var. The last is from the Niagara group near Waldron, Indiana, and is the only American representative of this peculiar genus known. It differs from the European varieties of the species chiefly in wanting the ridge which surrounds the umbilical cavity in those forms. The umbilicus in our variety is also a trifle narrower than usual.

Raphistoma, Hall, that long misunderstood and much debated genus, is now for the first time since 1847 correctly interpreted, limited and placed. Justice demands that Prof. James Hall, the author of the name, should be credited with having given a diagnosis that is strictly correct and sufficiently detailed to satisfy even the present requirements. He noticed and says distinctly that his *Raphistoma* has no band, and this fact of itself should have been accepted as fully justifying a separation from *Pleurotomaria*. Instead we find that authors have generally regarded his genus as indistingishable from *Scalites* Conrad, and both as synonyms of *Pleurotomaria*. Salter,* it is true, gives *Raphistoma*, together with his *Helicotoma* and Vanuxem's *Ophileta*, the rank of subgenera under *Scalites* (which he refers to the *Ianthinidæ*), and distinguished them from *Pleurotomaria* because of the absence of the spiral band. However, as we will show later on, *Helicotoma* and *Ophileta* are

* Canadian Organic Remains, dec. 1, p. 10, 1859.

euomphaloids and therefore quite different genetically from *Raphistoma*, while *Scalites* is not sufficiently known to be placed satisfactorily.

It is not worth while to review the literature of the genus that appeared during the time included between the years 1859 and 1890. It will suffice to say that the name gradually attained a somewhat precarious standing among American paleontologists as a convenient designation for lenticuliar shells which in other respects were supposed to be of the type of *Pleurotomaria*. Taking Miller's list of species referred to *Raphistoma** as a fair example of the use to which the genus had attained in recent years, it is evident that it is truly an incongruous assemblage. Of the nineteen species probably only the three originally referred to the genus really belong there. The others belong mostly to our new pleurotomarian genera *Eotomaria* and *Liospira*, and to *Raphistomina*, while several are too ill known to justify a definite arrangement under any genus.

In 1890† Koken endeavored to establish *Raphistoma* and to show its relations to *Pleurotomaria* on the one side and *Euomphalus* on the other. His effort has not proved entirely successful because he failed to grasp fully the essential peculiarities of the type species, *R. staminea*.‡ Unfortunately we cannot follow his arguments as closely as we would like, hence we are not quite certain that our objections to his statements are always fully justified. The main point, however, is that he holds to *Raphistoma* as a good genus. According to our views he should have gone a step farther and removed the genus entirely from the *Pleurotomariidæ*. The absence of a true slit-band alone seems to us fatal to a reference of *Raphistoma* to that family, and it is surely so when coupled with the rather obvious relations in which the genus stands with *Eccyliopterus* and *Eccyliomphalus* on the one hand and *Helictoma* on the other. Still, we are inclined to believe that Koken has overestimated the closeness of the line of the development which he seeks to establish between *Raphistoma* and *Eccyliopterus*.

Koken's observations are based chiefly upon European specimens which he has identified with *Raphistoma* in accordance, as he believes, with Hall's description of the genus in the first paleontological volume of the New York Survey. He starts with Schlotheim's *Euomphalus qualteriatus* which he regards as the European representative of our *R. staminea*. Considering the great variety of shells that have been referred to the species *qualteriatus*, it is to be regretted that Koken did not

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*North Amer. Geol. and Pal., p. 424, 1889.

†N. Jahrb. f. Mineralogie, etc., Beilagebd. vi, p. 315.

‡It is customary to cite *Maclurea striata* Emmons, as the type of *Raphistoma*, probably because the description of that species is the first to follow the generic description. From Hall's remarks under *R. staminea* (*op. cit.*, p. 29) it is quite evident that this is a mistake, for he says distinctly that "the generic character" was but "obscurely indicated upon" the *striata*. Besides, neither Emmons nor Hall refer to the character in their descriptions of the species, while the latter is very particular in showing its presence in *R. staminea* and *R. planistria*, going so far even as to use a wood-cut because it was not sufficiently brought out on the plate.

publish good figures of the form that alone is entitled to bear the name. Under the circumstances we are unable to decide whether it is a true *Raphistoma*. But we will concede for the present that it is. The second species is a new one which he calls *R. schmidti* and compares with the American *R. striatum.* This strikes us as not a true *Raphistoma,* the striæ upon the upper sides of the whorls curving backward too strongly and being neither interrupted nor sigmoidally curved. The figure (*op. cit.*, pl. XI, fig. 7) represents the shell as preserved on the inner volutions only, but a small peripheral rim or "collar" is rather distinctly indicated so that the species may be an undeveloped and closely coiled *Eccyliopterus* or an unusual type of *Helicotoma*. The remaining species constituting the supposed phylum (*Euomphalus marginale* Eichwald, *Raphistoma spirillum* Koken, *Pleurotomaria replicata* Lindström, and *Eccyliopterus alatus* Roemer, sp.) are doubtless all good species of *Eccyliopterus* and not *Raphistoma* at all.

In constructing the line Koken seems to assume that the other characters are equal, and then to depend upon the gradual sinking of the spire and on the increasing freedom of the whorls. Neither of these conditions, however, appears to us of material consequence in the case, both pertaining strictly to the *Eccyliopterus* end of the line and neither occurring ever in any true *Raphistoma.* Further, we doubt very much that *Raphistoma* and *Eccyliopterus* represent different stages of one and the same line of development, nor have we met with any evidence that might cause us to believe that the distinction between the two is ever likely to become arbitrary or artificial ("eine künstliche"). Finally, according to our opinion, the validity of *Eccyliopterus* will be determined not so much by its relations to *Raphistoma* as by its connection with *Ophileta* and *Helicotoma* and possibly *Eccyliomphalus.**

We find that *Eccyliopterus* is very closely related to the latter genera, only one so far constant peculiarity separating it in either case. The feature alluded to is the prominent thin plate into which the notch-keel is produced and which surmounts the top of the whorls like a high "collar." On seeing a shell like the Calciferous *Eccyliomphalus volutatus* Whitfield, which, from a careful study of a series of specimens recently sent us by Prof. H. M. Seely, we have determined to be a true *Eccyliopterus*, the first impression would naturally be that the genus is a very near relation to *Eccyliomphalus*. And so it may be, yet, if for a moment we leave out of sight the fact that its whorls are widely disconnected, and consider only the other characters, it will soon become obvious that the balance of agreements lies on the side of *Ophileta* rather than *Eccyliomphalus*. The whorls of *E. volutatus* are flattened on the lower side, although casts of the interior are rounded here, the shell

*When we say *Eccyliomphalus* we are to be understood as referring to shells of the type *E. intortus* and *canadensis* of Billings and *E. undulatus* Hall, which with other species form a distinct and natural group that it is presumed will include also Portlock's original types of the genus. At any rate, they are so nearly like them that, without more certain knowledge respecting Portlock's species, it is not safe to separate them.

being thickened at the outer and inner corners. This agrees with *Ophileta*, as does also the form of the aperture, and the course of the lines of growth. Finally, the position and character of the "collar" is certainly much more like the notch-keel of *Ophileta* than the more obtuse keel or angulation which marks the position of the rather broad and more shallow upper sinus in *Eccyliomphalus*.

Loosely coiled or disconnected whorls we do not consider as an essential characteristic of *Eccyliopterus*. All the species may perhaps exhibit a proneness to assume such a condition but it is certainly not very apparent in any of the American species. Of the latter, *E. volutatus* Whitfield sp., (see plate LXXIV) is the only one known to us having all the whorls separate, and it is doubtless closely related to the European *E. alatus* Roemer sp., the type of the genus. Then we have *E. triangulus* Whitfield sp., also from the Calciferous at Providence island and Fort Cassin, Vermont, which is exceedingly like the Swedish *E. replicata* Lindström sp., especially when it has the inner whorls in contact. The next species, our *E. beloitensis*, is from the Stones River group. It, like the preceding, has a representative in Europe, being apparently very similar to *E. marginalis* Eichwald sp. All the whorls are in contact in this species excepting occasionally the apertural portion in old examples. The fourth American species is the *Ophileta ottawaensis* of Billings, from the Trenton of Canada, while the fifth and, so far as known, the last is the *Ophileta owenana* of Meek and Worthen, casts of which are not uncommon in the Trenton group of Minnesota and Illinois. In both the whorls are always in contact. From the foregoing statements it is evident that, in the development of the genus from the Calciferous on, the evolute or free character of the whorls became gradually less and finally was lost entirely. All the other characters, however, are maintained with rare persistency.

If *Eccyliopterus* and *Raphistoma* are sections of the same line of development, then the evidence of their geological distribution indicates the former as the parent stock and not the latter, since *Raphistoma* occurs so far as known first in the Chazy when *Eccyliopterus*, which enjoyed its greatest development in the Calciferous formation, had already begun its decline. We do not wish to deny that much may be said in favor of such a derivation of *Raphistoma*, still we are confident that the modifications required are more difficult to prove and altogether less rational than in the view which derives the genus from *Raphistomina*. Billings has described a number of low-spired Calciferous and Quebec species among which we expect to find links connecting the last genus with the Chazy *Raphistoma*. His *Pleurotomaria hortensia* and *Pl. harpya* promise the required conditions.

In *Raphistoma* the spire of the upper side varies from flat to gently convex, but so far as we have observed, it is never sunken; the keel forms the periphery and is directed outward instead of upward; the umbilicus is always smaller, and the section of the whorls consequently different; finally, there is always an interruption or peculiar bend in the backward sweep of the surface striæ on the flat upper side of the whorls, the like of which we have never seen in any *Eccyliopterus*. The last peculiarity we have observed in only three other groups of species that have been referred to the *Pleurotomariidæ*, namely, the Upper Silurian *Euomphalopterus*, Roemer, a good genus that will include the majority if not all of Lindström's section *alatæ* of *Pleurotomaria*; our *Raphistomina*, founded upon Lower Silurian shells of the type of *Raphistoma lapicida* Salter; and our *Omospira*, which differs from *Raphistoma* chiefly in forming a high spire and in having much less angular whorls.

For the present we must take a decided stand against the view held by many paleontologists and definitely expressed by Koken (*op. cit.*, p. 315) that the developmental series in which *Raphistoma* was continued ended in unquestionable pleurotomarians. On the contrary so far as our observation permits of judgment, *Raphistoma* is a sharply limited type, in no case taking on pleurotomarian characters, and one that is entirely restricted in its geological range to the rocks lying beneath the base of the Upper Silurian. As may be seen from our *R. richmondense*, which is from the uppermost division of the Cincinnati period and the most recent species of the genus known, the generic type underwent exceedingly little modification from the first to the last. Nor have the changes been in any respect toward the *Pleurotomariidæ*. We admit, however, that a more complete knowledge of the Calciferous *Gastropoda* is necessary before it will be possible to reach perfectly satisfactory conclusions respecting the origin and development of *Raphistomina* and *Raphistoma* and their true relations to the equally ancient euomphaloid and pleurotomarian genera *Eccyliopterus* and *Helicotoma*, and *Liospira, Euconia, Eotomaria* and *Lophospira*. All these genera represent, in a measure, contemporaneous lines of development, often exhibiting very nearly parallel, or at any rate similar, series of modifications. But this does not necessarily imply that they pass into each other, not that there is any very close relationship amongst them. They may have merely given expression to characteristics and tendencies which they inherited in common from a remote ancestor.

If genetic relations exist between the *Raphistomidæ* and *Pleurotomariidæ*, and this is a condition that we believe will some day be demonstrated, then the faint sinus in the outer part of the upper lip may prove to be an undeveloped or incipient representation of the much narrower and deeper apertural notch of the early pleurotomarians. In that case Koken's view of the carina of *Euomphalopterus* (*op. cit.*, page 318) which he gives in opposition to Lindström, who regards it as homologous with the slit-band of the *Pleurotomariidæ*, would be correct in so far as the shells are concerned which we regard as *Pleurotomariidæ*. But he is certainly in error when he denies homology between the carina of the group of *Pl. alata* (*i. e. Euomplalopterus*) and of *Raphistoma* and *Raphistomina* on the one hand, and the "collar" of *Eccyliopterus* on the other. On later pages of his valuable work (438, 439) Koken compares the genus *Euomphalopterus* with *Delphinula* and particularly with the so-called *Solarium caillaudianum* of d'Orbigny, a Mesozoic shell. The agreement of the latter with *E. alatus* is exceedingly close, and we are quite willing to admit the justice of his comparisons because they accord so well with our view that the *Trochidæ* and *Onustidæ* were derived, like *Euomphalopterus*, from descendants of *Raphistomina*.

In his most exemplary work on the "Silurian Gastropoda of Gotland" Lindström describes and most beautifully illustrates a large number of shells which he refers to *Trochus*. A comparison of the figures, excepting *T. profundus* and *T. cavus*, is calculated to give the impression that the whole assemblage represents numerous and very diverse specific modifications of a single generic type. And yet it is possible to pick out several groups that may be brought into very plausible connection with widely different Lower Silurian types. Thus, the group of which *T. lundgreni* is the central form, with *T. astraliformis* and perhaps *T. stuxbergi* and *T. gothlandicus* on one side and *T. incisus* on the other, we regard with much confidence as derived from *Raphistomina; T. wisbyensis, T. lamellosus, T. fulminatus* and *T. dalli* remind one in all respects, excepting that their apertures are more oblique, of some of the smaller species of *Trochonema* figured in this work; finally we are so greatly impressed with the similarity between *T. mollis* and our *Cyclonema transversum*, that we can scarcely concede that they are not genetically related.

Now, with respect to these Gothlandic *Trochus*-like shells, the closeness of the resemblance existing between them may be explained in two different ways. The first, starting from the almost demonstrable assumption that the *Trochidæ* and *Turbinidæ* have been derived from an early type of *Raphistomina*, considers them as a great display of varietal or specific modifications of a single type, the varieties severally taking on more or less of the distinctive features of previously established lines that had their origin in the same ancestral stock. According to the second explanation the groups of species mentioned in the preceding paragraph are actual descendants respectively of *Raphistomina*, *Trochonema* and *Cyclonema*, which, because they lived under the same conditions, or for some other unknown cause, assumed similar characters with their neighbors, the gradual convergence of characteristics resulting in a series of forms that to many may seem almost inseparable. Both of these explanations are theoretically correct, and although we are inclined to accept the second as the most rational, it is not at all improbable that the truth lies between them.

RAPHISTOMA, Hall.

Raphistoma, HALL, 1847, Pal. New York, vol. i, p. 28.
Raphistoma (part.) and *Pleurotomaria* (part.), of many authors.

For the generic characters and a full discussion of the relations of this genus the reader is referred to the preceding remarks on the family. (See pages 931, 934.)

Of the nineteen species referred to this genus in the last edition of Miller's catalogue, perhaps only *R. stamineum* and *R. planistria*, with its variety *parvum*, really belong here. The majority of the remainder must be classed as doubtful, since we do not know whether they have a slit-band or not. Some may belong to *Raphistomina*, as does *R. lapicida* Salter, or to *Liospira*, as do *R. americanam* Billings sp. (= *lenticulare* Emmons) and *R. subtilistriatum* Hall sp. *R. niagarense* Whitfield certainly is not a *Raphistoma*. It seems to be congeneric with Meek and Worthen's *Platyostoma trigonostoma*. Two good species of the genus were described by Billings as *Pleurotomaria calyx* and *Pl. crevieri*, both from the Canadian Chazy. To these we add the two following new species.

RAPHISTOMA PERACUTUM, *n. sp.*

PLATE LXVIII, FIGS. 1–6.

Shell small, not known to exceed 12 mm. in diameter, consisting of three or three and one-half whorls, flat above, rounded below; periphery very sharp and thin; umbilicus equalling a little more than a fourth of the greatest diameter, its edge narrowly rounded; hight of shell very slightly exceeding a fourth of the width. Surface marked on the flat upper side with very fine subequal striæ sweeping on the whole rather strongly backward from the suture. About a third of the width of a whorl from the suture the striæ are interrupted by a delicate revolving line. Between the latter and the extreme edge of the peripheral carina the striæ make a distinct sigmoid curve. Below the periphery the surface is marked with similar striæ, which, in descending, curve first forward and then almost directly toward the center of the umbilicus.

In this species the hight is relatively less, and the peripheral edge consequently thinner, than in any previously described species of this genus. It is the only gastropod known to us as occurring in the Lower Silurian rocks of Minnesota having a perfectly flat spire.

Formation and locality.—Black River group, Ctenodonta bed, Goodhue county, Minnesota. Rather rare.

Collections.—E. O. Ulrich; W. H. Scofield.

RAPHISTOMA RICHMONDENSIS, *n. sp.* (*Ulrich.*

PLATE LXVIII, FIGS. 7–9.

Shell 15 to 20 mm. in diameter, the spire almost flat, the hight between one-third and two-sevenths of the width; volutions four, very slightly convex on the upper side, *i. e.* within the outer edge which forms a thin elevated rim; umbilicus very small in casts, apparently closed in shells. Surface striæ fine and subequal on upper side, making the usual sigmoid curve, the change in curves occurring near the middle of the whorls. Just before reaching the peripheral rim the striæ make another short backward turn. Beneath the periphery the striæ are more unequal. At first they turn forward then more directly inward.

This species resembles the Chazy *R. calyx* Billings, but is smaller and relatively wider. In *R. crevieri,* of the same author and formation, the edge is blunter, and the lines of growth curve more strongly forward beneath it. *R. peracutum* has an umbilicus and differs in several other respects. A very similar species, differing only in that it has a small umbilicus, occurs in the Stones River group in Tennessee.

Formation and locality.—Richmond group, Richmond, Indiana. Good specimens rare.
Collection.—E. O. Ulrich.

Genus RAPHISTOMINA, n. gen.

Raphistoma (part.) and *Pleurotomaria* (part.), of authors.

For generic characters and general remarks see pages 932 and 934 to 939.

As species of this genus are generally confounded with *Raphistoma*, it may be well to repeat the peculiarities upon which we base our separation. In *Raphistoma* the lines of growth on the lower side, which of course correspond with the outline of the lower lip, curve forward more or less strongly from from the peripheral edge. The outer half and more of the under lip therefore is convex, whereas in *Raphistomina* the corresponding portion is always concave. In species like *Raphistomina laurentina* Billings sp., this concavity is decided and extends over the whole anterior outline of lower lip. On the upper side of the whorls the striæ curve backward again in *Raphistoma* just before reaching the peripheral edge. This, together with the forward curve immediately beneath the edge, produces a small notch in the outer angle of the aperture. In *Raphistomina,* on the contrary, there is no notch, the angle being either rectangular or turned slightly forward, in some cases forming a beak-like projection. Comparing the upper and lower lips we find that in *Raphistoma* their outlines do not correspond, the lower being more prominent and simply convex in the outer two-thirds where the upper forms a sigmoid curve. In *Raphistomina,* however, the anterior outlines of the two lips are either equal, or the lower is more concave, the amount and extent of the sinuate portion varying with the species. Finally, the upper side of the shell is apparently never quite flat in *Raphistomina*, while this is generally the case in *Raphistoma*.

The shells of *Raphistomina* remind one in a general way very greatly of those of our new pleurotomarian genera *Liospira* and *Eotomaria*. Still, when the surface markings are preserved, no one is likely to have much trouble in separating them. A glance should be sufficient for those accustomed to handling fossil gastropods. The principal difference between these genera is that while *Raphistomina* has no slit-band, both of the other genera have, *Liospira* having it directly at the peripheral edge and *Eotomaria* immediately above it.

Besides the four species figured in this work, three of which are new, we have only one other species, *Pleurotomaria laurentina* Billings, which we can place here with certainty. However, we can scarcely doubt that some of the lenticular shells which, because they are insufficiently known, we must provisionally leave as doubtful forms of *Pleurotomaria* and *Raphistoma*, will eventually prove to belong to this genus.

RAPHISTOMINA LAPICIDA *Salter*.

PLATE LXVIII. FIGS. 18-20.

Raphistoma lapicida SALTER, 1859, Can. Org. Rem., Decade 1, p. 12.

Shell discoidal, nearly equally convex above and beneath the acute peripheral carina, usually about 25 mm. in diameter and but little more than half as high. Umbilicus deep, rather narrow, not abrupt, its width equalling about a fifth of the diameter of the shell. Volutions about four, gently convex on both the upper and lower sides except near the peripheral carina, where, especially upon the upper side, the surface is rather distinctly concave. Excepting the last whorl, which sometimes descends a little beneath the edge of the preceding, the spire slopes with very little interruption at the sutures. The lines of growth are as usual somewhat stronger below than above. As a rule they are irregular and unequal. On the upper side they are turned backward from the suture but not very strongly, nor is the sigmoid curve which they make a conspicuous feature. Still, the retral sweep is sufficiently overcome in the concave region near the edge to cause them to intersect the latter at nearly a right angle. On the lower side their course from the edge to the umbilical cavity is nearly a straight line, a slight anterior curve just before they descend into the umbilicus causing a faint sinus in the outer half. Aperture transverse, acutely ovate, the outer extremity or angle turned slightly forward in a view from below. Inner lip curved, slightly reflexed.

The above description is based chiefly upon a number of silicified shells from Tennessee which we owe to the kindness of Prof. J. M. Safford. These differ, so far as we can see, from the Canadian types of the species only in having the upper side of the volutions a trifle more convex. *R. laurentina* Billings sp., from the Calciferous of Canada, is closely related but is readily distinguished by the much deeper and wider sinus in the outline of its lower lip.

Formation and locality.—The original types are from the Black River limestone at Allumette island, in the Ottawa river, Canada. The Tennessee specimens come from an equivalent horizon near Lebanon. If the species occurs in Minnesota it will probably be found in the Ctenodonta bed.

RAPHISTOMINA DENTICULATA, *n. sp.* (*Ulrich.*)

PLATE LXVIII, FIGS. 21–23.

This species is very closely allied to *R. lapicida* Salter, yet there should be little trouble in distinguishing good specimens. Carefully compared we find that in the new species the umbilicus is much narrower, the hight of the shell relatively greater, the sutures deeper because the edge of the whorls projects somewhat over the top of the succeeding volution, the aperture is a little more oblique and the periphery of the whorls less acute. Further, there is to be observed, especially on casts of the interior, an obscure ridge running parallel with but some distance beneath the peripheral carina. Finally, the peripheral edge is minutely toothed, a character that does not occur on the even better preserved examples of *R. lapicida* seen by us. At present we know of no other species with which it need be compared.

Formation and locality.—Top of the Black River group, Mercer county, Kentucky.

Collection.—E. O. Ulrich.

RAPHISTOMINA MODESTA, *n. sp.* (*Ulrich.*)

PLATE LXVIII. FIGS. 14–17.

Differs from *R. lapicida*, which it resembles more closely than any other known, in being smaller (12 to 15 mm. in diameter), in having a proportionally smaller umbilicus, and in its surface markings. On the upper side, which is also a little more depressed, the lines of growth are very faint, while the peripheral edge turns rather distinctly upward. On the lower side the lines of growth are likewise obscure except in the peripheral half of the last whorl, where they appear as rather coarse undulations of which the best specimen has about seven in 5 mm. The course of the lines on this side, which of course corresponds with the outline of the lower lip, is more convex anteriorly than in *R. lapicida.* (Compare figs. 16 and 18 on plate LXVIII). *R. denticulata* is a larger shell, has a higher spire and deeper sutures.

Formation and locality.—Lower division of the Stones River group (Safford's Central limestone), near Murfreesboro, Tennessee. It is here associated with a broadly umbilicated and much larger species, apparently of this genus, of which, unfortunately, we have so far failed to secure satisfactory examples. Several other discoidal shells occur at this locality rendering great caution a necessity in discriminating between them.

Collection.—E. O. Ulrich.

RAPHISTOMINA RUGATA, *n. sp.*

PLATE LXVIII, FIGS. 10–13.

This pretty species differs in at least two respects from all of the foregoing species. First, the surface markings are relatively stronger, second, the umbilicus is more sharply outlined. As usual the surface markings are faint in the umbilicus and near the suture line, and much stronger in the peripheral portion of the shell. The umbilicus is rather larger than the average, its diameter equalling about a fourth of the entire width of the shell. Another peculiarity is that the upper surface of the whorls is almost flat from the but slightly impressed suture line to the edge; nor is there more than a barely perceptible concavity beneath the edge. Often the whole upper surface of the shell is perfectly flat, giving it more of the usual appearance of a *Raphistoma* than a *Raphistomina.* The spire is always lower than in any of its congeners, and in no observed case higher than in fig. 12.

Formation and locality.—Clitambonites bed of the Trenton group at various localities in Goodhue county, Minnesota.

Collections.—E. O. Ulrich; W. H. Scofield.

Genus OMOSPIRA, n. gen. (Ulrich.)

Murchisonia (part.), HALL, SALTER and BILLINGS.

For generic characters see page 932.

We are anything but satisfied respecting the systematic position of this genus. If *Scalites,* Emmons, could be proved to possess the essential characteristics of the *Raphistomidæ,* then we would have an undeniable link between *Omospira* and *Raphistoma*. In the absence of such a link, the general resemblance which *Omospira* bears to certain *Pleurotomariidæ,* like *Hormotoma bellicincta* and *Eotomaria elevata,* gives us not a little trouble to explain away in a convincing manner. Still, there are two features about the sinus in the upper lip and the band-like space resulting from it in the growth of the shell that are anything but indicative of pleurotomarian affinities. First, the great width of the band, and second, the oblique,—perhaps it would be better to say the outwardly increasing,—curvature of the lines crossing it. In all true *Pleurotomariidæ* the lunulæ or lines crossing the slit-band, providing the latter does not lie, as in *Liospira micula,* partly over the peripheral edge, form a uniform curve in passing from one to the opposite border of the band. (See fig. 13, plate LXIX). As may be seen in fig. 65 on plate LXX, this is not the case in *Omospira*, the lines in this case crossing obliquely and increasing in curvature downward. The lines on the band, furthermore, are of the same character as those above the band, only curved in the opposite direction, the two portions united forming a sigmoid curve as in *Raphistomina;* and their continuity is interrupted when the change in direction occurs by a raised line, as is frequently the case in *Raphistoma.* Is it fair to explain the conditions observed in *Omospira* by supposing that they have resulted, first, through the elevation of the spire and the consequent reduction of peripheral carina and hightening of the volutions, and second, either by a mere approximation toward the prevailing character of the *Gastropoda* with which they are chiefly associated, or by following the more prevalent tendency which they, as *Raphistomidæ,* inherited, like the *Pleurotomariidæ,* from their common ancestor? For the present we must confess that we have allowed such theoretical reasons as the foregoing to dominate our placement of the genus.

To whatever position *Omospira* may be ultimately assigned, the validity of the genus is not likely to be seriously affected. If it really belongs to the *Raphistomidæ,* then it will stand as a type obviously distinct from the other genera of the family, because of its high spire and comparatively rounded volutions. If, on the contrary, it proves to be one of the *Pleurotomariidæ,* then it will be readily distinguished by the peculiarities of the band mentioned in the preceding paragraph. The high position of the band would also serve in the latter association.

As to the specific representation of the genus, we know of only two species that can be referred here positively, namely, the type *O. laticincta* and *Murchisonia alexandra* Billings (*M. ventricosa* Salter, not Hall). Possibly Hall's *M. ventricosa* also belongs here, but Whitfield says it is a *Lophospira.*

Omospira laticincta, *n. sp.* (*Ulrich.*)

PLATE LXX, FIGS. 64 and 65.

Shell 50–60 mm. high; greatest width about three-fifths of the hight; apical angle varying between 49° and 55°, the angle formed by the first three or four whorls usually about five degrees more. Volutions about seven in number, obliquely flattened above, ventricose below, their sides almost vertical, the upper turns more rounded than the last three. Sometimes the flattened upper portion is more nearly horizontal than in the specimen illustrated. Aperture subtriangular, somewhat higher than wide, the outer lip thin and curving gradually inward from the shoulder-like upper angle to the narrowly rounded base; inner lip only moderately thick, nearly straight, and generally reflexed in its upper part over a minute umbilicus, more or less completely closing the latter in all save one of the specimens before us. Surface marked with fine, regular, equal, raised lines of growth. These curve rather strongly backward on the flattened upper portion of the whorls until they approach the shoulder-like angulation, when they turn sharply forward. About midway between the suture line and the outer angle, the growth lines are interrupted by a sharply elevated revolving line, causing the outer half of the upper slope to resemble an unusually wide slit-band. Beneath the angle the lines descend with a gentle forward curve to the base of the whorl.

This fine species is readily distinguished from *O. alexandra* Billings sp., by its higher and more angular whorls.

Formation and locality.—Top of Stones River group or base of the Black River group, near Lebanon, Tennessee.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

Omospira alexandra *Billings.*

PLATE LXX, FIGS. 66 and 67.

Murchisonia ventricosa SALTER, 1859, Can. Org. Rem., Decade 1, p. 23. (Not *Murchisonia ventricosa* Hall, 1847.

Murchisonia alexandra BILLINGS, 1865, Pal. Foss., vol. i, p. 172.

This species has the same general characteristics as the preceding, yet may be distinguished at once by its more depressed and more rounded volutions. Its apical angle also is narrower, being between 40° and 45°, while the aperture is more rounded. There is not a sign of an umbilical perforation.

The cast of the interior figured as possibly of this species may in reality belong to something quite different. At any rate, it is the only fossil from the northwestern states which we could say probably represents this species.

Formation and locality.—Base of the Trenton group or at the top of the Black River group, in Mercer county, Kentucky. The types are from the latter horizon at Allumette island in the Ottawa river, Canada.

Collection.—E. O. Ulrich.

Family PLEUROTOMARIIDÆ, d'Orbigny.

This large and most important family of fossil shells has given systematists not a little trouble to classify. The great number and variety of the species has occasioned many attempts to arrange them in convenient generic and subgeneric groups, sometimes happily, but in most cases the result proved neither convenient nor successfully defensible when subjected to the test of genetic relationship. As usual many of the subdivisions as drawn by authors were necessarily wrecked through the prevailing ignorance concerning the structural peculiarities and lines of development exhibited by the Paleozoic types, the early Paleozoic especially.

Each year the absolute necessity of extending our systematic paleontological studies backward as far as possible becomes more and more obvious. The rapid changes which took place among the early representatives of all classes of animals and the consequent relative ease with which the lines of evolution may be traced, gives them an importance in biology that is scarcely to be overestimated. For the *Gastropoda* the Lower Silurian species, because the class is but sparingly represented in the Cambrian, are the most likely to throw light upon the genetic relations of the succeeding forms, and are therefore deserving of the most careful investigation. Concerning the *Pleurotomariidæ*, the facts brought out in an extended study, of the Paleozoic species chiefly, have led us to conclusions that, while not greatly different from those published by Koken, who has adopted methods more nearly in accordance with our own than any previous observer, are still sufficiently original to cause great changes in the views and nomenclature heretofore in vogue. We have gone into the subject more extensively than the present work demanded or perhaps even justified, but the knowledge gained, if it cannot all bear fruit immediately, is still not in vain, since it will doubtless prove of use in our future work. We have most carefully considered the published papers of authors who have dealt with Paleozoic *Pleurotomariidæ*, particularly those of De Koninck, Sandberger, Lindström, Œhlert and Koken, and it would please us greatly to enter into a detailed account of their various views. But as this would require more space than we have at our disposal and would moreover be out of place in a work of this kind, we are obliged to postpone it to some more fitting occasion. Incidentally, however, we shall frequently refer to them, especially when our opinions happen to differ.

We believe it is admitted generally that the essential feature of the *Pleurotomariidæ,* and the peculiarity relied upon chiefly in distinguishing the family from other spiral shells, excepting of course the symmetrically enrolled bellerophontids and certain *Euomphalalidæ*, *Fissurellidæ*, *Turritellidæ* and *Cerithiidæ*, is a definitely limited narrow band, terminating anteriorly in the bottom of a more or less deep sinus of the outer lip merely, or in a long, open and sometimes periodically closed slit. The long parallel-edged slit occurs, as far as known to us, in but two Lower Silurian species (*Schizolopha* of this work), and is comparatively rare among the Upper Silurian and Devonian forms; but with the Carboniferous species it is common, while among the more recent forms it is nearly always present.

Of all the characters of the family, the peculiarities of the slit and band furnish us with the most reliable grounds upon which to base our generic divisions. According to these the family might be divided primarily into two principal groups, the first having a sinus only in the outer lip, the second a long parallel-sided slit or a series of openings. These groups are again divisible, according to the character of the slit-band, each into two similar groups, one having the band convex, the other concave. Such an arrangement might at first appear convenient, yet a careful study will soon reveal that it would be quite arbitrary, therefore unnatural, and in the end not even convenient. This is so obvious that it is quite unnecessary to cite proving instances. Still, there is an element of truth in the first of these suggested divisions, for it would separate what we may call the archaic from the more recent stages in the development of the family.

We have already referred to the almost total absence in the Lower Silurian *Pleurotomariidæ* of the long parallel-edged slit which occurs so generally among the more recent types of the family. This difference has not received the attention from paleontologists that it deserves, for surely it must indicate a structural difference in the animals. Lindström barely alludes to it, while Koken, much to our surprise, takes no notice of it whatever. Unfortunately, the presence or absence of the slit is not positively determinable except when the aperture is entirely preserved, the band behind the slit presenting, so far as we can say, no evidence that might lead the observer to suspect either the one or the other condition.

The slit which should be carefully distinguished from the apertural notch, which is more or less widely V-shaped and does not extend backward any farther than the bottom of the sinus formed by the lines of growth, seems to be a later phase in the evolution of the majority of the lines of development that can be traced from the Lower Silurian into subsequent periods. Its development appears to be the result of a tendency to which the whole family, rather than any particular generic line, is subject. As we have already said it is almost entirely absent in the Lower Silurian *Pleurotomariidæ*, in the majority of which the lines of growth, and, therefore, the outer edges of the lip, sweep backward toward the band more strongly than in the prevailing types of subsequent ages. We might then assume that the slit was represented in those ancient times by a deep notch, and that the presence of the latter in many Devonian and Carboniferous forms is merely a retention of a primordial character after its real cause or purpose had been removed or satisfied by the development of a long slit. However, before such a view can be accepted we must account for the extreme shallowness of the apertural sinus in such slit-less species as are comprised in the *Bicincta* section of *Lophospira*, which, as far as our present knowledge goes, existed in numerous species from the Chazy to the close of the Upper Silurian. Now, *Shizolopha textilis*, which has a long slit, was almost certainly developed from some member of the *Bicincta* section, so that the suggested explanation of the development of the slit cannot apply here and is rendered highly improbable in any case.

In one group of *Pleurotomariidæ*, i. e. *Hormotoma*, we have good evidence showing a gradual development of the slit. In all the Lower and Upper Silurian species of this genus a deep V-shaped apertural notch is present, but no slit. In, however, what we consider to be Devonian representatives of the same type of shell (e. g. *Murchisonia desiderata* and *maia* Hall) we observe that the bottom of the notch is prolonged into a short slit, but the backward sweep of the edges of the outer lip forming the notch is quite as pronounced as in the earlier species which have no slit. From this and the preceding case, therefore, it is evident that the slit did not take the place of a deep notch but that it is really an additional and distinct feature.

The length of the slit varies greatly in different members of the family. On the whole the length is considerably greater in Mezozoic than in Paleozoic species. In the latter the length has not been observed to exceed three-eighths of the circumference of the last whorl. In the Devonian *Pl. sulcomarginata* it is about one-fourth, likewise in the *Pl. turbiniformis* group (*Euconospira*), the *Pl. tabulata* or *Worthenia* group and the majority of the Carboniferous species. In *Schizolopha* it is a trifle longer, while in the Niagara *Pl. labrosa* group (*Phanerotrema* Fischer) it equals about one-third. In *Pl. sphærulata* it is about one-seventh, and in *Murchisonia maia* Hall not over an eighth, while in the *Pl. carbonaria* group it is even shorter and possibly absent entirely. Among Mesozoic and more recent forms, particularly *Leptomaria* and *Chelotia*, the length often exceeds one-half and may reach fully two-thirds of the last whorl. It is interesting to note that, as far as we now know, the slit which furthermore seems to have been developed almost suddenly, is longer in the earliest species known to possess one than in any of the later Paleozoic forms.

The band which is left behind by the gradual closing of the slit presents considerable variety in position and structure. As a rule, especially among Paleozoic species, it lies on the peripheral part of the whorls. When the volutions are angular it commonly forms the summit of the principal angle, as in *Lophospira* and *Worthenia*. In conical shells, like those of the group of *Pl. turbiniformis*, it forms a narrow vertical band at the extreme periphery of the whorls. In other conical shells, like *Pl. etna* Billings, it lies at the base of the flat slope, the lower edge of the band in such cases forming the periphery. In certain Mesozoic and recent types (*Pyrgotrochus*, *Perotrochus* and *Entemnotrochus* of Fischer) in which the shell is similarly conical, the band lies considerably above the angular periphery, but it never occupies such a position in any of the angulated Paleozoic types, being in these placed always very near or entirely upon the angle. Occasionally, as in the Carboniferous group of *Pl. brazoensis*, it lies in a broad peripheral concavity, beneath the principal carina.

What we conceive to be the most primitive type of slit-band occurs in the Lower Silurian *Lophospira*. In this genus it occupies, or rather forms, the summit of a more or less prominent peripheral ridge, above and beneath which the lines of growth curve backward in directions corresponding to the outline of the apertural notch. The band itself may be simply a blunt edge, upon which the growth lines make their turn; but more commonly it is defined on each side by a delicate raised line, which separates the lunulæ of the band from the surface striations. The markings of the band are always different from that of the rest of the surface, being as a rule more regular, while the arched transverse lines or lunulæ may be stronger or weaker, and farther apart or closer than the lines of growth either above or beneath the band. Occasionally, as in *Lophospira tubulosa* and *L. imbricata* Lindström sp., and our *L. notabilis*, the lunulæ are widely separated and strongly imbricating; sometimes, as in *L. bicincta*, they are much finer and very closely arranged; frequently they consist of simple elevated lines; in other cases they have a median excision (*Pleurotomaria limata* Lindström), or they are crossed by one (*Pl. ohioensis* James) or two (*Pl. scutulata* Lindström) median lines; or the central line may be developed into a thin undulating plate (*Lophospira serrulata* Salter sp.) or into a row of nodes (*Pl. [Worthenia] tabulata* Conrad). In short, the marking of the band in the members of the family is of great variety, but as a rule we cannot say that the various types are of much assistance in determining the generic or subgeneric position of the species.

Although we can already see some possible exceptions, we think that provisionally it is advisable to regard species having a concave band as generically distinct from those in which the band is convex. We have very carefully examined a large number of species, and so far the separation on this difference has resulted in a very much more satisfactory classification than any we have yet had. Considering the form of the band, as far as its being concave or flat on the one hand and more or less convex on the other is concerned, as a leading test of relationship, we bring together many forms that have hitherto been separated, while many others that had been associated are widely separated.

As generally understood heretofore, particularly among American and Canadian paleontologists, the two principal Paleozoic genera of the family are *Pleurotomaria*, De France, and *Murchisonia*, d'Archiac and Verneuil, the former embracing the species with a low spire and relatively few volutions, the latter those forming a high shell of numerous whorls. As viewed by us this broad separation or arrangement of the species according to the hight of the spire results in a most artificial classification, since it causes the separation of shells that comparative studies prove to be closely related genetically, while others are associated that have only very remote affinities for each other.* Besides it leaves a large number of intermediate forms which may be placed with equal propriety into either genus. But this is not all, for we believe with other authors that, as now constituted, these genera embrace material more than sufficiently various to admit of defining a comparatively large number of valid generic groups,—valid in the sense that they are relatively as important groups of species as are ordinarily considered to be of generic value.

Now, what are the characters upon which we propose to base these genera? First, upon the presence or absence and relative length of a true slit, as distinguished from a mere apertural notch; second, the characters of the slit-band, among which its outline, as exhibited in transverse section, is the most important; third, the width of, and the position of the band and slit or notch with respect to the hight of the volutions; fourth, the form of the volutions, with respect to angularity and roundness; fifth, the form of the entire shell; sixth, the character and depth of the suture; seventh, the form and outline of the aperture as shown by the lines of growth; and eighth, the changes in the character of the volutions from the embryonic to the mature stages. Corroborative and subordinate characters are furnished by surface markings, the apical angle, the relative size of the last volution, the presence or absence of an umbilicus, and minor peculiarities of the aperture, the notch, the slit and the band. The relative importance of these characters is not always the same, but they are sufficiently reliable for present requirements.

SYNOPSIS OF GENERIC AND SUBORDINATE GROUPS OF PALEOZOIC PLEUROTOMARIIDÆ.†

I. Lophospira, Whitfield, 1886.‡ Shells with more or less elevated spires; whorls closely coiled throughout or only in the upper part, the last often exhibiting a tendency to become disconnected; whorls angular on the periphery and bearing from one to five distinct carinæ; central or peripheral keel strongest and most prominent, carrying the band, which is obtusely rounded, or more or less distinctly trilineate, with the median line heavier and more prominent than the other two; axis rarely, if ever, solid; an umbilicus, usually of very small size, nearly always present. Inner lip generally thickened, often slightly twisted, turning around the umbilicus so as to form a kind of hollow pillar. Outer lip more or less deeply notched, but the center of the notch, which lies at the peripheral angle, is never prolonged into a slit. Surface markings parallel with the apertural edge; occasionally cancellated by fine spiral lines. Types, *Murchinsonia bicincta* Hall and *M. serrulata* Salter (=*M. helicteres* Whitfield, not Salter.)

*To appreciate the subordinateness of the value of differences in the hights of the spire within moderate limits, a comparison of the figures of species of *Lophospira* described in this work should suffice. We pass by almost imperceptible gradations from species like *L. ampla* and *L. notabilis*, in which the apical angle is 80 and 90 degrees, to others, like *L. bowdeni* Safford sp., in which the angle is of sometimes less than 25 degrees. And, so far as we can see, there is not the remotest chance for a generic separation between the first and the last of the species mentioned.

†Remarks on genera of which species are described in this work will be found on succeeding pages.

‡Bull. Amer. Mus. Nat. Hist., vol. 1, p. 312.

II. SCHIZOLOPHA, n. gen. (Ulrich.) In every respect like *Lophospira* excepting that the apertural notch is prolonged into a long parallel-edged slit. Type, *S. textilis*, n. sp. (Ulrich.)

III. PHANEROTREMA, Fischer, 1885.* Shell turbinate, whorls few in number, flattened above, the last large and high, the others rising step-like; spire short; slit long, region of band salient; aperture subquadrate, inner lip thick; lines of growth nearly vertical beneath the band, above it turning more decidedly forward; strong revolving lines occur especially on the lower and outer parts of the whorls. Type, *P. labrosa* Hall.

This Upper Silurian genus seems to have been derived from the *Trochonemoides* section of *Lophospira*, our *L. trochonemoides* and *L. knoxvillensis* being very similar in general form and having almost exactly the same kind of aperture. The band, though salient also in those species, is somewhat different, the central line being, as it should be in *Lophospira*, considerably stronger and more prominent than the bordering lines. Still, in our opinion, the peculiarities of the *labrosa* type of band were produced by an extreme development of the bordering lines, the space between the elevated edges being gently convex. Aside from the band, *Phanerotrema* is distinguished from all the Lower Silurian *Pleurotomariidæ*, except *Schizolopha*, by its long slit, and from the excepted genus by its relatively smaller spire, much larger last volution, peculiar band, and strong revolving lines. Further, it seems very clear that, although both types originated in *Lophospira* and deviated from the general character of that type in similar directions, their immediate ancestors represent widely different sections of that genus, and constitute distinct lines of development. Of the two species of *Schizolopha*, *S. textilis* evidently came from the *Bicincta* section, while *S. mooresi* accords more nearly with the *Perangulata* section. As to *Phanerotrema*, we have already said that it was most probably derived from the *Trochonemoides* section.

Phanerotrema includes besides the type species, *Pl. occidens* Hall, and a Gothlandic shell which Lindström erroneously identified with Hall's *labrosa*. The genus appears to be sparingly represented in the Devonian of Europe, but we know of none in American deposits of that age. Two of our Carboniferous species, however, *Pl. grayvillensis* Norwood and Pratten, and *Pl. marcouiana* Geinitz, appear to have all the essential characters of *Phanerotrema*, and we expect to find that they are actual continuations of the same generic type.

IV. WORTHENIA, De Koninck, 1883. Shell conical, tabulate, the general aspect much as in *Lophospira;* whorls angular on the periphery, the latter carrying the band; slit extending backward from the mouth between one-fourth and one-third of

* Manual de Conchyliologie, p. 851.

the circumference of the last whorl; band narrow, convex, the lunulæ not much curved, very strong and prominent at regular intervals, giving the band a crenulated or toothed appearance; columellar lip scarcely callous, reflected and forming a sort of false umbilicus; surface ornamented with spiral ridges; lines of growth moderately curved backward on the upper side of the whorls, nearly vertical beneath the band. Type, *Pl. munsteriana* De Koninck.

This genus is represented by three good species in the Carboniferous deposits of America, viz.: *Pl. tabulata* Conrad, *Pl. subscalaris* Meek and Worthen, and *Pl. speciosa* M. and W. We have before us a small undescribed species from the Devonian of Ohio that probably belongs here. The Worthenias remind one greatly of certain Lower Silurian types of *Lophospira*, particularly of the *Bicincta* section and *L. knoxvillensis*, and it is highly probable that they will be traced back to some member of that genus. We think further that they will be brought into connection with the Upper Silurian Phanerotremas. For the present they are readily distinguished from the latter by their higher spire, more gradually increasing volutions, and different band. From *Lophospira* they are separated by the denticulate band, strong spiral ornamentation and in having a true slit.

V. Liospira, n. gen. Shell sublenticular, the spire low, depressed conical, almost smooth, the sutures very close, scarcely distinguishable; volutions subrhomboidal in section, flat, gently convex or slightly concave above, sharply rounded at the periphery, convex below, and not infrequently angular at the edge of the umbilicus. The latter is usually present but may be filled entirely by an extension from the inner lip, in other cases it may be open during the younger stages only. Aperture deeply notched; band scarcely distinguishable as such, wide, situated on the narrow outer edge of the whorls though chiefly upon the upper side. Surface markings very delicate, rarely preserved, consisting generally of exceedingly fine transverse lines bending strongly backward on the apical side to the peripheral band over which they continue with little interruption to sweep sharply forward again on the lower side. Faint revolving lines occasionally observed. Types, *Pleurotomaria micula* Hall, *Pl. americana* Billings.

VI. Euconia, n. gen. (Ulrich.) Shell subtrochiform, regularly conical, base nearly flat, suture shallow; umbilicus usually of large size; mouth subquadrate, the inner lip but little reflected and scarcely thickened, the outer with a wide notch but no slit, the upper projecting beyond the lower; whorls numerous, enlarging very gradually, sharply angular at the lower edge; band not sharply defined, of moderate width, lying entirely upon the upper side of the peripheral edge; on the upper side of the whorls the lines of growth are fine and strongly curved backward from the suture to the band; on the lower side, where they are usually somewhat stronger, they pass almost directly across the whorl, a short backward curve occurring only just before they reach the periphery. Types, *Pl. etna* and *ramsayi* Billings.

At least two other species, the *Pl. amphitrite* Billings and *Pl. beekmanensis* Whitfield, are known to belong to this generic type. A possible fifth species (it may be the same as Billings' *etna*) occurs at Ft. Cassin, Vermont. With the exception of the species *amphitrite*, which may be a Chazy fossil, all these forms occur in the Calciferous formation, so that the genus represents one of the earliest fixed types of the family. Though fixed, in the sense that the known species adhere very strictly to the characters mentioned in the generic diagnosis, the type was evidently of short duration. We have very carefully examined the *Pleurotomariidæ* found in succeeding geological divisions but have failed entirely to discover any that might reasonably be viewed as descendants of *Euconia;* nor do we know anything positive about their ancestors. We are therefore obliged to consider the genus as a rapidly evolved, short and abruptly terminated branch from the stock which produced also *Liospira* on the one side and *Eotomaria* on the other. *Euconia* is distinguished from all of the Lower Silurian *Pleurotomariidæ* by the regularly conical spire and flat base, and the very slight curvature of the lines of growth on the under side of the whorls. These features are all reproduced in the Carboniferous group of shells which we propose to distinguish as *Euconospira,* but they have another character, namely, a long open slit, which is absent in *Euconia* and of itself demands a separation. The surface of the Carboniferous shells differs also in being spirally lined.

VII. Eotomaria, n. gen. Shell depressed-conical, sometimes sublenticular; base more or less convex, its bulk usually nearly equal to the apical part; umbilicus very small or wanting; volutions not very numerous, sometimes slightly turriculate or strongly angular near the mid-hight; aperture oblique, subquadrate, the inner lip slightly reflected or merely thickened, the outer deeply notched at the peripheral angle; no slit; band of moderate width, concave, sharply defined, oblique or horizontal, lying upon the apical side of the periphery. The surface markings consist of fine lines of growth only. These curve backward more or less strongly toward the band on both the upper and lower sides of the whorls. Type, *E. sublævis,* n. sp. (Ulrich.)

VIII. Clathrospira, n. gen. Shell in all respects like *Eotomaria* except that the band is nearly vertical and situated upon the periphery of the whorls, and the surface beautifully cancellated. Type, *Pl. subconica* Hall.

IX. Bembexia, Œhlert, 1887.* Shell depressed subconical, imperforate, volutions angular; band distinct, concave, vertical or oblique, situated on the periphery,

*Extr. Bull. Soc. d'Etu. Scientif. d'Angers, p. 24.

submedian on the last whorl; slit about one-fourth volution in length; aperture moderately oblique, the edge of the upper lip sweeping backward rather strongly, the lower broadly concave in the middle, the inner lip generally somewhat thickened and reflected. Surface with rather strong lines of growth; on one or both sides of the band often a more or less well-defined smooth space. Type, *Bembexia larteti* Munier-Chalmas sp.

We have adopted this name for the group which in America is typified by the well-known Hamilton species, *Pl. sulcomarginata* Conrad, and includes also *Pl. planidorsalis, Pl. adjutor,* and *Pl. nitella,* described by Hall from the same formation, and *Pl. shumardi* Meek and Worthen, and *Pl. elegantula* Hall, two Lower Carboniferous shells, the first from the Keokuk, the second from the St. Louis. Excluding the spirally striated forms, whose relations to the group under consideration we cannot consider as established, *Bembexia,* as here defined, corresponds very nearly with Koken's "*Pleurotomariæ interruptæ.*" The group, whether viewed as a genus or a subgenus is immaterial, seems to be a perfectly natural one. Provisionally we would give it an intermediate position between the Silurian *Eotomaria* and the Carboniferous *Euconospira,* the tendency of variation exhibited by the species being toward the latter, while their general expression reminds one of the former.

X. MOURLONIA, De Koninck, 1883. Shell conical or somewhat discoidal, umbilicated. Band forming the periphery of the whorls, extremely prominent, thin, flange-like. On the upper side of whorls lines of growth curve backward without interruption from the suture line to the extreme outer edge; on the lower side first forward, then in a broad curve backward, and finally forward again as they turn into the umbilicus. Surface with revolving lines or not. Type, *Pl. limata* Lindström (*Pl. carinata* Sowerby).

This type of shell is represented in American deposits by *Murchisonia worthenana,* a rather high species described by Miller from the Niagara limestone at Chicago. As now understood the principal peculiarity of *Mourlonia,* when compared with true *Pleurotomariidæ,* lies in the excessive development of the bounding plates of the slit-band. This particular feature reminds one of *Euomphalopterus,* Roemer, and it is possible that *Mourlonia* is really allied to that remarkable genus. Still, they are readily distinguished by the sigmoid instead of uniform curve of the lines of growth on the upper side of the whorls in *Euomphalopterus.* Despite the resemblances we are firmly convinced that the genesis of the two types is quite different.

XI. EUCONOSPIRA, n. gen. (Ulrich.) Shell almost regularly conical, the base nearly flat, sometimes a little convex but oftener slightly concave; not perforated, though a small umbilical depression is always present; whorls rather numerous, the first three or four, so far as observed, less flattened on the upper or visible slope than the following turns; aperture oblique, the width much greater than the hight, the inner lip scarcely thickened, the lower border, beginning at the inner extremity, first convex then broadly concave and finally convex again when the edge turns rather sharply backward to the slit which lies in the peripheral angle; upper margin sweeping backward very strongly from the suture; length of slit equalling between a third and a fourth of the last volution; band narrow, slightly truncating the pheriphery, visible on all the volutions, concave, lying between sharply elevated lines. Excepting the first three or four whorls, the surface is cancellated by fine spiral lines crossing the lines of growth. Types, *Pl. turbiniformis* Meek and Worthen, and *Pl. missouriensis* Swallow.

The deriviation of this genus is doubtful. There are two widely distinct Devonian groups of species from either of which it may have been evolved. With the evidence at hand, one derivation seems as plausible as the other, so we find ourselves unable to decide for either. The first brings the *Euconospiræ* from the *Pl. lucina* group, in which the slit-band and surface markings are similar while the form of the shell and of the volutions is very different. If this is the stock from which the genus under consideration sprang, the first change consisted probably in the gradual flattening of the dorsal surface of the whorls. In *Pl. filitexta, Pl. ella* and *Pl. hebe,* all species of the Hamilton group described by Hall, the necessary conditions are supplied in increasing ratio. The next step is furnished by Meek's Waverly species, *Pl. textiligera,* in which the apical side of the shell agrees exactly with the *Euconospiræ.* The basal portion, however, is very different, being ventricose instead of flat. Now, if we could find a shell having the convexity of the base considerably reduced, we might say that the chain connecting *Pl. lucina* and *Euconospira turbiniformis* is reasonably complete.

The second line of development would begin in, say *Pl. sulcomarginata* Conrad of the Hamilton, and include *Pl. nitella* Hall, of the same formation, *Pl. shumardi* Meek and Worthen, of the Keokuk, and *Pl. elegantula* Hall, of the St. Louis. The last species, though still too full at the base, nevertheless approaches very nearly to the form pertaining to the *Euconospiræ.* The principal feature lacking is the spiral sculpture, which is wanting in all of the *sulcomarginata* or *Bembexia* group. This difficulty, however, is lessened by the fact that the spiral lines are wanting also on the first volutions of at least two species of *Euconospira.* These early turns, furthermore, are slightly rounded on the dorsal surface, thus strongly indicating that the type was evolved from another in which the whorls were more rounded and without spiral markings. Taking all these points into consideration, the balance of agreement seems to be in favor of the second rather than the first line of development.

Euconospira is most probably related to the Mesozoic group of species which Fischer has distinguished by the name *Pyrgotrochus*, with *Pl. bitorquata* Deslongchamps, as the type. The latter differs from our genus principally in having the band near the middle of the dorsal side of the whorls instead of at the basal edge. The presence of a long slit distinguished the genus from *Euconia*, *Eotomaria* and *Clathrospira*.

XII. Trepospira, n. gen. Shell sublenticular to depressed conical; base convex; without umbilicus; whorls, six or seven, the first two or three very small, rounded, prominent and smooth, the next two flat and coiled more or less nearly in the same plane, the rest sloping according to the apical angle of the shell; aperture transverse, subrhomboidal, the upper lip projecting beyond the lower, the outline curving strongly backward to the slit; edge of lower lip strongly convex in the middle; inner lip rather thin but continuing into a concave callosity which is spread over the umbilical region; slit very short, scarcely extending beyond the notch formed by the converging lips; band rather wide, slightly concave, smooth, visible on the last whorl only, so situated that its lower edge forms the peripheral angle of the volution; beginning with the fourth turn the sutural edge bears a row of nodes covering the band of the preceding whorl. The rest of the surface is nearly smooth, the lines of growth being nearly always obscure. Type, *Pl. sphærulata* Conrad.

In its most essential characters—form of shell, nearly smooth surface, short slit, and direction of lines of growth on the lower side—this genus resembles the Lower Silurian *Liospira* very closely. Still, we are fully satisfied that *Trepospira* is not a continuation of that early type. In coming to this conclusion we rely principally upon the character of the embryonic whorls. These, as stated, are rounded and smooth, wherefore we should look for the ancestors of the type among shells having similar whorls. The required conditions, it seems to us, are furnished by *Pl. rotalia* Hall, of the Hamilton group. In this species we see a callus filling the umbilicus, a nearly smooth surface, strongly curved lines of growth on the lower side of the whorls, the band hidden on the upper turns by overlap of the thickened and plicated sutural edge. Excepting the last, which is somewhat compressed and, therefore, obtusely angular, the whorls may properly be called rounded. Now, it is not a great step from *Pl. rotalia* to the small Upper Silurian shell which Lindström calls *Pl. helicina* in his great work on the Gothland *Gastropoda*, and more recently, because the name was preoccupied, *Pl. kokeni*. The latter has neatly rounded whorls, an open umbilicus and the band a trifle too high, but in all other respects the agreement with *Pl. rotalia* is sufficiently exact to indicate close genetic relations between them. As to the umbilicus, this is not of much consequence, especially since *Pl. kokeni* has a ridge-like thickening of the shell around the umbilicus which may well represent the callus found in *Pl. rotalia* and typical species of *Trepospira*. From what line *Pl. kokeni* was derived, we are not prepared to decide, though inclined to regard *Liospira* as the most likely. Should that prove to be true, then *Trepospira* would furnish us an interesting case of reversion. Similar reversions are shown or noticed in other parts of this work.

Descendants of the *Trepospira* type are to be looked for among the Mesozoic pleurotomarian shells which are commonly referred to Deslongchamps' *Cryptœnia*. The Triassic *Pl. radians* Wissman certainly resembles *T. depressa* very closely, but Koken's figure and description prove it to have a more inflated ("pear-shaped") embryonic whorl, and, if we understand him correctly, it has, like *Pl. heliciformis*, the type of *Cryptœnia*, a narrow and long slit, which would exclude it from *Trepospira*. According to the figures which we have seen, *Pl. polita* Goldfuss (Lias), which also is usually referred to *Cryptœnia*, agrees better with *Trepospira* so far as the position and width of the band and depth of the slit is concerned, but in the rounded form of its volutions, and, more importantly, in the direction of the lines of growth between the band and the umbilical callus, it differs widely.

Besides the type, we place here the closely related *Pl. depressa* Cox, *Pl. illinoisensis* Worthen, *Raphistoma junior* De Koninck, and possibly *R. radians* of the same author, all Carboniferous species. Perhaps it would be well to include the Hamilton *Pl. rotalia* Hall.

XIII. SEELYA, n. gen. (Ulrich.) Shell turbinate, consisting of from five to seven rapidly enlarging rounded or ventricose whorls, coarsely though usually not very deeply grooved spirally; apertural sinus shallow, broadly >shaped, slit wanting, band distinct, rather wide, more or less prominent, concave, nearly central on the last volution, infra-median on the upper turns; axis minutely perforated, the inner lip usually thin and reflected so as to form a hollow columella; aperture slightly produced below. Type, *S. ventricosa*, n. sp. (Ulrich.)

XIV. PLETHOSPIRA, n. gen. (Ulrich.) Rather short, turbinate shells, consisting of four or five rapidly enlarging ventricose whorls, the last produced below and greatly exceeding in hight the rest of the spire; band wide, submedian in position on the last whorl, flat or slightly concave, vertical, margined on each side by a raised line; apertural sinus not very deep, slit wanting; surface marked with lines and wrinkles of growth only; these are only moderately arched, especially upon the lower half of the volutions where, excepting near the band, they are nearly vertical. Type, *Holopea cassina* Whitfield. Range, Lower Silurian.

XV. HORMOTOMA, Salter, 1859.* Shell elongate, beaded, practically imperforate, composed of rather numerous (eight to fourteen) rounded or subangular whorls; aperture acuminate subovate, narrow and more or less prolonged below; outer lip with a broad and deep >shaped notch and no slit; band median or submedian, generally obscure, of moderate width, flat or slightly concave, in the perfect condition margined on each side by a delicate raised line; surface marked with lines of growth only; these are never very sharp and always sweep backward very strongly, from below especially, to the band. Type, *H. salteri* Ulrich [=*M.* (*H.*) *gracilis* Salter, not Hall].

XVI. CŒLOCAULUS, Œhlert, 1887.† Similar to *Hormotoma* but the shells are longer, and composed of more numerous depressed whorls. Axis perforate, the umbilicus small but extending quite to the apex. Aperture rounded, not produced below; inner lip thin. Type, *Murchisonia* (*Cœlocaulus*) *davidsoni* Œhlert.

XVII. TURRITOMA, n. gen. (Ulrich.) High shells, consisting of numerous whorls; whorls somewhat flattened, convex above, slightly concave in the middle, and most prominent in the lower part where the band is situated; other features apparently as in *Hormotoma*. Type, *Murchisonia acrea* Billings. Range, Lower and Upper Silurian.

This is a well marked group of species and readily distinguished form *Hormotoma* (to which the group is related) by the flattened instead of uniformly rounded volutions, and by the lower position of the band. For the present the new genus will include the following species: *Murchisonia ada* Billings, Calciferous; *M. acrea* Billings, Quebec; *M. laphami* Hall, Niagara; *M. boylei* Nicholson, *M. constricta* Whiteaves, Guelph; and *M. cava* Lindström, Upper Silurian of Gotland.

XVIII. SOLENOSPIRA, n. gen. (Ulrich.) Small shells usually, forming a high and very slowly enlarging spire, consisting of numerous, generally depressed volutions; near the middle of each whorl and occupying nearly a fourth of its hight, the spiral band forms a deep channel between two salient thin ridges; the flat or convex slopes above and beneath the band may be free of ridges, or there may be a third above and a fourth below, or there may be, including those bordering the band, as many as five or even six on each whorl. Outer lip with a broad >shaped sinus but no linear slit. Type, *Eunema pagoda* Salter.

Doubtful and insufficiently known generic and minor groups of Paelozoic species usually referred to Pleurotomaria and Murchisonia.

MURCHISONIA, d'Archiac and Verneuil, 1841. (Bull. Soc. Géol. France, vol. 12, p. 154.) We prefer not to give a description of this genus at this time, because

* Canadian Organic Remains, Decade I, p. 18.
† Extr. Bull. Soc. d'Etud. Scientif. d'Angers, p. 20.

of doubt respecting the proper selection of the essential from the non-essential among the exceedingly diverse characters exhibited by the original type of the genus, *M. coronata* Goldfuss and its numerous varieties. We will say positively, however, that none of the preceding genera can properly be united with *Murchisonia*. Indeed, we are anything but satisfied that *M. coronata* is a true member the *Pleurotomariidæ*, and it appears that Koken felt more doubt on this point than he expressed in the remark (op. cit., p. 367) that "the method of growth, the rapid enlargement of the first volutions and other peculiarities remind of the *Pyramidellidæ*." On the same page he says also, in speaking of *M. coronata* and varieties, "it is just this type that impresses me as though it did not belong with the other Silurian, Devonian and Carboniferous species that are called *Murchisonia*." With a few exceptions, we have seen specimens of all the American species which have been described as of *Murchisonia*, and are quite prepared to maintain that strictly speaking the genus is not represented among them. The continued use of the genus for American species therefore is not justified except as a provisional receptacle for those which, because of insufficient knowledge of their characters, cannot yet be referred to their proper positions.

We had intended to add remarks on De Koninck's *Ptychomphalus*, *Gosseletia*, *Pithodea*, *Agnesia*, *Rhineoderma* and *Baylea*, and Œhlert's *Gyroma*, *Platyloron* and *Stenoloron*, (all proposed since 1880 as divisions under *Pleurotomaria*), but a lack of space makes it necessary that their consideration be postponed to some future opportunity. It may be well, however, to state here that each of these divisions embraces species genetically distinct from those in the others and that, while they will have to be redefined and their contents revised, none is likely to prove entirely useless in the classification of the future. As to *Pleurotomaria*, De France, if the genus is confined between reasonable limits, it is not recognizable among the Paleozoic species known to us, nor are the sections *Talantodiscus*, *Pyrgotrochus*, *Perotrochus* and *Entemnotrochus*, proposed by Fischer in 1885. The same is to be said of *Chelotia*, Bayle, and *Cryptænia* and *Leptomaria*, of Deslongchamps, which are variously recognized as sections, subgenera, or as distinct genera.

Genus LOPHOSPIRA, Whitfield.

Lophospira, WHITFIELD, 1886, Amer. Mus. Nat. Hist., vol. i, p. 312.
Murchisonia and *Pleurotomaria*, of authors.

For generic characters see page ——.

As here understood and described this excellent genus constitutes perhaps the most important of all occurring in the Lower Silurian. The species are numerous, some have comparatively an extended geological range, and most of them are to be counted among the common fossils at the localities where they occur. Moreover, in our opinion, the species are comparatively constant and therefore easily distinguished, although in practice among collectors no group of species has been more persistently thrown together as of one or two species than has the majority of the numerous types which on the following pages we endeavor to distinguish in such a manner that any one having good material at his command may without much trouble recognize them.

As far as known *Lophospira* ranges from the Calciferous to the Hamilton group, in other words from the base of the Lower Silurian or Ordovician to the middle of the Devonian system. However, by far the greatest development of the genus occurred in the various groups of the Trenton period. That the genus extended through the Devonian into the Carboniferous rocks is, to say the least, doubtful. We come to this conclusion despite the fact that the Worthenias of the Coal Measures (see p. 952) so greatly resemble the average Lower Silurian types of the genus that it is difficult to escape the conviction that they are direct descendants of them. *Worthenia,* though sufficiently distinguished by having an apertural slit, might readily have acquired this difference through gradual development, but we know absolutely of no intermediate later Devonian and Sub-Carboniferous *Lophospira*-like shells from which they might have been derived. For the present therefore, especially after considering that the apex of the shell of *Worthenia* is blunt and the embryonic whorls rounded, we incline to the view that the Carboniferous genus was evolved from some low-spired round-whorled shell like those which Œhlert proposes to distinguish as *Gyroma.* Excepting the initial cell or turn, which we have not seen, the apical whorls of *Lophospira* are not materially different from those following.

Many of the species now referred to this genus have heretofore been placed, according to the hight of the spire and the whim of the author, under either *Murchisonia or Pleurotomaria.* No genus is better calculated to show the unreliability, as a generic character, of the hight of the spire. This fact is we believe strikingly shown by the figures on plates LXXII and LXXIII. Take for instance various species of the *Bicincta* section, beginning with *L. humilis* Ulrich, the spire of which is so low that according to methods prevailing heretofore no one would have hesitated in placing it as a *Pleurotomaria.* From this it is certainly not a great step to reach *L. bicincta* Hall which Lindström calls a *Pleurotomaria,* while American authors generally have referred it to *Murchisonia.* Next we have *L. concinnula* U. and S. and *L. fillmorensis* U. and S., in which the spire is higher, and finally *L. procera* Ulrich in which it is very much higher than in *L. humilis.* Fully as great or greater differences in the hight of the spire are to be observed in the *Perangulata* section. Beginning with forms like *L. ampla* Ulrich and *L. multigruma* Miller, in which the apical angle varies from 70 to more than 90 degrees, we pass by numerous and easy gradations to *L. bowdeni* Safford, in which the angle is sometimes as narrow as 25 degrees. While the hight of the spire only rarely deserves to be counted among the generic characters, we believe it is, within reasonable limits, usually an excellent specific character.

Concerning the systematic position of the genus, we may say with considerable confidence that it is the oldest of the many types strictly belonging to the family *Pleurotomariidæ*. We say this not so much because the genus goes far back in geological time, for, according to known facts, several other types are equally ancient, but because it shares characters with types belonging to other families which, like the *Pleurotomariidæ*, originated somewhere in the interval between the Calciferous and the Upper Cambrian. Thus the simplicity of the band and apertural notch allies the genus with the *Euomphalidæ*. A striking resemblance, indicating, we believe, also close relationship, obtains between certain species of *Trochonema* and *Lophospira notabilis*, *L. knoxvillensis* and *L. trochonemoides*. This relation of *Trochonema* to the notched pleurotomarian and euomphalid genera is shown not only by the species of *Lophospira* just mentioned, but is indicated quite as strongly by such undeniable Trochonemas as *T. retrorsa* and *T. bellula*. The latter have an apertural notch at the end of the supra-peripheral angle, causing the lines of growth to curve backward toward the angle from both above and below. Only one feature remains to distinguish the *Trochonemoides* section of *Lophospira* from *T. retrorsa* and its allies, and that is, that while the Lophospiras have a distinct band, the Trochonemas have none, the lines of growth curving backward to and then over the angle without interruption in the latter.

Lophospira is divisible into four sections, and two of these into several subsections as follows:

A. *Perangulata section:*—Apertural notch >shaped, deep and wide, the lines of growth sweeping backward strongly from both above and below to the peripheral band.

1. *Perangulata subsection:*—Shells not very high, whorls five to eight, strongly angular. Species: *L. perangulata* Hall, *L. sorocula* Billings sp., *L. modesta* Billings sp., *L. medialis* U. and S., *L. decursa* Ulr., *L. pulchella* U. and S., *L. saffordi* Ulr., *L. abnormis* Ulr., *L. centralis* Ulr., *L. oweni* U. and S., *L. ampla* Ulr., *L. peracuta* U. and S., *L. elevata* U. and S., *L. multigruma* Miller sp., *L. tropidophora* Meek sp., *L. sumner-*

ensis Safford sp., *L. perlamellosa* Ulr., *L. perforata* U. and S., *L. spironema* U. and S. *L. tennistriata* Ulr., *L. conradana* U. and S., *L. gothlandica* Ulr.*

2. *Bowdeni subsection:*—High shells, eight to twelve whorls, less angular than in preceding subsection. Species: *L. bowdeni* Safford sp., *L. producta* Ulr., *L. augustina* Billings sp., *?L. major* Hall sp., *L. macrospira* Hall sp.

3. *Cicelia subsection:*—Differs from 1 in having a much higher spire, and from 2 in having more numerous and more sharply angular volutions. Species: *L. cicelia* Billings sp., *L. estella* Billings sp., *L. extenuata* Hall sp.

4. *Serrulata subsection:*—Distinguished from 1 by the plate-like extension and wavy character of the central part of the peripheral carina. Only known species: *L. serrulata* Salter sp.

B. *Bicincta section:*—Lines of growth curving very slightly, or not at all, backward to the peripheral keel, the apertural notch being very shallow.

1. *Bicincta subsection:*—Surface markings fine, generally quite regular, sharply elevated and closely arranged. Species: *L. bicincta* Hall sp., *L. quadrisulcata* U. and S., *L. obliqua* U. and S., *L. humilis* Ulr., *L. concinnula* U. and S., *L. fillmorensis* U. and S., *L. aspera* Billings sp.

2. *Tubulosa subsection:*—Similar to preceding, but surface markings much stronger, lamellose and imbricating, particularly on the band. Species: *L. tubulosa* Lindström sp., *L. laqueata* Lindström sp., both from the Upper Silurian of Gothland.

3. *Imbricata subsection:*—Relatively high small shells, with coarsely lamellar imbricating lines of growth; the latter turn backward on the basal portion of the whorl very soon after leaving the peripheral band, the aperture being unusually oblique. Species: *Murchisonia imbricata, munda, tortuosa, cochleata* and perhaps *cancellata,* all Upper Silurian of Gothland and described by Lindström. Unknown in America except by an undescribed species in the Clinton iron ore of New York.

4. *Holmi subsection:*—Lines of growth fine and equal as in the *Bicincta* subsection but with a direction as in the preceding. Only known species: *Pleurotomaria holmi* Lindström (Gothland.)

5. *Helicteres subsection:*—Agrees in all respects with the *Bicincta* subsection excepting that the last whorl or two is free. Only known species: *L. helicteres* Salter sp.†

C. *Robusta section:*—Shells rather short, whorls comparatively rounded, ventricose, scarcely angular even at the peripheral band, which is distinctly trilineate.

*The name *Lophospira gothlandica* is proposed for the shell which Lindström describes from the Upper Silurian strata of the island of Gothland as a species of *Pleurotomaria* under Hall's specific name *bicincta*. It is beautifully illustrated on plate VIII of his great work on the "Silurian Gastropoda of Gotland." The figures, together with specimens received from Dr. Lindström, prove it to be quite distinct from the American *bicincta*.

†*Murchisonia soluta* and *M. tropidophora* of Whiteaves, from the Guelph of Canada, for which the subgenus *Loxoplocus* is proposed by Fischer (Manual Conch., p. 847; 1885,) may belong to this subsection, but in the absence of reliable information respecting the characters of the peripheral band and apertural sinus, we prefer to leave them unclassified.

Surface, the basal half chiefly, usually with large though not very prominent revolving ribs. Lines of growth recurving moderately toward the peripheral band, indicating a wide but not very deep sinus in the outer lip. Species: *Pleurotomaria ohioensis* James, *Pl. robusta* and var. *lævissima* Lindström, *Pl. trilix* Hall.

D. *Trochonemoides section:*—In all respects like *Trochonema* save that the supra-peripheral keel bears a distinct band. Differs from ordinary types of *Lophospira* in the relatively depressed form, large umbilicus, thick shell and oblique mouth. Species: *L. trochonemoides* Ulr., *L. knoxvillensis* Ulr., *L. notabilis* Ulr.

LOPHOSPIRA BICINCTA *Hall.*

PLATE LXXII, FIGS. 1–5.

Murchisonia bicincta HALL, 1847, Pal. N. Y., vol. i, p. 177, pl. XXXVIII, figs. 5*a*–5*f*, (?5*g* and 5*h*.)
Murchisonia milleri HALL, 1877, 1st Ed. Miller's Amer. Pal. Fossils, p. 244.

Hight 15 to 30 mm.; apical angle 59° to 63°, usually about 60°. Volutions five or six, subangular; last one ventricose below, tricarinate, the upper ones bicarinate the lower carina being hidden by the suture; central or peripheral angle margined on either side by a sharp elevated line, with a narrow groove between, the angle, therefore, being composed of three lines of which the central one is a little stronger and more prominent than the lateral ones; lower carina thin, abruptly raised, the space between it and the peripheral angle scarcely concave and almost perpendicular; upper carina sharp, rather strong, removed a little more than a third of the biconcave upper slope of the volution from the suture; aperture somewhat obliquely subelliptical, higher than wide, narrow below, subangular at the lower inner corner; inner lip but little thickened, slightly twisted, never completely covering the minute umbilicus; outer lip very slightly sinuate. Surface marked by fine sharp subequal striæ, curving backward very gently from the suture to the peripheral band; beneath the latter they pass in a vertical direction to the lower carina which scarcely interrupts their course to the umbilicus, near which only a slight backward curve is noticeable. On the most perfect specimen seen all the transverse lines present the appearance of being minutely papillose or toothed, while the central line of the peripheral band is crossed by straight lines of which there are nearly twice as many in a given space as of those coming from above and below.

The most marked and important feature of this species is the exceeding shallowness of the sinus or notch in the outer lip. It is true Prof. Hall mentions an abrupt retral and forward curve of the surface striæ at the mesial band, but if we accept his fig, 5*e* as correct, it is evident that this statement is quite at variance with his illustrations. We prefer to accept the evidence of the cited figure upon the point in question rather than the description, especially since it is not at all improbable that the idea of an abrupt retral curve of the striæ was received from some similar associated but distinct shell. That he united more than one species or variety under the name *bicincta* is shown, provided the form has been correctly drawn, by his figures 5*g* and *h*. In the first, representing the fossil of the natural size, no upper carina is shown; nor is the peripheral angle trilineate. The second represents a part of the last whorl magnified and shows not only one, but two carinæ on the lower half. Perhaps these figures are not entirely trustworthy.

Although very frequently quoted, we thought it best to restrict the synonomy of the species to the original description, because we found it almost impossible to decide in most instances whether an author had the true *bicincta* before him or not. With collectors the practice prevails to a large extent to identify almost any set of Lower Silurian *Lophospira* with the *bicincta*, and we have seen no less than ten distinct species in collections bearing the one label "*Murchisonia bicincta* Hall." Salter's *M. bicincta* (Can. Org. Rem., Dec. 1, p. 19; 1859) clearly belongs to the next species or variety (*L. obliqua*) while Meek and Worthen's (Geol. Sur. Ill., vol iii, p. 317; 1868) we describe as another new species under the name *L. perforata*. Then the Upper Silurian shell from the island of Gothland, which Lindström identifies with this species (he calls it a *Pleurotomaria*) and describes and figures so beautifully in his classical work on the *Gastropoda* (Up. Sil. Gastropoda of Gotland, p. 106, pl. 8; 1884) is most certainly not the same as the American species. We have specimens of the Gothland shell before us and can say most emphatically that it has scarcely a single specific feature in common with *L. bicincta*. Comparing it with the other American species of *Lophospira*, we find that while it resembles *L. sumnerensis* Safford more than any of the others, it is still readily distinguished.

The essential characters of *L. bicincta*, as here identified and restricted, are (1) the ventricose whorls, (2) the sharp and regular lines of growth, and (3) the exceedingly shallow sinus in the outer lip and vertical direction of the surface striæ from the peripheral band downward.

Formation and locality.—Trenton period, Stones River group, not uncommon in the "Central limestone" at Murfreesboro, Tennessee, and rather rare in the Vanuxemia bed at Minneapolis, Minnesota, Dixon, Illinois, and Beloit, Wisconsin; Black River group, Mercer county, Kentucky: Trenton group, Middleville, New York; Clitambonites and Fusispira beds at several localities in Goodhue county, Minnesota; Cincinnati period, Richmond group, at Spring Valley and other localities in Fillmore county.

Collection.—E. O. Ulrich.

Lophospira obliqua, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIGS. 6–8.

Murchisonia bicincta Salter, 1859, Can. Org. Rem., Dec. 1, p. 19. (Not *M. bicincta* Hall, 1847.)

This form agrees in all respects with *L. bicincta* excepting that the surface striæ are less sharp and not so regular, and that instead of passing vertically downward from the peripheral band they cross the space between the central and lower carinæ somewhat obliquely, thus indicating a deeper sinus in the outer lip. Casts of the interior could not be distinguished excepting perhaps those which preserve the aperture entire, when the difference last mentioned may serve.

It is strange that two shells can be so very much alike and yet maintain certain almost minute characters so persistently as in this case. We have 42 specimens of the *obliqua* and there is never any doubt about them, the peculiarities mentioned being very constant.

Formation and locality.—Rare in the upper part of the Stones River group, at High Bridge, Kentucky; more common in the Black River and Trenton groups at various points in Mercer county, Kentucky.

Collection.—E. O. Ulrich.

LOPHOSPIRA CONCINNULA, *n. sp.*

PLATE LXXII, FIGS. 16–19.

Hight usually 10 to 15 mm., in one case reaching 21 mm.; apical angle 52° to 59°. Volutions six or seven, angular, not ventricose; upper central and lower carinæ all strong. Lines of growth fine, sharp, thread-like, regular, almost vertical beneath the peripheral band, and but little curved backward above it. In the grooves between the lines there are numerous short connecting bars, producing a minutely cancellated appearance.

The peripheral band and surface markings, excepting the delicate connecting bars, are precisely as in *L. bicincta*, and we are satisfied that the new species is closely related to that shell, if indeed it is really not merely a variety of it. Still, the connecting bars are a feature deserving some recognition, and when we add that the volutions in *L. concinnula* increases less rapidly and that they are less ventricose and more angular, because of the greater prominence of the spiral carinæ, it seems to us that a specific distinction must be conceded.

We describe three other species, *L. pulchella*, *L. spironema* and *L. tenuistriata*, which, if the aperture is imperfect and the surface markings abraded, it would be quite impossible to distinguish from each other and from *L. concinnula.* With any part of the exterior layer of the shell preserved the difficulties vanish, the first named three forms having a deep sinus in the outer lip and, therefore, strongly recurved lines of growth, while in *L. concinnula* the retral curvature is, as in *L. bicincta*, very slight indeed. The character of the transverse striæ also is different, being stronger and sharper in *L. concinnula.* For other differences see descriptions of the species mentioned.

Formation and locality.—Black River group, Ctenodonta bed, Minneapolis and Cannon Falls, Minnesota.

Collections.—E. O. Ulrich (9 specimens); W. H. Scofield (1 specimen).

Lophospira, fillmorensis, *n. sp.*

PLATE LXXII, FIGS. 20–24.

Hight 19 to 25 mm.; apical angle 53° to 56°; volutions about six. This form is represented by six casts of the interior and one macerated testiferous example. In its general aspect it, the cast especially, reminds one greatly of *L. concinnula* and it is not at all improbable that it is a later variety of that species. Still the testiferous example shows that on the exterior of the shell the spaces separating the upper and lower carinæ from the central one are more decidedly concave or groove-like. The surface markings also are different, consisting as near as can be made out, of transverse lines only. These furthermore are not sharp and equal but consist of more delicate lines with each third or fourth stronger than the others and sometimes distinguishable on the casts. The direction of the lines of growth is about the same in the two species. *L. bicincta* Hall has more ventricose whorls, less prominent keels and more equal and sharper surface striæ. For comparison with *L. perforata* see that species.

Formation and locality.—Trenton group, Fusispira bed, Wykoff and Fountain, Fillmore county, Minnesota.

Collections.—E. O. Ulrich; Dr. C. H. Robbins.

Lophospira quadrisulcata, *n. sp.*

PLATE LXXII, FIGS. 10–11.

Hight 12 to 22 mm.; apical, angle 67° to 70°; volutions about six, the last large and ventricose below, quadrisulcate, its upper slope with a strong subcentral carina, dividing two distinctly concave spaces; peripheral angle thick, trilineate; beneath it a wide concave band, next a sharp carina, then a narrower groove and finally the convex base; umbilicus very small, generally bordered by an obscure ridge. Lines of growth sharp, thread-like, regular, just visible to the unaided eye, curving gently backward on the upper slope, more abruptly bent backward and then forward on the peripheral angle, and nearly vertical between the periphery and the umbilicus.

This beautiful shell, though closely related, is readily distinguished from *L. bicincta* Hall, and all other species now referred to *Lophospira*, by having a fourth carina and groove beneath the usual lower carina. The revolving grooves are also deeper, the carinæ being more prominent than in that species. The upper one besides is usually further removed from the suture. The lines of growth are precisely the same in the two shells excepting that on the trilineate peripheral band in *L. quadrisulcata* they are abruptly curved, while they are straight in *L. bicincta*.

Formation and locality.—Not uncommon in the Richmond group of the Cincinnati period at several localities in Fillmore county, Minnesota. The majority of the specimens were collected in a railroad cut about two miles east of Spring Valley.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield; U. S. National Museum.

Museum Register, No. 7384.

Lophospira humilis, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIGS. 12–15.

Hight 7 mm. to 14 mm.; apical angle 80° to 90°. Related to *L. bicincta* Hall, but distinguished at once by its low spire and two carinæ instead of one on the upper slope of the whorls. One of these carinæ is close to the suture, the other about midway between the suture and the peripheral band.

Formation and locality.—Upper part of Trenton group, Mercer and Boyle counties, Kentucky, and Hartsville, Tennessee.

Collection.—E. O. Ulrich.

Lophospira procera, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIG. 9.

Hight about 30 mm., width about 16 mm., apical angle 43° to 45°.

The surface markings show that this species belongs to the Bicincta subsection, the direction of the lines of growth on the concave space beneath the peripheral angle, though oblique, being approximately straight. The comparatively great hight of the shell distinguishes it from the other members of its subsection.

Formation and locality.—"Central limestone" of the Stones River group, Murfreesboro, Tennessee.

Collection.—E. O. Ulrich.

Lophospira serrulata, *Salter.*

PLATE LXXII, FIGS. 51–55; PLATE LXXIII, FIG. 57.

Murchisonia tricarinata (Conrad) Hall, 1847, Pal. New York, vol. i, p. 178, pl. xxxviii, fig. 6c (not figs. 6a and 6b); Whitfield (part.) 1882, Geol. of Wis., vol. iv, p. 219.
Murchisonia serrulata Salter, 1859. Can. Org. Rem., decade 1, p. 20, pl. iv, fig. 1.
Murchisonia helicteres (part.) Whitfield, 1882, Geol. of Wis., vol. iv, p. 220, (not Salter, 1859, Can. Org. Rem., decade 1, p. 21, pl. iv, figs. 2—4.)

Hight 20 to 45 mm.; apical angle of upper volutions 56° to 62°. Volutions five to seven, closely coiled in the upper part of the spire but in fully grown individuals the last whorl descends very rapidly and becomes widely separated from the preceding one; volutions sharply and very prominently carinated on the periphery, the flange-like and obliquely undulated carina with a delicate line on each side of its base; carina frequently terminated by a series of spine-like prominences producing the serrated edge that has suggested the specific name. Sometimes the edge is merely wavy instead of toothed, while on the last or free whorl of old specimens the prominences are, if not wanting entirely, at least much more irregularly developed. In all the body whorl has four nearly equidistant sharp carinæ, one on the upper slope a third or a little more of its width distant from the suture, a third beneath the peripheral one already described, and a fourth marking the limits of the rather large umbilicus. The latter has a distinctly convex slope, while the space between the third and fourth keels is gently convex in the middle, those between the peripheral one and the third and first decidedly concave, and that between the summit of the first keel and the suture line more gently hollowed out. As long as the whorls are in contact the upper edge is sharp so that the suture is not excavated, but soon after the last turn becomes free this edge is lost, the whole upper surface, that is, above the first carina, becoming almost uniformly rounded. Aperture, excepting the angulation at the peripheral carina, subcircular; in a side view the outer lip is deeply notched at the principal carina and somewhat angularly produced at the extremities of the first and third keels. Surface marked with regular strong sharp equidistant lines of growth on the upper whorls, the striæ becoming more irregular and assuming an aged appearance on the free last turn. Their number in a given space varies, but the average at the first or upper carina is about three in 2 mm. The direction of the striæ, beginning at the suture, is first gently backward and then with a slight forward curve to the summit of the first carina. From here they sweep regularly and very decidedly backward to the peripheral keel, and beneath this forward again in a corresponding degree to the third carina on which they make a rectangular turn and proceed with less curvature than above to the fourth or umbilical keel. In the umbilicus, finally, the last backward direction continues until overcome by the curve when a transverse course is maintained until the circuit is completed on the upper side of the whorl.

In casts of the interior of young individuals all save the first three whorls, which are but rarely preserved, may preserve in a decided degree the angularity which marks the exterior, but in fully grown examples only the last whorl retains the angles and even here the peripheral carina only is distinct. (This is one of the points relied upon in distinguishing internal casts of this and the next species.)

We have very little doubt of the specific identity of this common shell of the Stones River group in Minnesota, Wisconsin and Illinois, with the *Murchisonia serrulata* described by Salter from the Black River group of Canada.* We grant that Salter neither mentions nor figures his species as having the last volution uncoiled, but this is readily explained if we assume, and his illustration justifies us in doing so, that he had only young or imperfect examples. We have numerous

* With the Canadian geologists this term includes the Birdseye or Stones River group.

specimens precisely like his in that respect. Two other features, however, shown in his illustrations are less easily reconciled with our specimens, and we confess that we can do so only by assuming that his drawings are not entirely trustworthy. We are loath to admit so much variation in at least one of the characters for we have found it to be remarkably constant in all other species. We refer namely to the direction of the lines of growth. These, we believe, do not bend sufficiently backward and forward in Salter's figures. In justification of our view we would point out the fact that his two figures (1 and 1*) are not exactly alike, so that it is not entirely unwarranted to assume that neither agrees exactly with the specimen. Then he represents the upper carina as nearer the suture than we have seen it, and farther from the peripheral angle than it should be if his description is correct is saying that the first and third keels are equally distant from the second.

As to *Murchisonia tricarinata* Hall, under which name Prof. Whitfield (*loc. cit.*) referred to young examples of both *L. serrulata* and *L. helicteres,* we have not the slightest doubt that Hall's fig. 6*c* was taken from an imperfect testiferous example of *L. serrulata.* This specimen, however, has four carinæ and is evidently distinct from the type represented by his figs. 6*a* and *b*. It was moreover only doubtfully referred to *tricarinata* by Hall himself. The validity of the species *tricarinata,* therefore, must be determined solely by the original description and type and not by Hall's second specimen which we have said is clearly referable to *L. serrulata* Salter. *L. serrulata* is the only species of the genus known to us having the flange-like peripheral keel serrated on the edge like a circular saw.* It is an excellent specific character, though unfortunately leaving no trace of its presence on casts of the interior. Still, the beds in which the species occurs in that condition are of such a nature that very often an excellent artificial cast of the exterior can be prepared from the natural mold enclosing the interior cast. The species is readily distinguished by other peculiarities, as may be seen by comparing it with other species described in this report. Some difficulty will probably be experienced in making a successful separation between it and the next species, *L. helicteres,* particularly when internal casts only are available. For comparisons see under that species.

Formation and locality.—Stones River group, in the Vanuxemia bed chiefly, at Minneapolis and St. Paul, Minnesota, Mineral Point, Janesville, Bellville and Beloit, Wisconsin, and Dixon, Illinois. Also in the Black River group (Upper Buff limestone) at Beloit, Wisconsin, and in central Tennessee (Carter's Creek limestone). In Canada the species occurs at Panquette's rapids in the Ottawa river in strata said to be of the age of the Black River group.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; Prof. J. M. Safford.

Museum Register, No. 7283.

* Prof. Whitfield on two occasions credits other species with such keels, the first time in Geol. of Wis., vol. iv, p. 221, where he says it is occasionally or frequently met with in *Murchisonia* (*Lophospira*) *helicteres* and *M. tricarinata;* the second time in 1886, Bull. No. viii, Amer. Mus. Nat. Hist., p. 311, when he says it occurs in "Many of the specimens [of *Lophospira*] especially of *M. milleri*" [*L. bicincta.*] We are convinced that in both cases he refers to specimens of the form which we identify with *L. serrulata* Salter, since among the numerous specimens of *L. helicteres* and *L. bicincta* studied by us we have never observed even a semblance of such a keel.

LOPHOSPIRA HELICTERES *Salter*, var. WISCONSINENSIS, *n. var.*

PLATE LXXII, FIGS. 25–28.

Murchisonia helicteres SALTER, 1859, Can. Org. Rem., Dec. 1, p. 21, pl. IV, figs. 2–4.
Murchisonia helicteres et *tricarinata* (part.) WHITFIELD, 1882, Geol. of Wis., vol. iv, pp. 219 and 220.

Hight 28 to 68 mm.; apical angle of upper volutions 58° to 65°, of entire full grown shell 40° to 45°. Volutions five or six, of which the first three or four are closely coiled and the last one or two, or even three, are free and widely separated. The free whorls are marked on the exterior by five keels, the uppermost being the least distinct and representing the suture line; the second is stronger and in the upper part of the shell situated almost midway between the suture line and the peripheral angle, but after the whorls become free it is moved relatively much nearer the sutural edge; the third or peripheral carina is the strongest and most prominent, and bluntly or rounded flat, or even concave at the edge; above it the surface is decidedly concave, beneath it for the greater part to the fourth carina almost flat; the latter is situated about the same distance from the central keel as the second but is scarcely as strong; the fifth keel is relatively weak and situated on the base of the whorl. Surface with distinct, sharp, equidistant lines of growth averaging eight or nine in 5 mm. Their course from the suture to the peripheral angle is almost direct, as it is also from here to the basal keel. Near and on the peripheral keel a more or less abrupt retral curve occurs, indicating an unusually restricted notch in the outer lip of the aperture.

In casts of the interior the two upper carinæ appear as very near each other, yet distinguishable as far up the spire as the third or even the second volution. The peripheral angle, though gradually losing its prominence, may be recognized on all the whorls. The fourth is but rarely distinguishable, the fifth, never.

The above describes the main characters of the Wisconsin and Minnesota variety of this species. As may have been noticed, it differs in two respects from the typical Canadian form, namely, (1) the surface striæ are more regular and much less curved backward in consequence of which the insinuation in the outer lip of the aperture is relatively very small; second, they have a basal or umbilical keel (similar to the one in *L. serrulata*) which is wanting in the typical variety. The latter occurs not only in Canada but in central Kentucky as well, while the var. *wisconsinensis* is, so far as known, restricted to the northwestern area.

This fine *Lophospira*, though really widely different, greatly resembles, in the usual condition in which they occur, the preceding species, *L. serrulata*. Both are strongly carinated and have the last whorls free, while the surface striæ also are similar in being strong and sharp in both. Still, when the shells themselves, or good molds of their exterior surface, could be compared, we found little difficulty in separating them. In the first place, the free whorls of *L. serrulata* have only four carinæ, being entirely without the uppermost or sutural keel which occurs constantly in *L. helicteres*. Then the surface striæ in crossing the shell from keel to keel in the latter are directed very much less backward and forward than is the case in the former. The outer edge of the aperture is therefore quite different in the two species. (Compare figs. 26 and 55 on pl. LXXII.) With practice it is possible to distinguish them almost at a glance, and it is not by any means a hopeless task even when we have nothing but the casts of the interior. When the casts are entire at the aperture, *L. serrulata* is recognized by the projecting angles at the extremities of the first and third carinæ and the wide >shaped notch between them. When this test is not available then we must rely upon the relative distinctness of the carinæ on the upper whorls. They are recognizable much farther up on the spire in *L. helicteres* than in *L. serrulata*, providing, of course, the specimens are of equal size.

It is possible that the shell above described is the one which Conrad named *M. tricarinata*, but Halls figures of that species are so poor that we cannot be blamed if we have made a synonym.

Formation and locality.—Stones River group, Minneapolis and St. Paul, Minnesota; Mineral Point, Janesville and Beloit, Wisconsin; and Dixon, Illinois. The typical form is from the Black River group at Pauquette's rapids, Ottawa river, Canada. We have it also from a similar horizon in Mercer county, Kentucky. It is said to occur also in the Upper Buff limestone in Wisconsin.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 6858, 7360.

Lophospira perangulata *Hall.*

PLATE LXIII, FIGS. 1–7.

Murchisonia perangulata Hall, 1847, Pal. N. Y., vol. i, p. 41, pl. x, fig. 4; not p. 179, pl. xxxviii, figs. 7*a*, 7*b*; Salter, 1859, Can. Org. Rem., decade 1, p. 19, pl. iv, fig. 7.

Shell small, hight 10 to 20 mm.; apical angle usually about 52°, but varying between 50° and 57°. Volutions about six, the last inclining to become free, scarcely ventricose below, very gently concave above; peripheral band prominent, sharp, trilineate; lower carina distinct though not very prominent, sometimes very obscure on casts of the interior; upper slope without a carina, the gentle concavity extending to the suture. A small, abruptly defined umbilicus always present. Mouth subtriangular, slightly drawn out below. Surface markings consisting of two sets of strongly recurved lines of growth, one distant and sublamellose, the other much finer and closely arranged between the former.

We have every reason to believe that the shell above described is identical with the Birdseye type of the species, but it is not the same as the Trenton form which

Hall united with it. The latter, if correctly represented by Hall's figures (*loc. cit.*), is so different that we have no hesitation in pronouncing it a distinct species. So far as our experience is concerned, *L. perangulata* is an unusually constant species. Our figures represent extremes of variation as exhibited in a large number of specimens.

Formation and locality.—Stones River group, Watertown, New York; Murfreesboro, Tennessee; Mercer county, Kentucky; and, somewhat doubtfully, Minneapolis, Minnesota; Black River group, Panquette's rapid, Canada.

Collection.—E. O. Ulrich. (About 100 specimens.)

LOPHOSPIRA ACUMINATA, *n. sp.* (or var. of PERANGULATA.)

PLATE LXXIII, FIG. 8.

Hight 10 mm. or less; apical angle about 42°. Volutions seven or eight, all contiguous; peripheral carina very prominent, trilineate, the central part of the band sharply angular; lower carina very strong, upper carina wanting; no umbilicus.

Resembles and perhaps is merely a later variety of *L. perangulata* Hall, yet readily enough distinguished by its more depressed and more numerous volutions, especially considering that it is a smaller shell. It differs further in being relatively higher, the apical angle being narrower, in the greater prominence of the carinæ, and in wanting the umbilicus which is so constantly present in Hall's species. A variety of *L. pulchella* is rather abundantly associated with this species at Spring Valley, Minnesota. It may be distinguished at once by its relatively strong upper keel, *L. acuminata* being without this keel.

Formation and locality.—Richmond group, Richmond, Indiana, Blanchester, Ohio; and near Spring Valley, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 7383.

LOPHOSPIRA MEDIALIS, *n. sp.*

PLATE LXXIII, FIGS. 23–29.

Hight 12 to 22 mm.; apical angle 58° to 70°, the average about 63°. Volutions six or seven, all contiguous, somewhat depressed, rounded below; upper slope nearly flat, generally a little concave in the outer half and gently convex toward the suture, occasionally convex enough to form an obscure subsutural angulation; lower carina becoming less distinct with age, never strong, generally quite indistinct; between it and the prominent peripheral carina, which carries the rounded band, the outline is more or less concave; umbilicus small but always present. Surface markings rather strong, lamellose, strongly curved backward, often gathered into undulating groups near the umbilicus.

Nearly intermediate between *L. perangulata* Hall and *L. sororcula* Billings sp., having a small umbilicus and depressed volutions like the former and a hight of spire and general appearance more like the latter. The convexity or obscure angulation of the upper part of the volutions, as well as the lesser development of the lower carina, distinguishes it from both and suggests relationship with *L. oweni* and *L. ampla.*

Formation and locality.—Rare in the Trenton group of Minnesota, in the Clitambonites bed at St. Paul, and the Fusispira bed at Wykoff; common in the upper beds of the Trenton between Burgin and Danville and at other localities in Kentucky; occurs also in middle Tennessee and in Lincoln county, Missouri.

Collection.—E. O. Ulrich. (45 specimens.)

LOPHOSPIRA MEDIALIS, var. BURGINENSIS, *n. var.* (*Ulrich.*)

PLATE LXXIII, FIGS. 30 and 31.

Hight 10 to 14 mm., apical angle almost constantly 60°; volutions six.

Agrees in all respects with *M. medialis* excepting that the average size is less, and the lower carina much stronger and more prominent. The lower carina causes also a flattening of the base that does not occur in the typical variety.

Var. *burginensis,* having a small umbilicus, must still remain separate from the Quebec group *L. sororcula* Billings. It resembles very greatly also *L. pulchella,* but has a wider apical angle, while the subsutural or upper carina is never well defined as it is in that species. In *L. perangulata* the apical angle is somewhat narrower, the slope of the upper side of the whorls less steep, and the space between the peripheral and lower carinæ more nearly vertical and less concave.

Formation and locality.—Upper part of the Trenton group, Burgin, Danville, Lexington and other localities in Kentucky.

Collection.—E. O. Ulrich. (35 specimens.)

LOPHOSPIRA ABNORMIS, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIGS. 36—40.

Hight 15 to 20 mm.; apical angle increasing with growth from 42° to 53°; volutions six or seven.

The size, surface markings, umbilicus and form of the volutions is almost exactly as in *L. medialis,* and if the last two whorls only were compared it would be most difficult to distinguish them. Still, a comparison of interior casts, the condition in which *L. abnormis* is usually found, will show that in the present species the umbilicus is less abrupt and the peripheral angle of the whorls more prominent and situated lower down, causing the upper slope to be slightly wider, higher and more convex. Besides the casts show an obscure revolving line or ridge close to the umbilicus which is not seen in *L. medialis.* But the peculiarity chiefly relied upon is the unusual fact that the apical angle of the first four or five whorls is only about 42°, while with the last turn the angle is increased to quite 53°; and taking only the last two volutions the angle is over 60°.

The marked increase in the apical angle distinguishes this species from all others now referred to *Lophospira.* Aside from this feature *L. perangulata* agrees nearly as well as *L. medialis.* Differing in the same manner as that species, the *perangulata* varies further in having constantly a carina beneath the peripheral one of which no sign is to be seen on *L. abnormis.*

Formation and locality.—Upper part of the Trenton group, Covington, Kentucky.

Collection.—E. O. Ulrich.

Lophospira decursa, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIG. 10.

Hight 22 to 28 mm.; apical angle 40° to 44°. Volutions about six; peripheral carina situated unusually low, causing the slope of the upper side to be uncommly steep; upper slope flat or with a slight swelling near the suture; concave space between peripheral and lower carinæ relatively narrow; no umbilicus.

Near *L. perangulata,* but is a larger and relatively narrower shell, with the peripheral carina lower and the concave space beneath it narrower. The absence of an umbilicus is also distinctive.

Formation and locality.—Trenton group, Burgin, Kentucky.

Collection.—E. O. Ulrich.

Lophospira producta, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIG. 21.

Hight about 42 mm.; greatest diameter 18 mm.; apical angle about 32°. Volutions about ten, strongly angular, rather high, the upper slope rather wide, concave to the suture except on the last whorl on which there is a slight thickening of the upper edge (not a carina) causing a slight deepening of the suture as we follow it down the spire; peripheral band prominent, rather thick, situated below the center of the exposed part of the upper whorls; lower carina well developed, exposed on all the volutions, its lower side forming the upper border of the suture line. Umbilicus open, comparatively large, the base of the shell rounding less abruptly into it than usual. Aperture rather high, straight upon the inner side, angular below; inner lip comparatively thin. Surface markings obscurely preserved in the specimen, apparently as in *L. perangulata.*

This species, considering that it is a close ally of *L. perangulata* and *L. elevata*, and therefore an undoubted *Lophospira*, is remarkable for the great elevation of the spire. It reminds decidedly of *L. bowdeni* Safford sp., but has a larger umbilicus, more angular volutions and a well developed lower carina, a feature that is scarcely distinguishable in that species. In our opinion *L. producta* has been developed from *L. perangulata*, while *L. bowdeni* probably had its origin in *L. oweni*.

Formation and locality.—Upper Trenton, Nashville, Tennessee.

Collection.—E. O. Ulrich.

LOPHOSPIRA CONOIDEA, *n. sp.* (*Ulrich.*)

PLATE LXXIII. FIG. 22.

Hight about 40 mm.; apical angle 42°. Volutions about six, somewhat loosely coiled. Peripheral carina prominent, situated very low for the genus, just above the deep suture, the edge thick and flat rather than round. An angulation about the middle of the under side of the last whorl surrounds a slight depression which farther inward sinks rather suddenly into a deep umbilicus. Upper slope slightly concave in the lower half, convex in the upper. Lines of growth sweeping strongly backward to the peripheral band, consisting without regularity of stronger and weaker striæ.

This species is remarkable for the low position of the peripheral band. In this it has gone a step farther than *L. producta*, which we believe connects it with *L. decursa* and through that with *L. perangulata*.

Formation and locality.—The type specimen was found by Prof. J. M. Safford in the Trenton group at Nashville, Tennessee.

LOPHOSPIRA PERACUTA, *n. sp.*

PLATE LXXIII. FIGS. 15–17.

Hight 25 to 40 mm.; apical angle 58°. Volutions five or six; peripheral band rather sharp and very prominent; upper surface of volutions gently concave to the suture, without a trace of the carina; lower carina wanting; umbilicus small, aperture rounded below and upon the inner side; surface markings obscure, curving backward strongly.

In this species the peripheral angle is sharper and more prominent than in any other known to us. The mouth is shorter and rounder upon the inner side and the volutions project over each other in a greater degree than in *L. oweni*. The shell is much larger, and the peripheral angle more prominent than in *L. perangulata*. That species differs further in having a lower carina. *L. ampla* has a wider apical angle, a subsutural carina, and a differently shaped aperture. In *L. sumnerensis*

(Safford) the last volution is relatively much higher and the peripheral angle not nearly so prominent. In general the species may be said to occupy an intermediate position between *L. elevata* and *L. multigruma* Miller and Dyer.

Formation and locality.—The type specimen is from the Glade limestone of the Stones River group at Lebanon, Tennessee. We have several imperfect specimens from the Ctenodonta bed of the Black River group at St. Paul, Minnesota, which may belong to the same species.

Collection.—E. O. Ulrich.

LOPHOSPIRA ELEVATA, *n. sp.*

PLATE LXXIII, FIGS. 11–14.

Hight 30 to 50 mm.; apical angle 52° to 54°. Volutions about six, contiguous but descending rapidly, an unusually large proportion of each exposed in the spire; peripheral carina moderately prominent, thick, situated about midway between the top and bottom of the whorl; beneath it a wide, slightly concave space, not very distinctly defined below by the obtuse lower angulation beyond which the surface turns rapidly inward to the small umbilicus; upper slope slightly concave to the suture, apparently never with a carina. Mouth very moderately drawn out below, the inner lip more or less curved and turned outward instead of being vertical as in most of the related species. Lines of growth rather obscure, curving strongly backwards to the peripheral band.

Very much like McCoy's *Murchisonia gyrogonia*, but if his figures are reliable then the two species must be quite distinct since the very slight retral curve in the lines of growth as shown in McCoy's illustration proves that his species belongs to the Bicincta section of *Lophospira*, while our *elevata* is an undoubted member of the Perangulata section. Compared with American species we find that the mouth is less produced below and, although the whorls are the same in number, the size of the shell much greater than in *L. perangulata*. The Tennessee species, *L. centralis*, is perhaps the nearest, yet we did not find much trouble in separating them. The apical angle is wider in that shell, the under side of the whorls more ventricose, the suture lines less oblique and the concave spaces over them narrower.

Formation and locality.—Five specimens from the Fusispira bed of the Trenton group at Decorah, Iowa, and Kenyon and Holden P. O., in Goodhue county, Minnesota. Several specimens from the upper part of the Trenton in Mercer county, Kentucky, are doubtfully referred here.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 7370.

LOPHOSPIRA SUMNERENSIS *Safford.*

PLATE LXXIII, FIGS. 18–20.

Murchisonia sumnerensis SAFFORD, 1869, Geol. of Tenn., pl. G., figs. 1, *a-f*. (Not defined.)

Hight 18 to 42 mm., usually 25 to 30 mm.; apical angle 60° to 73°, usually 64° or 65°. Volutions four or five, the last very large, the upper surface deeply concave, the sutural edge slightly thickened but never carinate, the peripheral angle not very prominent; beneath it the sides are at first nearly vertical then broadly convex to the umbilicus which is entirely closed by the curved inner lip; the latter is thick and expanded; aperture unusually high, narrowly rounded below, more broadly convex upon the columellar side. Surface markings somewhat irregular, moderately distinct though never very sharp, curving strongly backward from both above and below to the peripheral band.

The unusual hight of the last volution and the absence of upper and lower carinæ are the principal peculiarities of this species. The species is probably not far removed from *L. elevata* and *L. peracuta*, but all three forms seem to us to be easily recognized. In the last the peripheral angle is much more prominent, the last volution not nearly so high, and the upper surface much less concave. In the second there is a well-marked broad concave band beneath the peripheral angle, while the volutions are more exsert, the upper ones exposing more of their sides. In *L. multigruma* (Miller) the apical angle is greater, the volutions not so high, the upper surface nearly flat and the peripheral band more prominent.

Formation and locality.—Upper beds of the Trenton group, Nashville, Tennessee, and Mercer and Boyle counties in Kentucky. A single cast of the interior from the Fusispira bed at Wykoff, Minnesota, probably belongs to this species.

Collection.—E. O. Ulrich.

LOPHOSPIRA MULTIGRUMA *Miller.*

PLATE LXXII, FIGS. 36–39.

Murchisonia multigruma MILLER, 1878, Jour. Cin. Soc. Nat. Hist., vol. i, p. 104.

Hight generally from 25 to 35 mm.; greatest width equalling from 75 to 80-100ths of the hight; apical angle 75° to 80°. Volutions five, uniangular; base produced, rounded; umbilicus closed; columellar lip thick and slightly twisted below. Surface markings curved strongly backward to the peripheral band, coarse and rather irregular on the base of the last whorl, much less distinct on the nearly flat upper slope. When perfect the lines of growth are somewhat lamellose.

This species is closely related to *L. sumnerensis* Safford, but is distinguished by a wider apical angle, more prominent peripheral band, plane instead of concave upper slopes, and more twisted and thicker columellar lip. Dr. Miller says further that the base of his shell is more produced than in Prof. Safford's species. This is probably a *lapsus* since the hight of the base, indeed of the whole last volution, surely is relatively greater in *L. sumnerensis* than in *L. multigruma*. Another closely allied species, it is perhaps even nearer than Prof. Safford's, is our *L. ampla*. The last, however, usually has a higher spire, but a more reliable and striking difference is furnished by the subsutural carina, which is wanting in *L. multigruma*.

Formation and locality.—Occurs in all three of the divisions of the Cincinnati period (Utica, Lorraine and Richmond groups), very rare in the lowest, at Covington, Kentucky, more frequently in the middle at Cincinnati, Ohio, and rather commonly in the upper beds at Richmond, Versailles and Madison, Indiana, Clarksville and Middletown, Ohio, and Maysville, Kentucky.

Collection.—E. O. Ulrich.

LOPHOSPIRA CENTRALIS, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIG. 9.

Hight 20 to 30 mm.; apical angle 60° or 61°. Volutions five or six, all contiguous, with a concave slope above, somewhat ventricose below the moderately prominent, thick, faintly trilineate peripheral band; immediately beneath the band a concave space bordered on the lower side by an obtuse carina which grows less distinct with age; no upper carina though occasionally a slight thickening may occur at the upper edge of the whorls; umbilicus small, abrupt, nearly covered by the inner lip. Aperture but little produced below, obliquely rounded-quadrate in outline. Surface markings somewhat irregular and rather strong, especially beneath the lower carina; above the latter they turn almost sharply backward to the peripheral band; and on the upper side the retral curve is very decided.

Closely related to *M. perangulata* Hall, but is a larger shell, has a wider apical angle, and more rapidly enlarging volutions. The species is regarded as intimately connected with *L. oweni* and *L. ampla.*

Formation and locality.—Lowest division (Central limestone) of the Stones River group, Murfreesboro, Tennessee.

Collection.—E. O. Ulrich. (7 specimens.)

LOPHOSPIRA CONRADANA, *n. sp.*

PLATE LXXII, FIGS. 29-32.

Murchisonia ventricosa, WHITFIELD, 1882, Geol. of Wis., vol. iv, p. 218, pl. v, fig. 18.

Hight 21 to 31 mm.; greatest width about 7-10ths of the hight; apical angle 60° to 64°; volutions about six.

Of this species besides a single imperfect mold of the exterior we have seen only casts of the interior. In the former the upper whorls are rounded, but on the last two the periphery increases gradually in prominence until near the aperture it is sharply angular. The basal part of the last turn is decidedly ventricose, turning more or less abruptly into the deep though small umbilicus. On the flattened and nearly vertical sides, about midway between the peripheral angle and the basal outline, a faintly raised line (lower carina) is usually distinguishable. The suture is deep and the upper edge of the last whorl is flattened, and forms a shoulder-like prominence, between which and the peripheral angle the surface is strongly concave. Aperture obliquely subquadrate, rounded below. Surface markings only in rare cases leaving any traces upon the casts, consisting on the shell itself of lamellar lines of growth, .5 to 1.0 mm. apart, with much finer lines between them. They curve rather strongly backward from above and below to the peripheral angle.

Compared with species described in this report, *L. conradana* is distinguished by its strongly ventricose base. The general appearance of the shell might be considered to indicate close affinities with *L. bicincta* and *L. obliqua*, but the character and strong retral curve of the lines of growth prove that the species belongs to the *L. perangulata* section of the genus.

The Wisconsin specimen figured by Prof. Whitfield (*loc. cit.*) looks like an unusually large example of *L. conradana* that has been shortened by pressure, causing the apical angle to be abnormally wide. Still, the angle in the figure is only about 68°, while in his description Prof. Whitfield gives it at "about ninety degrees." Whatever the specimens described by him may turn out to be, we are satisfied that they are distinct from *L. ventricosa* Hall sp. In a more recent publication* Prof. Whitfield expresses himself as though he had arrived at a similar conclusion.

Formation and locality.—A frequent fossil of the Vanuxemia bed of the Stones River group at Minneapolis and St. Paul, Minnesota; occurs also, though rarely, in equivalent strata at Beloit, Wisconsin.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 5036.

LOPHOSPIRA OWENI, *n. sp.*

PLATE LXXIII, FIGS. 41–45.

Hight, of Black River specimens, 25 to 36 mm., of Utica specimens, 18 to 27 mm.; apical angle 59° to 62°. Volutions six or seven, the first very minute, decidedly angular. Peripheral band prominent, thick and rounded, sometimes margined by a delicate line on each side. Upper slope concave, except near the suture where there is usually a broad rounded ridge or carina; this ridge, however, becomes quite obsolete on the sixth or seventh volution. Lower side sloping inward, scarcely ventricose, the outline being first concave, next convex, then straight or concave and finally convex again, there being a peculiar swelling just behind the minute

* Bull. Amer. Mus. Nat. Hist., vol. i, no. 8, p. 313, 1886.

umbilicus. The first convexity beneath the peripheral band represents the lower carina of *L. perangulata* and other species, and in young shells it is sharp enough to be called a carina, but as growth proceeds it becomes more and more obtuse. Aperture straight at the inner margin, and somewhat narrowly produced at the lower angle. Surface markings rarely preserved; whenever preserved they consist of rather distant, delicate, sublamellose striæ, with very fine lines between them, all curving backward strongly to the peripheral band.

This is a much larger shell than *L. perangulata*, yet has about the same number of volutions. The apical angle also is greater, while both the under and upper sides of the volutions are obviously different in several respects. *L. centralis* never has so strong a subsutural swelling, its peripheral band is less prominent, and the under side of the whorls more ventricose.

Formation and locality.—Rare in the Stones River group at High Bridge, Kentucky; not uncommon in the Black River group, especially in the Ctenodonta bed, at St. Paul, Minneapolis, Cannon Falls, Chatfield and Fountain, in Minnesota; also in Mercer county, Kentucky. As yet it is not known to occur in the Trenton proper, but a smaller yet otherwise indistinguishable form reappears in the Utica group at Cincinnati, Ohio, and localities in that vicinity. About 60 specimens.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, Nos. 7521, 6865.

LOPHOSPIRA AMPLA, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIGS. 52–54.

Hight, of Loraine group specimens, 20 to 32 mm., of Richmond group specimens, 22 to 50 mm.; apical angle 70° to 80°. Volutions about six, the last equalling about two-thirds of the total hight. Upper carina thick, near the suture, present on all volutions; lower carina nearly obsolete, represented by a broad swelling or low ridge, above which to the prominent peripheral band the surface is more or less concave. Inner lip very thick, almost or entirely covering the minute umbilicus, very broad and turned obliquely downward and forward in the basal half. Surface markings very strongly curved, unequal, on the whole not sharply defined.

Closely related to *L. oweni*, yet easily distinguished by the greatly thickened, broad and obliquely extended inner lip. The apical angle also is greater, and the lines of growth are more curved, especially at the base, while the upper carina does not fade away on the last volutions as in that species. The presence of this carina distinguishes it from the associated and otherwise similar *L. multigruma* Miller. *L. medialis*, which is usually much smaller, with the same number of volutions, a smaller apical angle and more distinct umbilicus, also has no such sutural carina.

Formation and locality.—Cincinnati period, Lorraine group, Cincinnati, Ohio, and Covington, Kentucky; Richmond group, Richmond, Indiana, and at several localities in Boyle and Lincoln counties, Kentucky.

Collection .—E. O. Ulrich. (17 specimens.)

LOPHOSPIRA PULCHELLA, *n. sp.*

PLATE LXXIII, FIGS. 46—48.

Hight 8 to 15 mm.; apical angle 46° to 50° in the Richmond group variety and 50° to 56° in the Trenton types of the species; volutions angular, six in the latter and seven in the former. Peripheral band prominent, trilineate; upper or subsutural carina small and close to the suture, constantly present; lower carina obtuse, yet very distinctly defined by the concave band between it and the peripheral keel. Base of volutions somewhat flattened; umbilicus very small, closed entirely in the Richmond group variety. Growth lines as in *L. perangulata* and *L. medialis*, from both of which it is readily distinguished by the upper carina, those species being without that feature.

The development of an upper carina brings this species into closer relations with *L. oweni* and *L. saffordi* than it holds with the two species mentioned in the foregoing paragraph. The absence of the umbilical swelling and the small size of *L. pulchella* will of course suffice to distinguish it specifically from these. *L. spironema* and *L. tenuistriata* are exceedingly like it to the unassisted eye, but with the aid of a magnifier good specimens may be distinguished at once by their surface markings, the present species having lines of growth only, while both of the others have revolving lines as well. *L. pulchra* McCoy resembles this species very greatly, yet, relying on the accuracy of McCoy's illustrations, we see at once that his species is a member of the Bicincta section and not, as is the case with *L. pulchella*, of the Perangulata section. Indeed *L. pulchra* seems to be uncomfortably near certain varieties of *L. bicincta*.

Formation and locality.—Upper part of Trenton group, Burgin, Danville and Frankfort, Kentucky; Black River group, Ctenondonta bed, near Cannon Falls, Minnesota; Richmond group, Spring Valley, Minnesota. (Over 30 specimens.)

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 7383.

LOPHOSPIRA SAFFORDI, *n. sp.* (*Ulrich.*)

Hight 23 to 33 mm.; apical angle 59° to 65°. Volutions seven, very angular, the peripheral band unusually prominent, upper and lower keels both distinct; upper carina removed a third of the width of the upper slope from the suture; surface of whorl lying between the three keels decidedly concave; umbilicus small, rather abrupt, the surface between it and the lower carina either flat or slightly concave. Aperture quadrate, or it might be called subtriangular, moderately produced below, the inner lip nearly vertical, broadly reflexed. Surface markings consisting of unequal sublamellose lines of growth, sweeping backward very strongly to the peripheral band.

This elegant species is undoubtedly closely allied to *L. oweni*, but the persistence and sharpness of its upper and lower keels serve readily in distinguishing it. The lower extremity of the mouth also is more rounded, while the umbilicus is a trifle larger and the umbilical fold, which is a well-marked feature in that species, is much less developed or quite unrecognizable. *L. pulchella*, which also we regard as closely related, is a very much smaller shell. In *L. ampla* the apical angle is wider, the upper carina scarcely as sharp, the lower carina quite obsolete, and the inner lip peculiarly twisted.

Formation and locality.—Upper Trenton, near Nashville, Tennessee, where the seven silicified shells upon which the species is founded were collected by Prof. J. M. Safford. This gentleman is not only an illustrious geologist, but the kindest and most generous that it has been our good fortune to meet. We consider it, therefore, peculiarly appropriate that this shell, perhaps the handsomest of the fossil gastropods occurring in the state which he has so long and honorably served as state geologist, should be connected with his name.

LOPHOSPIRA SPIRONEMA, *n. sp.*

PLATE LXXII, FIGS. 44–47.

Hight 10 to 15 mm.; apical angle 58° to 62°. Volutions five or six, angular; periphery trilineate, very prominent, the surface on each side decidedly concave; lower carina sharp and strong; upper carina thin but distinct, close to the suture. Lines of growth very fine, not sharp, strongest near the suture, curving strongly backward from both sides to the peripheral angle; entire surface with very delicate revolving lines.

This shell, in its general expression, is exceedingly like *L. pulchella*, and we doubt very much that abraded examples of the two could be separated. The carinæ may be somewhat sharper and the apical angle greater, but the only reliable and important difference lies in the surface markings, that species having no spiral lines, while its striæ of growth are stronger. The next species, *L. tenuistriata*, approaches closely but has sublamellose lines of growth, finer spiral lines, less prominent carinæ and different peripheral band.

Formation and locality.—Ctenodonta bed of the Black River group, Chatfield and near Cannon Falls, Minnesota.

Collection.—E. O. Ulrich. (5 specimens.)

LOPHOSPIRA TENUISTRIATA, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIGS. 48–50.

Hight 10 to 16 mm.; greatest width about 69-100ths of the hight; apical angle about 57°. Volutions six or seven, angular, with only moderately developed upper and lower carinæ; central carina very prominent, thick, rounded, bordered on each side by a delicate raised line; basal part of shell somewhat ventricose, gently concave above the lower carina; upper slope moderately concave in the outer part; umbilicus very small, sometimes apparently covered by the reflected inner lip. Surface with transverse and revolving lines, the former curving strongly backward toward the peripheral band and consisting of two sets, one lamellar with distant raised edges, the others exceedingly fine, parallel with the other set, and five or six times as numerous. The whole surface, including the peripheral band, is covered with the revolving lines which are inclined to be irregular and more delicate even than the transverse set, requiring a good light and a magnifying power of no less than four diameters to be clearly visible. On the peripheral band the lunulæ are distant and strongly curved backward.

Differs from the earlier *L. spironema* in having the basal part of the last turn slightly more ventricose, the carinæ less strong, the peripheral band rounded instead of sharp, and the surface markings more delicate excepting the sublamellose growth lines which are wanting in that shell. *L. pulchella* also resembles it greatly but has a smaller apical angle and so far as observed its surface is entirely without revolving lines.

The extreme delicacy of the surface markings renders them unusually liable to removal through maceration and weathering. The best examples were obtained by picking away the thin parasitic bryozoan, *Leptotrypa clavis* Ulrich, which frequently covers this and other fossils of the Utica group. Without the characteristic surface ornamentation *L. tenuistriata* might be confounded with the young shells of the Utica form of *L. oweni*. In such cases, however, the presence of a lower carina in the *tenuistriata* and its absence in the *oweni* will usually suffice in distinguishing them.

We have before us two imperfect specimens, collected by one of the authors in the Stones River group at High Bridge, Kentucky, of another species of *Lophospira* with spiral lines. It is larger than either of the two of this type described in this work, and differs from them besides in having the revolving lines coarser and in wanting the lower carina. The general shape and character of the shell seems to have been very similar to our L. *medialis*.

Formation and locality.—Shales of the Utica group, Cincinnati, Ohio, and Newport and Covington, Kentucky.

Collection.—E. O. Ulrich.

LOPHOSPIRA PERFORATA, *n. sp.*

PLATE LXXIII, FIGS. 32–35.

Murchisonia bicincta? MEEK and WORTHEN, 1868, Geol. Sur. Ill., vol. iii, p. 317, pl. III, fig. 4. (Not *M. bicincta* HALL, 1847.)

Hight 33 mm.; greatest width 26 mm.; apical angle about 50°. Volutions six or seven, relatively depressed, with the hight and width, as shown in a transverse section, nearly equal. In internal casts of old shells the peripheral or central angle is sharp and prominent on the lower turns only, while it is nearly obsolete on the upper ones; last whorl exhibiting a well-marked lower angle between which and the peripheral carina there is a broad concave band, while the under side, between the lower angle and the relatively large and abrupt umbilicus, is only slightly convex; in the middle of the basal space the cast exhibits an obscurely defined line; upper slope gently concave or flat, except near the suture where the internal cast is slightly convex. The matrix shows that there was a thin upper carina on the shell. Surface markings but faintly indicated by the specimens at hand, but it is certain that they curved backward strongly as in *L. perangulata*, while it is probable that they agreed in other respects also with those marking that species.

The umbilicus is larger in this species than in any of genus previously described. In other respects it resembles *L. pulchella* very closely, though a much larger shell. *L. fillmorensis*, though considerably smaller and without an umbilicus, will strike the ordinary observer as even more like it. But if good specimens can be compared it will be noticed that the lines of growth on the concave band beneath the peripheral angle of *L. fillmorensis* are but little oblique and nearly straight instead of strongly curved backward—in short that that shell belongs near *L. bicincta*, while *L. perforata* is one of the group of which *L. perangulata* is typical.

We have before us the original type used by Meek and Worthen. After clearing it of the matrix we found that it has at least one more whorl than stated by them, and that the apical angle instead of being 55° is not more than 50°. The last whorl of the specimen is crushed in such a manner that the angle has been increased at least 5° beyond the normal. An examination of the matrix proved further that the shell really has an upper carina. Finally, it is clear that the umbilicus was not filled, as they supposed, by the columella. That it was not is conclusively shown by the core of limestone occupying all the cavity save a narrow space between it and the cast of the interior of the whorls which represents the space originally occupied by the walls of the shell.

Formation and locality.—Trenton group, Jo Daviess and Carroll counties, Illinois. We refer here two small casts from the Fusispira bed near Fountain, Minnesota.

Collections.—Illinois State Museum; E. O. Ulrich.

Lophospira perlamellosa, *n. sp.* (*Ulrich.*)

PLATE LXXIII, FIGS. 55 and 56.

Hight 13 mm.; greatest width about 10 mm.; apical angle 65°. Spire subconical, volutions about five, angular; upper side first gently convex and then slightly concave to the prominent peripheral band; base at first a little concave because of a low ridge a short distance beneath the band, then following the course of the striæ, with a concave outline to the acute basal extremity; umbilicus very small; inner lip nearly vertical, twisted, and greatly produced below. Surface markings very faint upon the upper side of the volutions; on the base they consist of rather regular, strong, overlapping lamellæ, curving strongly forward from the peripheral band and, finally, running in a nearly vertical direction, and almost parallel with the inner lip, to the narrow basal extremity of the aperture.

There is no described species (of this family) known to us having the aperture produced below as much or in the same manner as in this shell. A similar condition is exhibited by two specimens from the Lorraine group, one from Cincinnati, the other from central Kentucky, but as the apical angle is somewhat less in these (56° and 57°) and the lower side of the volutions more ventricose, we hesitate to say that they belong to the same species. The surface being abraded on them we cannot say how the markings compare with those observed on the type described and figured.

Formation and locality.—Richmond group of the Cincinnati period, Hanover, Butler county, Ohio.
Collection.—E. O. Ulrich.

LOPHOSPIRA BOWDENI *Safford.*

PLATE LXXII, FIGS. 40–43.

Murchisonia bowdeni SAFFORD, 1869, Geol. of Tenn., pl. G, figs. 2*a*–2c. (Not described.)

Hight 40 to 70 mm., usually 45 to 50 mm.; apical angle of Tennessee types of species averaging about 27° but varying between the extremes of 26° and 30°; of the Lorraine group variety 30° to 34°; of the Richmond group form 25° to 28° for specimens from Trimble county, Kentucky, and 27° to 33° for those from Boyle county in the same state; volutions eight to ten, moderately angular, the peripheral band thick, convex, varying as to prominence, situated beneath the center of the whorls; upper slope convex, sometimes obscurely carinated, in the upper half, more or less concave in the lower half; lower carina obscure, never sharp, often indistinguishable, the space above it to the peripheral carina generally a little concave; a minute umbilicus usually present, though in narrow specimens it is commonly covered by the reflexed inner lip; aperture subtriangular or irregularly quadrate, the outline depending upon the angle at which it is viewed; inner lip nearly vertical, generally exhibiting a small channel in its lower part. Surface with obscure undulations or unequal lines of growth. These are very strongly recurved toward the peripheral band, indicating a large and deep >shaped notch in the outer lip. The band is distinctly convex, occasionally subangular in the middle, has obscure lunulæ, and is bordered on both sides by a delicate raised line.

The prominence of the peripheral band varies considerably. As a rule it is the most pronounced in specimens from the Richmond group and least in those obtained from the "Upper Nashville" of Tennessee and the Lorraine of Kentucky and Ohio. The apical angle also is variable though fairly constant in specimens from a given locality and horizon. The Lorraine variety is the widest, the Trimble county Kentucky, and Tennessee specimens the narrowest. The latter look like our fig. 42 only not so angular. Fig. 40 is perhaps a fair average for the species.

Cincinnati collectors formerly confounded casts of this species with *Hormotoma bellicincta* Hall sp., but we now know it as a totally distinct shell. *Hormotoma* has a concave band and, as may be seen from our figures, differs in many other respects, while *L. bowdeni* has the band of a *Lophospira* and in reality differs from such a typical species of the genus as *L. oweni* chiefly in the hight of the spire.

Formation and locality.—"Upper Nashville" near Hartsville and at other localities in Tennessee; Lorraine group at numerous localities in Ohio, Indiana and Kentucky; Richmond group at many localities in the same states, especially in the upper fifty feet in Kentucky.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

LOPHOSPIRA AUGUSTINA *Billings.*

PLATE LXXI, FIGS. 1 and 2.

Murchisonia augustina BILLINGS, 1865, Pal. Foss., vol. i, p. 234.

Hight 80 to 120 mm., apical angle 33° to 40°; whorls eight or nine, perhaps ten, yet casts of the interior, in which condition only the species has been observed in Minnesota, rarely preserve more than the last four or five. Whorls (of casts) strongly convex, obtusely angulated just below the middle, angular above, forming a narrow horizontal space at the broad open suture. Aperture about as wide as high, slightly drawn out and channelled at the lower angle. The lip is free all around, on the upper side in contact with the penultimate whorl, on the inner side with a broad fold which never quite closes the umbilical perforation. The latter is represented in casts by a flattened spirally twisted core. Casts of the interior preserve not even a trace of the surface markings, nor are they clearly indicated in the molds of the exterior seen by us. As near as can be determined from the material at hand, they consist, as described by Billings, of obscure undulations curving strongly backwards to the rounded peripheral band. The shell itself was strong and thick, especially in its sutural parts.

This is one of the forms usually identified with Hall's *Murchisonia major*, but if our views of that shell are correct, then this is most certainly distinct, while it seems to be equally certain that it is the same as the Newfoundland species which Billings has called *Murchisonia augustina.* Billings, it is true, considered the *augustina* as a variety of *Murchisonia*, or, as it should now be called, *Hormotoma bellicincta*, but relying on the accurracy of his description and figure, this cannot be so, since the angular whorls and convex band remove his *augustina* far from *Hormotoma* in which the band is concave or flat and the whorls nearly always rounded. In our opinion the species is related to *Lophospira bowdeni* Safford sp., differing therefrom chiefly in the lesser angularity of its whorls. Of course it is not likely to be confused with that species, being a much larger and relatively wider shell.

Formation and locality.—Maclurea bed of the Trenton group, Stewartville and other localities in southern Minnesota. Billings' types are said to be from divisions H, I, K, L, M, N, of the Quebec group, at Pistolet bay, Burnt cape, Table head, and Point rich, Newfoundland.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, Nos. 7345, 7478.

LOPHOSPIRA AUGUSTINA, var. MINNESOTENSIS, *n. var.*

PLATE LXXI, FIGS. 3 and 4.

Hight 80 to 120 mm., apical angle 36° to 45°.

Of this supposed variety we have only three casts of the interior which one of the authors found in the same block of limestone from which he extracted a number of good casts of *L. augustina*, and three fragments belonging to the Survey collection.* The obtuse angulation of the whorls, which marks the position of the band, is lower than in the typical form of the species and the whorls are on the whole less convex, the result being a more conical form, probably not greatly unlike, externally, *L. conoidea* (Pl. LXXIII, Fig. 22). Continuing our comparisons with *L. augustina* we find that the under side of the whorls is also less ventricose and the total hight of each somewhat less.

In the absence of any knowledge of the external markings, we prefer to rank this form as a variety though strongly inclined to believe that it will prove specifically distinct.

Formation and locality.—Maclurea bed of the Trenton group, Stewartville, Minnesota; Ottawa, Canada.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, Nos. 7389, 8726.

LOPHOSPIRA (? SEELYA) LIRATA, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIGS. 56–59.

Hight 15 to 24 mm.; apical angle 65° to 70°, the angle of the first three whorls usually a little wider. Volutions about five and a half, ventricose, the carinæ not greatly interfering with the general roundness of their outlines. Peripheral band median, appearing lower on the whorls of the spire, very slightly prominent, trilineate, the lines of equal strength and elevation or the median one is a little

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* Since the above was written, I have received a specimen of this variety from Mr. W. R. Billings, who found it in the Trenton limestone at Ottawa, Canada. E. O. ULRICH.

weaker and not as sharply defined as the margined ones. About midway between the band and the suture lines a small ridge or carina divides the upper slope into two flat or slightly concave spaces. Nearly the same distance beneath the lower margin of the band in the typical form of the species we meet with the first and strongest of about eight revolving ribs. These ribs, excepting occasionally the first, are wanting in a variety which, if it is desirable to name it, might be called var. *obsoleta*. Umbilicus exceedingly small, sometimes closed by a slight overlap of the inner lip. Aperture subovate, rounded below, and rather straight at the inner side. Lines of growth sharp, thread-like, regular, either fine and equal on all parts of a whorl or they may be farther apart with interpolations on the upper slope as shown in figs. 58 and 59. The lunulæ of the band are fine and regularly curved.

This species is not closely related to any American fossil known to us. It resembles *Plethospira semele* Hall sp. in its general form and size and casts of the interior are not easily distinguished. They are, however, widely distinct genetically and as long as good exteriors are available there is little danger of confusion between them. In the *Plethospira* the band is simple and concave (not bi-concave) while the very delicate line near the suture and the other on the lower half of the whorl compare very ill with the revolving ridges and ribs of *Lophospira lirata*. A true relative is described by Lindström from the Upper Silurian of Gothland as *Pleurotomaria robusta*. That it was derived from the same stock as our species seems very obvious, for, aside from several minor differences, the same characters occur in both. *L. lirata* has a relatively higher spire while the central line of the band is not as prominent as in *L. robusta*.

Our main reason for referring these two species to *Lophospira* instead of *Seelya* is that the band is of the convex instead of the concave type. With *L. humilis* Ulrich as an intermediate form it is not difficult to reconcile the other characters with the more common types of *Lophospira*.

Formation and locality.—Not uncommon, chiefly as casts of the interior, in the Utica group at Cincinnati, Ohio.

Collection.—E. O. Ulrich.

LOPHOSPIRA (?) KNOXVILLENSIS, *n. sp.* (*Ulrich.*)

PLATE LXV, FIGS. 38–40.

Hight 30 to 40 mm., width about the same; apical angle about 105°; whorls three and a half or four. The shell is about the size and looks much like *Trochonema beloitensis* and *T. eccentrica*, the whorls having a broad vertical peripheral space bordered above by the slit-band and below by a simple angle, and the aperture being oblique and subquadrate or, if the small lower-outer side be considered, subpentagonal in outline, with the lower half of the entire peristome thick and reflexed. The upper side of the whorls is distinctly concave to the narrowly yet deeply impressed suture. The channel-like character of the suture is discernible only in a view of the upper side. The basal slope to the edge of the moderate umbilicus is more or less flattened. The slit-band, which occupies the upper of the two peripheral angles, consists of a sharp ridge-like center with a delicate raised line on each side of its base. The surface markings consist of lines of growth only. These curve very strongly backward and are comparatively weak on the concave upper slope. Beneath the slit-band they increase in strength downward, while their direction is first, with a moderate curve forward, down to the lower angle of the vertical periphery of the volution. Here they turn backward and proceed across the base to the umbilicus in a direction conforming with the broadly sinuate under lip. The depth of the sinus, however, seems to have increased with age.

Though there may be some doubt as to the strict propriety of referring this and the two following species to *Lophospira*, we believe that a careful consideration of the whole of their characters will show that of all the established genera the claims of the one in which we have placed them are supported by the strongest evidence. We take it for granted that, despite their remarkable resemblance to the most typical species of *Trochonema* and the remote genetic relations so strongly indicated therein, all will agree that the possession of an unequivocal slit-band renders an alliance with *Trochonema* out of the question. We say this too without losing sight of the fact that we describe species of that genus (e. g. *T. retrorsa* and *T. bellula*) having a notch in the aperture of very nearly the same character and at the same point at which it occurs in the trochonemoid species of *Lophospira* under consideration. There is one feature about these notched *Trochonemas* that must always distinguish them, the upper peripheral angle toward which the lines of growth are recurved is comparatively thin and sharp with the lines continuing without interruption over the summit. (See pl. LXXVII, fig. 38.) In the Trochonemoides section of *Lophospira* on the other hand, the angle at the end of which we find the notch, is thick and carries a true pleurotomarian band of which it is probably unnecessary to say that it interrupts the continuity of the lines of growth.

Phanerotrema, proposed by Fischer for species of the type of *Pleurotomaria labrosa* Hall, also reminds one in a general way very strongly of these shells. That the latter have a large umbilicus and *P. labrosa* none, is probably not of much consequence, but there are other differences that doubtless are of greater importance. Of these we will point out only one, namely, the long apertural slit which occurs in *Phanerotrema* and is wanting in *Lophospira*, and which of itself is considered sufficient to warrant a generic separation.

Formation and locality.—Lower part of Trenton period (?Chazy) near Knoxville, Tennessee. We owe the opportunity of describing this as well as the following two equally interesting species to their discoverer, Prof. J. M. Safford.

LOPHOSPIRA (?) TROCHONEMOIDES, *n. sp.* (*Ulrich.*)

PLATE LXV, FIGS. 41–44.

Hight 22 mm.; width 23 or 24 mm.; apical angle 100°; volutions four and a half; general appearance of shell decidedly like *Trochonema bellula* Ulrich. Upper peripheral carina thick, rounded, lower carina moderately distinct and sharp except on the latter half of the last whorl on which it grows gradually weaker until at the aperture it is quite obsolete; outer two-thirds of upper slope distinctly concave, remaining third flat to the suture; umbilicus large, only moderately steep, at first sharply outlined by a ridge which gradually becomes indistinct and at the same time moves outward causing the slope to the bottom of the umbilicus to become proportionally more gentle. Surface markings and aperture about as in *L. knoxvillensis*, from which the present species is distinguished by its smaller size, more slowly enlarging volutions, relatively larger umbilicus and by the upper carina which is wanting in that species.

As *L. trochonemoides* occurs at the same locality and geological horizon as *Trochonema bellula*, and as the two might very easily be confounded by persons not thoroughly accustomed to separating fossil *Gastropoda* it may be well to point out some of the differences. First, both the lower peripheral and umbilical carinæ are stronger and more persistent in the *Trochonema;* then the space between the upper carina and the suture line is concave instead of flat; finally, the upper of the peripheral carinæ is not so thick and sharper than it is in the *Lophospira*, while the lines of growth, since there is no slit-band, pass over its summit without interruption.

Formation and locality.—"Central limestone" of the Stones River group, Murfreesboro, Tennessee.

LOPHOSPIRA (?) NOTABILIS, *n. sp.* (*Ulrich.*)

PLATE LXXII, FIGS. 33–35.

Hight and width nearly equal, a full grown specimen measuring about 27 mm., a small one 19 mm.; apical angle about 87°; volutions five. Shell like that of a *Trochonema*, with a moderate umbilicus, oblique aperture, and strongly carinated whorls, the last partly free in old specimens. Upper carina very strong and prominent, situated midway between the suture and slit-band; lower peripheral carina also unusually strong and prominent; midway between these carinæ, and separated from them by concave spaces but little wider than itself, is the broad and salient slit-band, composed of comparatively distant, convex imbricating lamellæ, averaging on the last whorl about seven in 10 mm. The top of the whorls (*i. e.* the space between the suture and the upper carina) is flat and the base moderately ventricose with an obscure carination around the umbilical depression. The aperture is oblique, more rounded than angular, and abruptly notched at the extremity of the slit-band; the peristome is entire, the lower portion thick. The surface markings consist of rather coarse and irregular lines of growth. These, in crossing the whorls from above downwards, are not much recurved until just before they reach the slit-band. On the concave peripheral space they are approximately vertical, on the base broadly recurved about as in *L. knoxvillensis* and *L. trochonemoides*.

The most striking feature of this remarkable shell, and one that will distinguish it at once from every one of the host of Lower Silurian *Pleurotomariidæ* known to us, is the coarsely marked slit-band. This, as well as the form of the aperture and, in fact, the general aspect of the whole shell, is so different from the usual types of *Lophospira* that, if we had not at the same time seen *L. knoxvillensis* and *L. trochonemoides* which, while having the usual *Lophospira* band, yet agree very closely with it in all other respects, we would have considered ourselves justified in proposing a new genus for its especial benefit. As it is, we are not at all satisfied that it would not be better to set these three species apart as a distinct genus, thereby facilitating reference to a genetic relationship that before the discovery of these shells was not even suspected. That a relation of this kind does exist between *Trochonema* and the *Pleurotomariidæ* is now scarcely to be denied, for it seems almost inconceivable that such intimate agreement in structure could occur except in near branches of the same stock. For further remarks on this group of species see under *L. knoxvillensis*.

Formation and locality.—Black River group (Carter's Creek limestone) Maury county, Tennessee, and Mercer county, Kentucky.

Genus SCHIZOLOPHA, Ulrich.

For generic characters see page 952.

Of all the known Lower Silurian *Pleurotomariidæ*, the two species of this genus alone possess a true apertural slit. In both the length and actual presence of the slit were established by the fact that a parasitic crust, in one case of a coral, in the other a bryozoan, which covered the shells evidently during life, grew up to but not over the slit and thus left a narrow space uncovered corresponding in width and length with the slit in the shell. In *S. moorei* the slit extends backward for a distance equaling about one-fifth of the circumference of the last whorl, in *S. textilis* about two-ninths. The general expression of the two shells reminds one strongly of *Lophospira*, and when we add that the slit-band is of the convex type, we believe we are fairly justified in assuming that they were derived from some member of that genus.

Schizolopha may be compared with *Phanerotrema*, Fischer, an Upper Silurian and Devonian genus, also provided with a long slit but differing in having a concave slit-band. *Phanerotrema* reminds one in some respects very strongly of the Trochonemoides section of *Lophospira*, but it recalls in other features the Calciferous *Lophospira cassina* Whitfield quite as much. The last species is represented in the collections before us, and we can say most positively that it is not a *Lophospira*. Having a concave band, situated somewhat obliquely upon the periphery, it had perhaps best be placed under *Eotomaria*, though scarcely as a good species of that genus. Having a concave band and agreeing also in all other respects, save in wanting a slit and revolving surface markings, we believe we have in *Lophospira* or *Eotomaria cassina* a reasonably plausible progenitor for *Phanerotrema*—certainly a more likely one than any of the forms that we refer to *Lophospira*. If this is correct, then *Schizolopha* and *Phanerotrema* must be maintained as representing two distinct though almost parallel lines of development.

SCHIZOLOPHA TEXTILIS, *n. sp.*, (*Ulrich.*)

PLATE LXV, FIG. 30.

Hight 30 mm., width 27 mm.; apical angle about 80°. Shell turbiniform, volutions about five, ventricose below, with a subcentral and only moderately prominent peripheral angle; above this a slightly concave space to the summit of a ridge which lies somewhat less than midway to the suture, then a wider and more deeply concave space to a scarcely perceptible shoulder at the suture; immediately above the last lies the slit-band of the preceding whorl; umbilicus very small; aperture subovate, higher than wide, the inner lip not very thick and curving outward in the lower half; slit about 0.6 mm. in width and 15.0 in length. Entire surface very delicately cancellated, the revolving lines much the finer of the two sets, the lines of growth rather regular, raised, just about visible to the unassisted eye, moderately recurved to the slit-band.

Formation and locality.—Upper part of Trenton group, Nashville, Tennessee.

Collection.—E. O. Ulrich.

SCHIZOLOPHA MOOREI, *n. sp.* (*Ulrich.*)

PLATE LXV, FIGS. 31—37.

Hight of Richmond group form 28 to 38 mm., width 27 to 41 mm.; apical angle of same 75° to 82°; hight of Lorraine group form 20 to 29 mm., width variable, usually about the same as the hight; apical angle 65° in one instance, 83° in another, usually about 75°. Of whorls there are at least six in the shell, but casts of the interior, in which form the species occurs almost invariably, rarely if ever preserve more than three or four, the first two or three having been filled with shelly matter. In casts it is only the last whorl that is strongly carinate on the periphery, the upper ones being more or less rounded. The umbilicus is variable, being as a rule relatively larger and less steep in the Richmond group form, which we regard as the typical one for the species, than it is in the Lorraine group variety. On the shell of the latter the edge of the narrow umbilicus is angular. That a similar angle surrounds the umbilicus in the typical form is doubtful, though we have seen no specimens showing this part of the shell. Very few casts give any idea whatever of the surface markings. As seen on gutta percha impressions of natural molds of the exterior, they appear as rather coarsely lamellose and strongly recurved lines of growth. The convexity of the slit-band seems to grow less with age, the elevated line on each side of it stronger.

Formation and locality.—Lorraine group at numerous localities in the vicinity of Cincinnati, Ohio; reappears in the upper part of the Richmond group, of which it is one of the most characteristic fossils, at many localities in Indiana and Ohio, being perhaps the most abundant at Richmond in the former state and Oxford in the latter.

Collection.—E. O. Ulrich.

Genus LIOSPIRA, n. gen.

In part *Pleurotomaria* and *Raphistoma* of many authors.

For generic characters see page 953.

We doubt that any one can, after a thorough investigation, deny that this is not only a very convenient but also a most natural division of the *Pleurotomariidæ.* The lenticular form of shell which pertains to the majority of the species is of course shared by other types, notably *Raphistomina* and *Trepospira*, and in a lesser degree by *Eotomaria;* but who will say that the differences which exist between these various types of shells, and which have in part been pointed out on preceding pages, are not amply sufficient for their separation and recognition? *Raphistomina*, as we have shown on pages 931–939, and 941, and as may be seen from the figures on plate LXVIII, has a very different aperture, being entirely without the peripheral notch and band. These differences are so important that the two genera cannot possibly belong even to the same family. As to our *Trepospira*, it resembles *Liospira* greatly, and may really be, though we are much inclined to doubt it, a lineal descendant of the Lower Silurian type. However that may prove to be, a generic separation must always be maintained because of the changing characters of the whorls of the spire and the short apertural slit which together characterize *Trepospira* and not *Liospira*. We refer the reader to page 957 for more detailed observations on these points.

When it comes to *Eotomaria*, we are willing to admit something more than mere resemblance. The form in that genus is more conical than lenticular, the suture better defined, the lines of growth generally stronger, and the peripheral band situated entirely upon the upper side of the edge, while the inner lip, so far as known, is never reflected over the umbilicus as is so commonly the case in *Liospira*. In the latter the sutures are nearly always enamelled and so that part of the band is covered. In *Eotomaria*, on the other hand, all of the band is visible and the outer edge of the inner whorls projects slightly above and over the inner edge of the next. These differences, we believe, are quite sufficient to separate the two types of shells as distinct genera, especially as they hold their own without any appreciable tendency to run into each other. Still, we believe that one was derived from the other.

Of the two genera *Liospira* probably was the older. We come to this conclusion because its band is of the convex type, which, it seems to us, is necessarily a more primitive structure than the concave band. The convex form of band we believe always points to an alliance with the *Euomphalidæ* which, theoretically at least, are older than the *Pleurotomariidæ*. *Liospira* undoubtedly began earlier than the Calciferous, in which it was represented by at least one good species. What it was derived from we cannot say at present, yet we feel convinced that *Lophospira* originated in the same stock. As to the origin of *Eotomaria* we are not so confident, still we are strongly inclined to regard it as evolved from *Liospira*. There is nothing unreasonable about this belief, for that the necessary changes in the position and character of the band may have occurred is indicated by *L. decipiens*, in which the periphery is sharp and that portion of the band which lies on its upper side is not only decidedly concave but much the greater part of the whole.

We describe, and in most cases illustrate, a total of fourteen species of this genus. Besides these we regard *Raphistoma prævium* Whitfield (Calciferous), *Pleuro-*

tomaria numeria Billings (Quebec group), *Pl. eugenia* Billings, *Helicotoma larvata* Salter (Black River group), *Pl. subtilistriata* Hall (Trenton group), and *Pl. helena* Billings (Hudson River group) as belonging here. Then there is a considerable number of other Lower Silurian lenticular shells which cannot be placed satisfactorily because the most essential characters are neither mentioned in the descriptions nor shown in the figures so far published. There may be some of *Liospira* among them, but there is just as much reason for referring them to *Raphistoma, Raphistomina* or *Eotomaria.* Finally, there is a group of species of which *Pleurotomaria docens* Billings is a good representative. This species was recently referred to *Raphistoma* and it cannot be denied that in the general form of the shell it agrees very well with the most typical species of that genus. Still, *P. docens* has a band and that alone positively forbids its being referred to *Raphistoma.* Now, as to the band, is it entirely on the upper side of the peripheral angle, or does it turn over the edge and thus lie upon both sides of it? Judging from a Tennessee specimen which Billings himself identified with his species, we should say that the latter is the case and, therefore, that the species is to be viewed as a flat-topped *Liospira.*

As at present constituted *Liospira* includes five species (*L. larvata* Salter sp., *L. numeria* Billings sp., and our *L. rugata, L. mundula* and *L. angulata*) that remind one very strongly of the euomphaloid genus *Helicotoma.* But they all have an unquestionable slit-band and one that, so far as we have been able to learn, is in every respect like that of the most typical forms of *Liospira. Helicotoma,* however, has no true slit-band. Instead we find merely a thin sharp ridge—with occasionally a line on only one side of its base—placed entirely upon the upper side of the whorls. That these species belong to *Liospira* is, we believe, shown conclusively by such obviously intermediate forms as *L. subconcava, L. persimilis, L. helena* and *L. eugenia.* It seems to be merely another case showing how some of the subdivisions of ordinarily widely different branches of the same radical may come to agree in structure through, in this case we presume, a kind of atavism.

Liospira micula *Hall.*

PLATE LXVIII. FIGS. 24–29.

Pleurotomaria micula Hall, 1862, Geol. Rep. Wis., p. 55. (Figured but not described.)

A small discoidal shell having the umbilicus filled by a reflexed callosity of the inner lip. This filling is concave externally, perfectly smooth, and generally rather distinctly outlined and distinguished from the finely striated under side of the volutions. There are about four volutions, and within these a minute nucleus, the sutures are very shallow, the spire, excepting an occasional slight convexity of the upper whorls, forming an almost continuous even slope from the apex to the slightly obtuse periphery. The surface markings consist usually of fine lines of growth only, but nearly all of the best specimens show traces of an exceedingly fine set of revolving lines. On the under surface of the whorls the lines of growth make a broad curve, the inner half being the most curved. The band occupies the periphery though somewhat obliquely, nearly twice as much of it being visible in a view of the upper side than is seen in a basal view. It is to be distinguished only on the best specimens, but we have at least fifty before us showing it very clearly. The inner lip is almost vertical in the Trenton variety of the species and always more nearly so than in the Utica form.

This species rarely, if ever, exceeds 16 mm. in diameter, the average for most localities being 11 or 12 mm. The Maquoketa shales types are commonly less than 10 mm. in diameter. Aside from the fact that it is considerably smaller there is little to distinguish *L. micula* from *L. progne* Billings sp. They are doubtless closely related species.

Formation and locality.—Trenton group, Burgin, Danville and Frankfort, Kentucky; Utica group (Maquoketa shales) at various localities in Minnesota, Wisconsin, Illinois and Iowa, associated with *Ctenodonta fecunda;* also in Ohio and Kentucky, where there is reason to believe that it ascends into the Lorraine group.

Collection.—E. O. Ulrich.

LIOSPIRA ABRUPTA, *n. sp.*

PLATE LXXXII, FIGS. 36-38.

A small species like the preceding but with the spire relatively less elevated and not entirely smooth at the sutures, the outer edges of the inner whorls projecting just enough to be noticed readily by the naked eye. The band is also more distinct, especially upon the upper side where it reminds one considerably of the concave band of an *Eotomaria;* then it is also sharper on the edge, while the lower half of the band is usually much more distinct. The umbilicus is not filled but extends up to the apical whorl, showing all the whorls within; its edge is sharply angular, the sides nearly vertical, while its width equals something like a fourth of the greatest diameter of the shell. The base is a trifle higher than the spire, the basal slope, from the periphery to the edge of the umbilicus, gently convex; the aperture is triangular, its width slightly exceeding the hight. Aside from the peripheral band, the surface appears to have been without markings of any kind. There are four whorls without counting the minute nucleus.

The largest of four specimens from Minnesota, belonging to this or a closely related species, has a width of 8.5 mm. The width in about one hundred specimens from Tennessee varies from 7 to 10 mm., and in nine-tenths of these from 8 to 9 mm. The Minnesota specimens doubtfully referred here differ from the Tennnesee and Kentucky types of the species in the more rapid expansion of the whorls, three sufficing where it requires four in the latter, and in having a relatively higher spire. In both of these points they agree with *L. micula* Hall sp., and we would refer them to that species were it not that they have an open umbilicus.

Formation and locality.—Stones River group, Murfreesboro, Tennessee; High Bridge, Kentucky. Two of the Minnesota specimens referred to are from the limestone at Minneapolis, the others from the Black River shales at Chatfield.

Collection.—E. O. Ulrich.

LIOSPIRA VITRUVIA *Billings.*

PLATE LXIX, FIGS. 3–8.

Pleurotomaria vitruvia BILLINGS, 1865, Pal. Foss., vol. 1, p. 171.
Pleurotomaria (or *Raphistoma*) *lenticularis* (part.) of numerous American authors.

Specimens of this well marked species are not known to exceed 30 mm. in diameter, a good average being about 25 mm. The hight is about half of the width. The upper side of the last whorl is frequently a little concave because of a slight elevation of the peripheral band. The umbilicus is open but varies somewhat in size, its width being often not more than a fourth, at other times quite a third of the greatest diameter of the shell. The principal peculiarities of the species occur on the under side. Here we have first the open umbilicus with its angular margin and flattened sides; and then the unusual prominence and the sharpness of the curve of the central portion of the outline of the lower lip. The angularity of the margin of the umbilicus is of course much less marked in casts of the interior than on the shell itself. Still it is always indicated with sufficient clearness to be unmistakable to the trained observer. For comparisons see following species.

Formation and locality.—Ranges from the base of the Stones River group to the Richmond group. The geographical distribution also is very extended, it having been found in Canada, New York, Tennessee, Kentucky, Ohio, Indiana, Illinois, Iowa, Wisconsin, and Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, Nos. 6765, 7287, 7380.

Liospira americana *Billings.*

(Not Figured.)

Pleurotomaria americana Billings, 1860, Can. Nat. and Geol., vol. 5, p. 164.
Pleurotomaria (or *Raphistoma*) *lenticularis* (part.) of American authors. (Not Sowerby's species.)

Diameter 30 to 40 mm., hight one-half the diameter or less; apical angle about 130°.

This species grew to somewhat larger size than *L. vitruvia*, with which it is generally confounded and excusably so, considering the imperfect condition of the great majority of specimens. We have found it much less abundant than that species, while its vertical range also is less extensive, being restricted apparently to the Trenton period. When good specimens are compared it may be distinguished at once from *L. vitruvia* by the different shape of the under lip and a corresponding difference in the course of the lines of growth. In *L. vitruvia*, namely, (see pl. LXIX, fig. 4) the central portion of the lower lip projects greatly forward, the anterior outline being sharply rounded in consequence. In *L. americana*, on the other hand, the projection is much less and the curve of the outline, therefore, broader, the conditions being about as in *L. micula* and *L. progne*. (See pl. LXVIII, figs. 24 and 38.) When the aperture is imperfect and the lines of growth are not preserved, we must depend upon the characters of the umbilicus, which is a little wider and less abrupt in casts of *L. americana*, while the shell itself presents no sign of the angulation which encloses the umbilicus in *L. vitruvia*. Where casts of the interior only were available we found it sometimes impossible to distinguish them from *L. progne*, but fortunately it is very rare to find casts of *L. americana* in which the umbilical cavity is freed entirely of the matrix. This fact affords an almost infallible clue, for, if the cavity contains any of the stony matrix in which the fossil was imbeded, the observer may rest assured that the specimen is not one of *L. progne*. In the latter species the relatively large umbilical space is completely occupied by shell-matter, so that the cavity remaining after the dissolution of the shell could not, under ordinary circumstances, be filled with matter of the same kind as that which fills the interior of the whorls.

Formation and locality.—Stones River group, Lebanon, Tennessee; Black River group, Maury county, Tennessee; Trenton group (Fusispira bed), Fillmore county, Minnesota; also several localities in Manitoba.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, Nos. 7348, ?7395.

Liospira progne *Billings.*

PLATE LXVIII, FIGS. 38–44.

Pleurotomaria progne Billings, 1860, Can. Nat. and Geol , vol. 5, p. 163.

Width 25 to 35 mm.; hight about half the width; volutions four to four and a half; apical angle about 120°.

This is another of the forms that, especially where it occurs as casts of the interior, is generally referred to as *Raphistoma lenticulare* =*Liospira americana* Billings sp. Although casts of the interior resemble that species very closely (for comparisons see preceding page) the affinities of *L. progne* are really much nearer *L. micula* Hall sp. Indeed, the last is probably nothing more than a dwarfed variety of *L. progne*, and if it were not for the fact that it held its own with remarkable constancy through a long period and is perhaps the most common type of the genus, we would be inclined to place its name on the list of synonyms. The closed umbilicus distinguishes both very easily from *L. americana*, *L. vitruvia*, and other species of the genus having an open umbilicus, while the extreme faintness of their suture lines and the flatness or slight convexity of the upper surface of their volutions separates them at once from such close allies of *L. helena* Billings sp. and *L. persimilis* Ulrich.

Formation and locality.—Stones River group, Murfreesboro and Lebanon, Tennessee; Black River and Trenton groups, Mercer county, Kentucky, and near Ottawa, Canada; Trenton group, Clitambonites and Fusispira beds, Goodhue and Fillmore counties, Minnesota.

Collection.—E. O. Ulrich.

LIOSPIRA ANGUSTATA, *n. sp.*

PLATE LXVIII, FIGS. 35–37; PLATE LXIX, FIGS. 1–2.

Stones River group variety: Width about 17 or 18 mm., hight about 9 mm.; apical angle 125°. Trenton group variety: Width 29 to 45 mm., hight 15 to 22 mm.; apical angle about 130°. Number of volutions four to five.

This species, casts of which are exceedingly like those of *L. americana* and *L. progne,* is distinguished from the former by the great and gradually increasing deposit of shell-matter on the umbilical side of the whorls, and from the latter by the fact that this deposit does not, as is the case in that species, fill the umbilical cavity entirely, but leaves a narrow subcentral perforation. As shown in figure 37 on plate LXVIII, the umbilical perforation is relatively much larger in the younger stages of the shell than it is in fully grown examples, showing that the deposit, which we take to be a callous reflection of the inner lip, was proportionally much greater in later stages of growth. The callosity did not spread itself over the bottom of the umbilicus but was confined to its sides, and herein lies the principal difference between *L. angustata* and *L. progne*. Another difference is that the anterior outline of the lower lip is more broadly and less uniformly convex.

Formation and locality.—Of the small Stones River group variety we have four specimens which one of us collected in the Vanuxemia bed at Minneapolis. Of the larger variety, which occurs in the Fusispira bed of the Trenton group at several localities in Fillmore county, we have five specimens.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 7494.

LIOSPIRA OBTUSA, *n. sp.*

PLATE LXVIII, FIGS. 30–34.

Hight of a large specimen 25 mm., width of same 44 mm.; hight of a small example 17 mm., width of same 32 mm. Volutions four to five, with the periphery rounded and the upper side very slightly convex. Umbilical cavity rather large in casts but in the shell itself it is filled, excepting a minute central perforation, by a distinctly outlined, thick external deposit on the inner side of the whorls. This deposit is as heavy relatively on the inner whorls as on the last. The last feature, together with the obtuse character of the periphery, distinguishes this species from *L. angustata*.

Among a lot of Lower Silurian *Gastropoda* kindly sent us by Prof. J. M. Safford, we find two specimens which he collected from the "Ridley limestone" in Rutherford county, Tennessee, which agree in all respects with this species save that the umbilicus is not constricted by a deposit of shell such as we find in this and the preceding species. The umbilicus is about as large as in *L. vitruvia* but the margin of it, though rather abruptly rounded, is not angular as in that species. We believe these specimens represent another undescribed species of this important genus and one that, if time and space had permitted, we would have illustrated because we expect it will prove a necessary link in showing the evolution of the family. Since it is easily recognized, and as it would facilitate reference to it, we propose to call it *Liospira convexa.*

Formation and locality.—Vanuxemia bed of the Stones River group, Minneapolis, Minnesota, Dixon, Illinois, and Beloit, Wisconsin.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 687.

LIOSPIRA DECIPIENS, *n. sp.* (*Ulrich.*)

PLATE LXXXII. FIGS. 39—41.

Width 18 to 23 mm ; hight 8 to 11 mm.; apical angle about 135°; angle formed by slope of spire and outer half of basal slope about 60°. Volutions five, flat above from the suture to the sharp, thread-like inner or upper margin of the peripheral band. At least two-thirds of the latter lies upon the upper side of the acute edge of the shell. This portion of the band is distinctly concave and presents exactly the appearance of the entire band of an *Eotomaria*. When, however, the edge is in good condition, it will be seen that the remaining third of the band turns over the edge and lies, as it should in *Liospira*, on the under side of the periphery. Excepting the slight elevation of the band, the upper side of the shell forms a smooth even slope, with the lines of growth very obscure. On the under side the umbilicus is covered about as in *L. subconcava* and *L. progne*, the forward curve of the lines of growth is only moderate, the mouth transverse, acuminate-ovate.

The unusual sharpness of the peripheral edge and the distinctly concave character of the upper part of the band are the principal peculiarities of this species. These features will distinguish the species at once from all others now referred to *Liospira*. At the same time, when the upper side only is visible, one is very liable to mistake the generic position of the shell.

Formation and locality.—Safford's "Central limestone" of the Stones River group, Murfreesboro, Tennessee.

Collection.—E. O. Ulrich.

LIOSPIRA PERSIMILIS, *n. sp.* (*Ulrich.*)

PLATE LXVIII, FIGS. 45—47.

In size and general expression, especially in a view on the upper side, this fine shell resembles *L. helena* Billings sp. very greatly, but when we turn them over and compare the basal portions, at least one decided difference is quickly observed. Namely, in *L. helena* (we have an authentic specimen of this species before us) while the umbilicus is in most cases entirely closed, there is, nevertheless, a small depression, the umbilical region, with the callous reflection of the pillar lip, appearing about as the same part in *L. micula* and *L. progne.* In *L. persimilis*, on the other hand, this region is scarcely, or at any rate less, depressed, while the smooth callosity extends as a thin sheet for a considerable distance beyond what may be properly included in the umbilical region. Among other differences we may mention that the proportional hight of the Canadian shell is as a rule greater, being from two-thirds to three-fourths of the greatest width, while in *L persimilis* it varies between one-half and two-thirds. The upper side of the whorls also is generally more strongly concave than in our species. Compared with other species *L. persimilis* is distinguished from all others of the family known to us by the great extent of its umbilical callosity. The next species is closely related. The largest specimen seen is 30 mm. in diameter, the smallest 18 mm. 25 or 26 mm. appears to be a fair average.

Formation and locality.—Trenton group, Hartsville, Tennessee, where the seven specimens used in the above description were collected by Prof. J. M. Safford.

Liospira subconcava, *n. sp.* (*Ulrich.*)

PLATE LXIX, FIGS. 30–32.

Average diameter about 20 mm., but varying in thirteen specimens between the extremes of 15 and 25 mm. The hight, which is about equally divided between the spire and base, compares with the greatest width about as six to eleven. On the upper side of the shell the surface of the whorls is concave, but this concavity is produced chiefly by the elevation of the two edges, the peripheral one being thick and the sutural one thin and sharp. The umbilicus is filled, the surface of the filling but slightly concave and its outer margin, which includes a space with a diameter equalling somewhat less than a third of the greatest width of the shell, more or less sharply defined. The anterior outline of the lower lip bows rather strongly forward in the outer two-thirds, and always more so than it does in *L. persimilis*. If we add to this that the umbilical cavity is much less depressed, and its filling not nearly so extensive as in that species, we have at least three good characters by which ordinarily good specimens of the two species may be distinguished.

Compared with other species we find that both *L. helena* and *L. eugenia* of Billings are closely related. In the first the hight is relatively greater, the inner lip higher and more nearly vertical and the umbilical depression narrower, more abrupt, and much deeper. In the second the outer part of the basal half of the shell is more nearly vertical, the form of the aperture more nearly quadrate, and the whorls "gently convex above near the suture."

Formation and locality.—Lowest division of the Stones River group, near Murfreesboro, Tennessee.

Collection.—E. O. Ulrich.

Liospira rugata, *n. sp.* (*Ulrich.*)

PLATE LXIX, FIGS. 33–36.

In ten representative specimens the width varies from 14 to 20 mm. The hight equals about two-thirds of the width. Volutions four or five, with a thick ridge above along the suture, deeply concave between this and the elevated band which is set obliquely upon the upper angle of the periphery. The latter is vertical, rather wide and unusually well defined below where it passes into the moderately convex base. Lower and outer portions of peristome bowed strongly forward, and prominent at the obscure angle of the periphery, above which the outline curves strongly backward toward the band. Inner lip thick, turned outward, excavated in front, reflected and completely covering the umbilicus. Mouth rounded-pentagonal; shell rather thick. The surface markings are not well preserved. As far as known they consist of strong, almost wrinkle-like, lines of growth. As this is an unusual feature among species of this genus, we have chosen a specific name that will call attention to it.

Of previously described species, only *L. eugenia* Billings, need be compared. That species agrees closely in most respects, but evidently has finer surface markings, while it differs decidely in the more uniform convexity of the under side of the whorls. *L. helena* Billings is farther removed. Two other Canadian species, *L. numeria* Billings sp., and *Helicotoma larvata* Salter, resemble our species, yet may be distinguished at once by the umbilicus which is open in them and closed in *L. rugata*. The next species, *L. mundula*, is as closely related as any.

Formation and locality.—Richmond group, Lincoln county, Kentucky.

Collection.—E. O. Ulrich.

Liospira (?) mundula, *n. sp.* (*Ulrich.*

PLATE LXIX, FIGS. 37–41.

The average width of this shell, according to twenty specimens, is about 12 mm., the hight about 7 mm. The largest seen has a width of 15 mm. The species is closely related to *L. rugata* but does not attain the size of that shell, has finer lines of growth, a more uniformly rounded base, and relatively smaller and deeper umbilical depression. From *Helicotoma larvata* Salter, with which it is associated in the Black River group of Canada, it is distinguished by having a more obtuse periphery and the umbilicus not only a trifle smaller but also covered entirely by the reflection of the inner lip. In *H. larvata*, which may belong to *Liospira*, the umbilicus is open, angularly outlined, and exposes all the whorls.

Formation and locality.—Black River group, Pauquettes Rapids, Ottawa River, Canada; lower part of Trenton group, Mercer county, Kentucky; upper beds of same near Danville, Kentucky.

Collection.—E. O. Ulrich.

LIOSPIRA ANGULATA, *n. sp.*, (*Ulrich.*)

PLATE LXIX, FIGS. 42–46.

Hight and width respectively as five is to eight or nine. Average width about 15 mm. Width of the largest of thirty specimens 17 mm. Whorls slender, about five in number on the upper side, with a slightly elevated peripheral edge, concave within this and convex in the inner third. This convexity and the raised edge of the whorl next within produces a deeper suture line than in any other species of the genus known. Periphery obtuse, nearly vertical beneath the slit-band; base convex to the angular edge of the umbilicus. The latter slopes rapidly without being vertical, exhibits all the whorls within, and as a rule makes up about one-third of the width of the shell. Aperture subpentagonal; anterior outline of lower half of peristome not very strongly bowed forward, the inner extremity of the upper lip extending slightly beyond it.

This species seemed at first to be the same as *L. numeria*, described by Billings as a *Pleurotomaria* from division G of the Quebec group of Newfoundland. A second and more careful comparison, however, brought out at least one difference upon which to base a separation. Namely, the upper side of the whorls is said to be "nearly flat or gently concave" in *L. numeria*, and Billings' figure (Pal. Foss., vol. I, p. 229, fig. 213*a*) shows that this concavity extends inward quite to the suture. His description, which would almost certainly do so if anything of the kind occurred in the Newfoundland shell, makes no mention of a ridge-like convexity in the inner third like that which occurs here in *L. angulata* not only on the exterior but on casts of the interior as well.

Formation and locality.—In cherty layers of the Black River group, Mercer county, Kentucky.

Collection.—E. O. Ulrich.

Genus EOTOMARIA, n. gen.

In part *Pleurotomaria* and *Raphistoma* of American authors.

For generic characters see page 954.

Restricting *Pleurotomaria* to species agreeing closely with the original type of the genus, *P. anglica*, we find that it is characterized (1) by a long slit, (2) the supra-peripheral position of the band, (3) the posterior direction of the outer lip beneath the band, and (4) the coarsely nodose and longitudinally striated surface of the whorls. In *Eotomaria* there is a notch in the outer lip merely and no slit, one edge of the band, the lower, forms the periphery of the whorls, the lines of growth curve more or less forward beneath the band and the surface is marked by simple lines of growth only. *Raphistoma*, as we have shown on preceding pages, is a totally different type of shell, being without not only slit but a band as well, while the lines of growth, which of course indicate the outlines of the lip, follow a simple or double sigmoid curve in crossing the flat upper side of the whorls.

The true relations of *Eotomaria* seem to be with *Liospira*, *Euconia*, *Bembexia* and *Clathrospira*. In *Liospira* the surface is smoother, the sutures generally much less distinct, and the band less sharply defined, convex instead of concave, and turned partly over the peripheral edge instead of being placed entirely upon the upper side. *Bembexia*, which is mostly a Devonian genus, and of which we consider *Pl. sulcomarginata* Conrad (see accompanying figures) a characteristic species, is

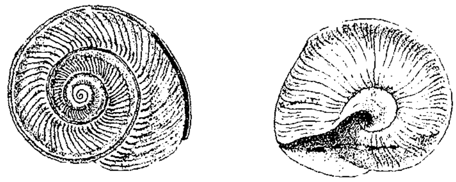

FIG. 6.—Views of the upper and lower sides of a perfect shell of *Bembexia sulcomarginata* Conrad sp., natural size, showing long apertural slit and other features distinguishing *Bembexia* from *Eotomaria*. The specimen is from the Hamilton group of New York, and now in the collection of E. O. Ulrich. For description and remarks on *Bembexia* see pages 954 and 955.

probably a direct descendant of *Eotomaria* and chiefly distinguished by its long apertural slit. *Clathrospira* has the band directly upon the periphery and a cancellated surface. *Euconia*, whose relations to *Eotomaria* perhaps are more apparent than real, has a more strictly conical form, more numerous whorls and a flattened base, while the anterior outline of the under lip is straight excepting in its extreme outer part where it turns slightly backward before it reaches the lower edge of the band.

We believe *Eotomaria* was derived from *Liospira*. Although the actual connecting links are unknown, we can, after a comparison of known species, readily imagine the modifications required to produce the main distinguishing feature of *Eotomaria*, viz.: a *concave* band lying entirely upon the sloping upper side of the volutions instead of a *convex* band lying upon the peripheral edge, and partly visible in a view of the base. In the most typical species of *Liospira* no part of the band can be described as concave and both margins are very distinctly defined. In *L. abrupta* Ulrich, however, the upper border of the band is better defined and an appreciable concavity lies between it and the extreme periphery of the whorl. In *L. decipiens* Ulrich, which might easily be mistaken for an *Eotomaria*, the band is sharply marked and its upper part decidedly concave, while only a small portion ot the band turns over the peripheral edge. After reaching this stage but a small step remains to bring us quite within the limits of *Eotomaria*. Nothing more was required than to continue the upward movement of the band until its lower boundary coincided with the peripheral edge of the whorls.

To give a just idea of this new generic group we have illustrated all of the six species which we are reasonably satisfied belong here. All belong to the age of the Trenton period, and three occur in Minnesota, while the others are so far known only from localities in Tennessee.* These species exhibit considerable variety in the form of the lower lip. In *E. vicina* U. and S., and *E. dryope* Billings sp., the outline of this portion of the apertural margin is comparatively straight, the outer half being less curved and produced than in *E. canalifera* Ulrich, and very much less than in *E. supracingulata* Billings sp. The last species reminds one very strongly of the *L. mundula* section of *Liospira*. At first we believed that the several species which group themselves about *L. mundula*, together with *E. supracingulata*, should be viewed as a distinct genus. A reconsideration, however, seemed to show that such a course would scarcely be justifiable at present, first, because the *mundula* group is closely connected with the more typical species of *Liospira* by *L. progne* Billings and *L. subconcava* Ulrich, and second, because the species *supracingulata* differs decidedly from the others in having a concave band. The latter reason decided the question, since, with our present knowledge, we cannot admit that concave-banded species are congeneric with convex-banded forms. For further remarks on the *L. mundula* group of species see page 994.

EOTOMARIA CANALIFERA, *n. sp.* (*Ulrich.*)

PLATE LXIX, FIGS. 9-14.

Width 15 to 30 mm.; hight about two-thirds of the width, in young examples relatively greater than in old; apical angle 80° to 85° for the first three or four whorls, the following whorls spreading more rapidly and in some cases bringing the angle of the entire shell to 100°; volutions five to six and a half in number.

Shell subconical, moderately convex below, with a very small umbilicus and distinct yet not deep sutures. Band concave, sharply defined, channel-like, its outer border slightly overhanging the suture and forming the sharply angular periphery of the whorls, the inner border strongly defined, elevated, its prominence increasing with the growth of the shell. The contour of the upper surface of the whorls changes considerably with growth. The apical whorl has not been observed, but the second and third are nearly flat and the fourth very gently convex, while in the fifth and succeeding turns a furrow just within the band gradually widens and deepens until at least two-thirds of the space between the band and suture is distinctly concave. (The specimens illustrated on plate LXIX are not sufficiently developed to show the last of these changes satisfactorily). Aperture subrhomboidal, a little wider than high; inner lip oblique, not very thick. Lines of growth rather unequal, never strong, very fine on the upper turns. On the upper surface they are strongly recurved, indicating a deep notch in the aperture. Beneath the periphery they first curve forward but soon, and rather abruptly, turn backward and finally forward again as they descend into the umbilicus. Lunulæ of band very delicate, rarely preserved.

Formation and locality.—Stones River group ("Central limestone") near Murfreesboro, Tennessee.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

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* We suspect that two or three other species described by Billings and Hall will prove to belong to *Eotomaria*, but as our efforts to see the original types have failed, and as the published descriptions and illustrations are too indefinite to admit of certainty, we have thought it best to postpone their consideration.

Eotomaria labiosa, *n. sp.* (*Ulrich.*)

PLATE LXIX, FIGS. 15-17.

Width about 24 mm., hight about 20 mm.; apical angle 90°; volutions four and a half or five.

This species is associated with, and in most respects greatly resembles, *E. canalifera*. Carefully compared, however, several minor differences, as well as one that must be regarded as important, will soon convince the observer that the two forms are less closely related than the first superficial glance may lead one to suppose. The principal difference lies in the relative development of the inner lip. This is somewhat excavated and much stronger in *E. labiosa*, while the lower border also is expanded in a way that has not been observed in *E. canalifera*. Among other differences we may mention that the upper sloping surface of the whorls is on the whole flatter, the band less sharply defined, the surface markings more obscure, the base more ventricose, and the umbilical perforation even smaller than in that species.

Formation and locality.—Lower division of the Stones River group, Murfreesboro, Tennessee.

Collection.—E. O. Ulrich.

Eotomaria vicina, *n. sp.*

PLATE LXIX, FIGS. 18-20.

Shell rather small, 14 to 20 mm. wide, 10 to 14 mm. high, depressed conical above the angular periphery, moderately ventricose beneath; apical angle 97° in one specimen, 107° in another. Volutions four, the upper sloping surface nearly flat, the last a little convex above near the slightly impressed suture line. Band only moderately distinct, apparently more nearly vertical than usual for the genus. Umbilicus equalling nearly a fourth of the width of the shell, the convex base turning rather abruptly into it.* Lines of growth showing obscurely on casts of the interior, rather strongly defined exteriorly, particularly upon the under side. On the upper slope they curve strongly backward from the suture to the band, on the lower surface very slightly forward.

The umbilicus is larger and the anterior outline of the lower lip less curved than in either of the preceding species. In both of these features it agrees with *E. dryope* Billings sp., with which it is also found associated in Minnesota, but the relative flatness of the upper slope of the whorls distinguishes it readily from that species.

Formation and locality.—Stones River group, Minneapolis, Minnesota, and Mineral Point, Wisconsin.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 5106.

Eotomaria dryope *Billings.*

PLATE LXIX, FIGS. 21-25.

Pleurotomaria dryope Billings, 1865, Pal. Foss., vol. 1, p. 170.

This well-marked species differs from *E. vicina* in the contour of the upper side of the whorls, the outer two-thirds or three-fourths of the slope being decidedly concave, the remaining fourth next the suture convex. In other respects the two species agree very closely.

Although the surface markings in our specimens are not as regular as in Billings' figures, the resemblances in all other particulars are so exact that we cannot doubt for a moment that they are specifically identical with the Canadian types. We notice a slight difference between the specimens obtained from the Stones River group and those from the Black River limestone. In the latter the apical angle is not so wide, being about 100°, while the whorl next to the last is, as described by Billings, "slightly

*In the reproduction of figure 20 on plate LXIX some of the shading failed to "come up," causing the umbilicus to appear narrower than it is in the specimen.

turretted." In the Stones River specimens the last feature is not apparent and the spire is more depressed, giving an apical angle of about 110°.

Formation and locality.—Stones River group, Vanuxemia bed, Minneapolis and Cannon Falls, Minnesota. Black River group, Maury county, Tennessee.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

EOTOMARIA SUPRACINGULATA *Billings.*

PLATE LXIX, FIGS. 26-29.

Pleurotomaria supracingulata BILLINGS, 1857, Rep. of Progr., Geol. Sur. Can., p. 302; 1863, Geology of Canada, p. 181, fig. 175.
Pleurotomaria nasoni HALL, 1861, Geol. Rep. Wis., p. 34; WHITFIELD, 1895, Mem. Amer. Mus. Nat. Hist., vol. i, pt. 2, p. 61, pl. VIII, figs. 4-7.
Raphistoma nasoni WHITFIELD, 1883, Geol. of Wis., vol. iv, p. 215, pl. VI, figs. 2-3.
Raphistoma nasoni WALCOTT, 1884, Pal. Eureka District, p. 78, pl. XI, figs. 21, 21*a*.

Original description.—"Obtusely conical or lenticular, apical angle 105°; hight about two-thirds the width; whorls four, angulated and keeled on their upper outer margin, their sides vertical, their upper surfaces gently convex from the distinct suture half-way to the margin, and then scarcely concave to the spiral band; lower side of body-whorl convex; the spiral band narrow, and lying wholly on the upper side of the whorl, where it forms a border along the margin following all the whorls to the apex; umbilicus large; width one inch and a quarter; hight ten lines; width of umbilicus at center of body-whorl three lines and a half; width of band on last whorl about half a line."

To the above we may add that the lines of growth are generally not strongly marked, and when they are distinct it is only on the lower side of the last whorl of old shells. On the best specimens they consist of obscure undulations, from 1 to 2 mm. apart, with four or five very fine lines between any two undulations, all curving backward on the upper side in the usual manner and degree. Beneath the band, however, the lines make a sharper and longer sweep forward than in any pleurotomaroid shell known to us. Just before reaching a point midway between the band and the obtuse edge of the umbilicus they begin an almost equally strong backward curve, which in turn is overcome as they enter the umbilical depression on the sides of which they bend once more, this time gently forward. In accordance with the lines of growth, the aperture is very deeply notched and the outer lip greatly produced, the most prominent point on its narrowly rounded anterior outline extending slightly beyond the sutural extremity of the upper lip, while the lower lip is broadly and rather deeply sinuate. These features of the aperture are shown in our figures 27 and 29 on plate LXIX. The band is sharply defined and concave on the exterior of the shell, rounded or obscurely flattened on casts of the interior. The outer side of the whorls is never quite vertical, nor is the band horizontal. The latter slopes with the spire. The largest specimen seen is 43 mm. wide and about 27 mm. high.

That *Pleurotomaria nasoni* Hall is a synonym for *Pl. supracingulata* Billings is so obvious that we cannot understand why the fact was not discovered years ago. Perhaps it is because one was described from a testiferous specimen, while the other was founded on casts of the interior. Another thing that we cannot understand is how Prof. Whitfield can say that "this shell appears to possess all the features requisite for a true *Raphistoma*." So far as we can see it has not one of the essential characters of that genus. There is some reason for calling the species a *Pleurotomaria*, but none that we can discover for placing it with *Raphistoma*. Excepting the unusual prolongation of the outer lip, and this is not an insuperable objection, every feature conforms strictly with our genus *Eotomaria*.

Formation and locality.—Stones River group, Dixon, Illinois; Mineral Point and Beloit, Wisconsin. Black River group (Upper Buff limestone), Beloit and Janesville, Wisconsin; Rockton and Dixon, Illinois; St. Joseph island, lake Huron. According to F. W. Sardeson this species occurs in the Vanuxemia bed at Minneapolis.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 7296.

EOTOMARIA ELEVATA, *n. sp.* (*Ulrich.*)

PLATE LXX, FIGS. 68-69.

Shell resembling *Lophospira;* width 15 mm.; hight about 20 mm.; hight of aperture about 12 mm. apical angle 74°; volutions four or five, the last comprising much the greater part of the shell, slightly; turretted, the upper slope nearly flat; band slightly concave, the outer border forming the angular periphery of the whorls, the inner border consisting of a sharply elevated thin line; band very wide, occupying nearly two-fifths of the sloping space between the periphery and suture; base large, its surface moderately convex, with a slightly concave band a short distance beneath the periphery; aperture obliquely subquadrate or subtriangular, narrow below, the hight greater by a fifth or a sixth than the width; columellar lip thick, reflexed, almost entirely covering the minute umbilicus; surface marked distinctly though rather irregularly with lines of growth, strongly recurved above, more gently below; lunulæ of band uniformly curved, unequal, occasionally strong.

The fact that the band is placed wholly above instead of *on* the periphery of the whorls, distinguishes this peculiar shell at once from *Lophospira*, several species of which it resembles in form. The great width of the band may suggest relations to *Omospira*, but the uniform curvature of the lunulæ proves that the species belongs to the *Pleurotomariidæ* and not to the *Raphistomidæ*. In placing the species under *Eotomaria* we have been guided principally by the position of the band.

Formation and locality.—Upper part of the Trenton group, Hartsville, Tennessee.

Collection.—E. O. Ulrich.

Genus CLATHROSPIRA, n. gen.

Pleurotomaria (part.) of numerous American and European authors.

For generic characters see page 954.

In this genus we propose to include subconical or turbinate shells differing from *Eotomaria* in having a delicate cancellated surface sculpture and the band, which is of the concave type, placed vertically and directly upon the periphery of the whorls The outer lip is merely notched, not slit as in *Pleurotomaria* and similar genera The group is represented by at least three species, two of them new, in Lower Silurian strata of America, and by four—possibly six—European species that Lindström has described from the Upper Silurian rocks of the island of Gotland, under the following names: *Pleurotomaria claustrata*, *P. glandiformis*, *P. hindei*, *P. latezonata*, *P. gradata* and *P. scutulata*. The last two of these six species, though agreeing in most respects very well with *Pl. subconica* Hall, the type of the proposed genus, are peculiar in having a pair of thin elevated lines just above the center of the slit-band. The significance of these lines is not clear at present, but we suspect that they represent homologically the median line of the band of *Lophospira bicincta*, and if that is a fact, then the species in question cannot belong to *Clathrospira*, for this genus and *Lophospira* are widely distinct genetically.

As near as we could learn, all of these Gotland species agree with the American species in having no slit. All differ, however, in having the anteriorly curved portion of the lines of growth just beneath the band much shorter and the anterior outline of the lower lip, as seen in a view of the base, much straighter. But this modification is in accordance with a tendency that has been followed almost generally in the development of the whole family. As a rule it appears to have preceded the development of the apertural slit.

At present we regard *Clathrospira* as the stock from which the Devonian group of species that includes *Pleurotomaria lucina*, *P. hebe*, *P. itys*, *P. filitexta* and *P. ella* (all described by Hall) was derived. The aperture in all of these species, so far as known, is without a slit, and the surface cancellated. Taken as a group, their whorls are more rounded than in their supposed Lower Silurian ancestors, but this difference, provided that our information concerning the remaining characters is reliable, would be no serious objection to classing them as congeneric with *Clathrospira subconica*. Still, we cannot be too cautious in matters of this kind, and we wish to be understood as merely suggesting and not as proposing the transference of these Devonian species to *Clathrospira*. If the old genus *Pleurotomaria* is to be successfully broken up according to the principles of ontogenetic classification, we must be reasonably sure of our ground before making sweeping changes in nomenclature. For other remarks on these Devonian shells see page 956.

CLATHROSPIRA SUBCONICA *Hall.*

PLATE LXIX, FIGS. 47–50; PLATE LXX, FIGS. 5–6

Pleurotomaria subconica HALL, 1847, Pal. New York, vol, i, pp. 174 and 304; WHITFIELD, 1883, Geol. of Wis., vol. iv, p. 216.

Shell with a short conical spire, consisting, when fully grown, of six and a half or seven volutions, of which the two at the apex are usually broken away; greatest width and hight nearly equal, varying generally between 25 and 30 mm., but attaining occasionally a width of over 40 mm.; apical angle 70° to 80°, but in four specimens out of every five the variation is only about one degree either way from 74°. Volutions flattened above in the direction of the slope of the spire, the inner half of the slope gently convex, the outer half correspondingly, or more strongly concave; convex portion of slope just touching or failing to reach a line drawn from periphery to periphery of succeeding whorls; under side of whorls rounded, occasionally very slightly concave near the periphery, this condition appearing, however, only in specimens in which the band is unusually prominent, umbilical depression small, terminating generally in a minute axial perforation. Band prominent, sharply defined, rather wide, concave, nearly vertical, situated on the periphery of the last volution, and lying immediately above the suture line on the upper whorls. Aperture subquadrate, outer lip broadly notched; columellar lip not very strong, thin, folding about the small umbilical perforation. Surface sculpture beautifully cancellated, consisting of two sets of fine, subequal, thread-like lines, one revolving, the other running parallel with the margin of the aperture. The transverse lines, of which three to five occur in the space of 1 mm., are recurved as usual on the upper side and quite as much on the lower side. At intervals, sometimes quite regular, many specimens exhibit more or less distinct undulations of growth, in some examples little more than a millimeter apart, in others two, three, or four millimeters. Considerable variety as regards strength and arrangement of the lines forming the surface sculpture may be observed in specimens from different localities. As a rule the revolving lines are strongest on the basal portions of the shell, and in some of the specimens from the "Glade limestone" of Tennessee they appear to be wanting entirely on the upper side. In the latter cases the transverse lines are stronger than usual In all the specimens from the Stones River group of Illinois, Wisconsin and Minnesota that retain the markings, the two sets of lines are almost equally developed, and on the whole finer than on the Tennessee shells. The lunulæ of the band are distinct, strongly curved, and crossed by a varying number of delicate revolving lines. Suture linear and inconspicuous except between the last two whorls of old shells. The last volution usually descends more rapidly than the preceding whorls.

In casts of the interior, the condition in which this fossil usually occurs, the suture, for obvious reasons, is deeper than in the shell itself, the periphery of the whorls oftener rounded than flat or concave, and the surface markings restricted to more or less obscure impressions of the varices of growth. Even the molds of the exterior in the dolomitic limestone in which the species occurs so abundantly in Wisconsin and Minnesota, only in rare instances preserve any recognizable traces of the delicately cancellated surface sculpture. But we have never failed to detect it whenever the grain of the matrix was fine enough. That the surface in these specimens was originally cancellated, as shown in figure 5 on plate LXX, is further established by two specimens collected by one of the authors in the fine-grained upper member of the Stones River group at Dixon, Illinois. These specimens preserve not only portions of the outer layer of the shell with its beautiful markings, but here and there retain irridescent patches of the nacrous inner layer which, since it has been observed in so many different forms, probably pertained to all of the *Pleurotomariidæ*.

We are in doubt as to the occurrence of this species in the Black River shales of Minnesota. The small casts usually referred here by collectors belong chiefly to our *C. conica*. Some of the others may represent *C. subconica*, but we have not seen any of which we would like to say positively that it does. Nor have we seen a specimen in either the Clitambonites, Fusispira or Maclurea bed of the Trenton group. If it occurs at any of these horizons in Minnesota, it must be very rare. Casts of a species of *Clathrospira* occur in the Lorraine and Richmond groups of the Cincinnati region. They have always been regarded as belonging to *C. subconica*, but every testiferous specimen of *Clathrospira* that we have seen from that region has proved to belong to our *C. conica*. Though it must be admitted that the occurrence of *C. subconica* in the Cincinnati rocks requires verification, we are fully prepared to believe that many of the interior casts found there are really of that species, and until we know better they should be so regarded.

Formation and locality.—Stones River group, Minneapolis, St. Paul, Cannon Falls, and other localities in Minnesota; Beloit, Janesville, and other localities in Wisconsin; Dixon, Rockton, and Jo Daviess and Calhoun counties in Illinois; High Bridge, Kentucky; Lebanon and other points in Tennessee. Also in the Black River group at several of the foregoing localities. In Canada and New York it occurs in the Black River and Trenton groups, and probably also in the Hudson River group. In Ohio, Indiana and Kentucky, casts supposed to belong to this species occur at many localities in both the Lorraine and Richmond groups.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 5037.

CLATHROSPIRA CONVEXA, *n. sp.*

PLATE LXIX, FIG. 51.

Casts of the interior, the only condition in which we have observed this rare species, agree very closely with *C. subconica* in all respects save in the contour of the upper side of the volutions. This, instead of being nearly flat (*i. e.* gently convex above and slightly concave below) in the space between the suture and the upper margin of the peripheral band, is rather strongly convex. The elevation of the band produces a narrow concavity immediately above it, but this does not greatly effect the general roundness of the whorls. They are more rounded than angular; in *C. subconica* the opposite is the case. The specimen figured on plate LXIX has all the appearances of being fully grown. If this is true, then *C. convexa* is a smaller shell than *C. subconica.* The same specimen preserves traces of the surface sculpture. This is of a coarser pattern than that of *C. subconica*, there being only four or five of the transverse lines in 2 mm. instead of seven to ten.

Formation and locality.—Stones River group, Calhoun county, Illinois.

Collection.—E. O. Ulrich.

Clathrospira conica, *n. sp.*

PLATE LXX, FIGS. 1–4.

This species has been, we believe, often confused with young specimens of *C. subconica* Hall sp. Though greatly resembling that species, especially in the condition of casts, and perhaps derived from it, it is nevertheless a well-marked form and worthy of a distinct name. It is always smaller, the largest of over fifty specimens being only 25 mm. wide, while in at least four-fifths of the specimens found in the Black River and Trenton groups the width is less than 18 mm. The average width of the Cincinnati form is somewhat greater, being something like 23 or 24 mm. Aside from the matter of size, the species differ constantly from *C. subconica* in at least two particulars. First, the upper slope of the whorls is nowhere convex but is either gently concave throughout or flat from the linear suture to the rising base of the upper boundary of the peripheral band. The second difference lies in a more or less well-marked concave space which occupies the outer third of the base of the whorls. The inner border of this space is often very sharply defined on testiferous examples and readily traced on most casts of the interior. Among less obvious and perhaps less constant differences we may mention that the periphery is more angular, the whole base less convex, and the surface markings altogether less beautiful, less distinct and less regular. In *C. subconica* the lines of the surface sculpture are sharply raised and look like woven threads; in *C. conica* they are neither sharp nor thread-like and generally require a good glass to bring them out at all.

Formation and locality.—Not uncommon in the shales of the Black River group (Ctenodonta bed chiefly) at Minneapolis, St. Paul, Cannon Falls, Chatfield, and other localities in Minnesota. Also, but not so frequently, in the Clitambonites and Fusispira beds of the Trenton group at localities in Goodhue and Fillmore counties. In central Kentucky it occurs in the Trenton group; at Cincinnati, Ohio, in the Lorraine group.

Collections.—E. O. Ulrich; W. H. Scofield.

Genus PLETHOSPIRA, n. gen. (Ulrich.)

In part *Pleurotomaria* and *Holopea*, the first of HALL, the second of WHITFIELD.

For generic diagonosis see page 958.

This genus is proposed for more or less turbinate *Holopea*-like shells, consisting of not more than five rapidly expanding ventricose whorls, with a broad, flat or concave, band situated near the middle of the whorls. There is no slit and the surface markings consist simply of lines of growth. None of the preceding genera are very closely related. *Lophospira* has angular whorls and a convex band, and represents quite a different line of development. *Eotomaria* may be nearer, yet is quite as easily distinguished. Both *Phanerotrema* Fischer, and *Bembexia* Œhlert, possess a long apertural slit besides peculiarities of their own. The true position of *Plethospira* appears to be in the immediate vicinity of *Hormotoma*, Salter, and *Seelya*, Ulrich. From the former it differs in having fewer and more rapidly enlarging volutions, and a shallower apertural notch, the forward curve of the lines of growth beneath the band, corresponding with the lower half of the outer lip, being much shorter than in Salter's genus. The lower extremity of the aperture also is much less produced and wider than is usual in that genus. *Seelya* includes very similar forms but they are easily distinguished by their different surface sculpture.

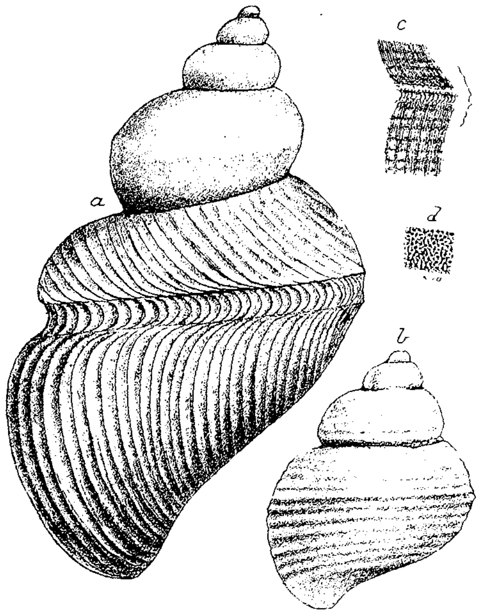

FIG. 7.—*a*, *Plethospira cassina* Whitfield sp., Calciferous formation. Fort Cassin, Vermont. Somewhat restored view of a good specimen belonging to the U. S. National Museum. The last whorl retains much of the shell, and shows the characters of the band and surface markings. *b*, *c*, *d*. *Seelya ventricosa* Ulrich, n. sp., Calciferous formation, Fort Cassin, Vermont. *b*, Cast of the interior of a rather small specimen, collected by Prof. H. M. Seely and presented to one of the authors. The ridge which forms the lower margin of the band is not prominent enough in the figure. *c*, Surface of the shell of a species of *Seelya* from Fort Cassin, x2, taken from an incomplete specimen belonging to the U. S. National Museum, showing the band and surface markings. *d*, small portion of the same, x10, showing the grano-punctate character of the outer surface. This specimen probably belongs to *Seelya difficilis* Whitfield sp. Another specimen of *S. ventricosa* in the National Museum is much larger than *b*, being 57 mm. high and 40 mm. wide. The last whorl descends very much as in *a*, and is marked by five ridges above and five below the band.

Plethospira probably will not prove to be a large genus, yet, as it represents an easily recognized type of shells that moreover continued through a long period of time, it deserves and probably will receive recognition from systematists. *P. cassina* Whitfield sp. is a fine species from the Calciferous rocks of the Lake Champlain region. A second species from that region was somewhat doubtfully identified by Whitfield with Billings' *Murchisonia arenaria.* For some unaccountable reason Whitfield places both of these Calciferous species under *Holopea.* A third species, evidently very closely related to the preceding, was called *Murchisonia hyale* by Billings, who gives it as from "the Chazy or perhaps the Black River limestone" of Canada East. The same author has described other Lower Silurian shells that may belong here, but, as we have not yet seen his original types, we prefer to postpone their removal from the genera to which he assigned them. Lindström's *Pleurotomaria valida,* an Upper Silurian species, has a very thick shell and rather too high a spire, but otherwise seems to agree very well with *Plethospira.* Regarding the following two species, perhaps they are not very good examples of *Plethospira,* still, it would be difficult to pick out any important differences; at any rate, we cannot suggest a more fitting disposal of them at present.

PLETHOSPIRA SEMELE *Hall.*

PLATE LXX, FIGS. 8-10.

Pleurotomaria semele HALL, 1861, Geol. Rep. Wis., p. 36; WHITFIELD, 1895, Memoirs of the Amer. Mus. Nat. Hist., vol. i, pt. 2, p. 61, pl. VIII, figs. 8-10.

Original description.—"Shell subconical; spire ascending; hight and breadth nearly equal, consisting of four or five rounded or subangular volutions, the last one ventricose, subangular on the periphery, regularly rounded below into the small umbilicus. Aperture round. Surface marked by a subangular carina a little below the suture, and on the periphery by a moderately broad revolving band, sharply elevated at the margins and concave in the middle. Entire surface marked by sharp, elevated, closely arranged, concentric striæ, which are curved abruptly backwards from the suture to the revolving band, on which they make a shallow retral curve, and below the band have a gentle forward curvature in passing downward to the umbilicus. Hight a little more than one inch; width three-fourths of an inch "

We have two specimens of this species besides an interior cast that may belong to some other species. One of these (the specimen represented by figures 8 and 9 on plate LXX) retains considerable of the shell with its markings, and permits us to add several particulars to the above description. First, there is a slight angle or ridge, about midway between the peripheral band and the margin of the umbilicus, that shows only on the last whorl, being just covered in the preceding whorls. The space above it is flat or a trifle concave. Next, the umbilical perforation is very small and partly covered by the reflexed columellar lip. Finally, the lines of growth are quite regular, with between two and three in the space of one millimeter. The apical angle is about 65°.

We cannot understand how Prof. Whitfield's figure 10 (*loc. cit.*) can possibly be a true portrayal of the surface markings of the original type of the species. Certain it is that it does not give them as they are in the specimens which we have identified with *P. semele*. Nor does it agree with Hall's description, while our specimens do. Hall says that the lines of growth below the band "have a gentle forward curvature in passing downward to the umbilicus." In Whitfield's figure, however, they are represented as curving very *strongly* forward. The latter shows also an angular bend in the striæ at the upper carina which is not mentioned by Hall, and which is, to say the least, a very rare condition among shells of this family. Now, either Whitfield's illustration is wrong or Hall's description, and as our specimens agree with the latter, we are obliged to believe that the fault lies with the figure. The course, as well as the character of the striæ is, we believe, accurately represented in our figures 8 and 9.

Whitfield's remark that "there is no doubt that this shell is a true *Murchisonia*, unless it prove to be a *Lophospira*," strikes us as a very peculiar statement. He proposed *Lophospira* and should therefore know when he has a species of his own genus before him and when one of *Murchisonia*. However that may be, *P. semele* most certainly belongs to neither of those genera. As we have said on a previous page, the occurrence of a true *Murchisonia* in American strata is yet to be established. As to *Lophospira*, it has a convex band, and includes only shells having strongly angular whorls, while *P. semele* has rather rounded whorls and is a species of the concave-banded types.

Concerning the original of our figure 10, we wish to say that if it really is an interior cast of a shell of this species, and a small patch of shell on the under surface, as well as a flattening of the peripheral band near the mouth indicates that it is, then casts are sometimes dangerously like casts of *Lophospira bicincta*.

Formation and locality.—Utica group (Maquoketa shales), Maquoketa creek and Graf, Iowa.

Collections.—Geological and Natural History Survey of Minnesota; E. O Ulrich.

Museum Register, No. 7334.

PLETHOSPIRA STRIATA, *n. sp.* (*Ulrich.*)

PLATE LXX, FIG. 7.

Shell turbinate, apical angle at least 85°, hight nearly 22 mm., width about 19 mm.; volutions at least four, probably five, convex below, nearly vertical in the middle third, concave above the band, horizontal between the upper carina and the suture; band supra-median on the last, infra-median on the whorls of the spire, decidedly concave, with thick and prominent margins; lines of growth rather regular, strong and heavy, rounded, wave-like, five or six on the last whorl in 4 mm.; on the upper side they curve strongly backward, beneath the band they are almost vertical saving a very short retral curve above; lunulæ obscure; aperture rounded-pentagonal, outer lip with a broad but very shallow notch, columellar lip straight, obtusely angular below, reflexed, completely covering the minute umbilicus.

This well-marked species cannot be confounded with any other shell known to us. The surface markings are highly characteristic.

Formation and locality.—Richmond group, Hanover, Butler county, Ohio.

Collection.—E. O. Ulrich.

Genus SEELYA, n. gen. (Ulrich.)*

Pleurotomaria, in part, of MEEK and WORTHEN, and WHITFIELD.

For generic diagnosis see page 958. For figures of typical species see page 1009.

The species which we propose to arrange under this generic title agree closely with *Plethospira* in all respects excepting that they have a narrower band and a spirally furrowed surface sculpture. As the group is easily recognized, a natural one, and ranges from the Calciferous to the top of the Niagara, we think that it should be distinguished by a name of its own. Whether the group is to be viewed as a genus or as a subgenus is of little consequence now. Our knowledge of Paleozoic Gastropoda is yet far from that point when we may decide such questions with anything like confidence in the stability of the result.

In the Calciferous of the Champlain valley we have two species of this genus, the type, *S. ventricosa* Ulrich, and *Pleurotomaria difficilis* Whitfield. These possibly are not distinct, but if Whitfield's figures of his species are correct, and we have no reason to doubt it, then it is clearly another form, having a lower spire, more numerous revolving furrows, and a shoulder-like angulation near the suture that is wanting in *S. ventricosa.* An imperfect specimen in the U. S. National Museum, which seems to belong to Whitfield's species, differs further in having a larger umbilical perforation.

Judging solely by the illustration given by Billings in Paleozoic Fossils, vol. i, p. 187, fig. 171, of his *Murchisonia cassandra,* we would say that the species was

* The genus is named in honor of Prof. H. M. Seely, of Middlebury College, who, because of his valuable work on the Calciferous-Chazy fauna and rocks of the Champlain valley, in connection with Prof. Brainerd, has fully earned the compliment. One of the authors is also indebted personally to Prof. Seely for numerous specimens, among them the type of the present genus, from Fort Cassin and other localities in the Champlain valley. These have been of much assistance in our work. Some paleontologists probably will contend that the name should have been written *Seelyia*, but the shorter form *Seelya* seemed so preferable that we concluded to risk their criticism.

founded on an interior cast of a rather slender shell of this genus. It is from the Point Lévis limestone of the Quebec group. We know of no species in the Trenton, and the Cincinnati species about to be described is a very modest representative. There are at least two Upper Silurian species. One of these occurs in the Niagara limestone at Chicago, and was described by Meek and Worthen as *Pleurotomaria cyclonemoides.* The other is the well known *Pleurotomaria lloydii* of Sowerby, occurring in England and Gotland. Several good varieties or closely related species are included in the European species, and one, as figured by Lindström, greatly resembles our *S. ventricosa.*

SEELYA MUNDULA, *n. sp.* (*Ulrich.*)

PLATE LXX. FIGS. 11-12.

Hight and width nearly equal, 10 to 13 mm.; apical angle 70° to 75°; volutions four, subangular; band prominent, narrow, concave; upper side of whorls with a strong angulation or carina midway between the band and the suture, and sometimes with a small ridge close to the suture, the intermediate spaces more or less concave; lower side convex except immediately beneath the salient band, with two or three (perhaps more) small revolving ridges; umbilical perforation very minute; aperture rounded, lines of growth obscure.

Remembering that the band is concave, we know of no shell in the Trenton and Cincinnati or Hudson River periods that might be confounded with this species.

Formation and locality.—Lower part of Lorraine group, Cincinnati, Ohio, and Newport, Kentucky. Good specimens appear to be very rare.

Collection.—E. O. Ulrich.

Genus HORMOTOMA, Salter.

Murchisonia (part.) of authors.
Hormotoma, SALTER (as subgenus of *Murchisonia*, D'Arch. and Vern.), 1859, Can. Org. Remains, Decade 1, p. 18; ŒHLERT, 1887, Extr. Bull. Soc, d'Etud. Sci. d'Angers, p. 18.
Goniostropha (part.), ŒHLERT, *op. cit.*, p. 13.

For generic characters see page 959.

This division of the *Pleurotomariidæ* seems to us as in every way fully deserving the rank of a distinct genus. In the first place, the species of *Hormotoma* have no discoverable relation to the original types of *Murchisonia*, the genus with which they have been heretofore almost universally associated. Next, the generic type maintained its peculiarities through a long period of time, beginning no later than the Calciferous and extending upward through the intervening beds to the top of the Upper Silurian. Beyond this horizon we meet with slightly modified but undeniable descendants in the lower and middle divisions of the Devonian system. The latter, because they have developed a short apertural slit, should perhaps be separated, in which case the somewhat inappropriate term *Goniostropha* might be utilized.* The third qualification lies in the comparatively obvious fact that the rather numerous species comprised in the genus constitute an evolutional series. That this is so can scarcely escape anyone who will take the trouble to compare critically the various forms which we refer here. A fourth and very important quality of the genus is its convenience in classification. The use of the term *Hormotoma* tells us at once that we are dealing with practically imperforate shells forming a high spire composed of numerous rounded or subangular whorls having simple surface sculpture and a subcentral flat or concave band terminating in a deep >shaped notch. These features furthermore are all readily apparent on all reasonably well preserved specimens.

The most natural position and true relations of *Hormotoma* appear to be with *Plethospira*, Ulrich, on the one side, and *Turritospira*, Ulrich, on the other. From the former it is distinguished by its higher spire, more numerous and slowly enlarging volutions and deeper apertural notch; from the latter chiefly by the central position of the band which, in that genus, lies considerably beneath the middle of the whorls. *Turritospira* may not be as closely related as the great similarity of its shells leads one to suppose. Considering the position and relative prominence of the band and the external contour of the whorls in that genus, we see much to remind us of those low-spired and equally ancient genera *Euconia* and *Eotomaria*. Accordingly we are prepared to see it proved that *Turritospira* is nothing more nor less than a high-spired type of one or the other of those genera.

In some of its forms *Lophospira* slightly resembles *Hormotoma*, but the more angular whorls and, especially, the convexity of the band in that genus renders confusion in this direction highly improbable. And yet, there is a possibility that some kind of relation exists between the two genera. Evidence of such a condition is furnished by two species, one, a Calciferous form described by Billings as *Murchisonia artemesia*, the other, an Upper Silurian shell described by Lindström as *M. attenuata* Hisinger sp., which have all the characters of *Hormotoma* except the band which is convex as in *Lophospira*. We are in doubt as to what should be done with these geologically widely separated two species, but would advise that they be referred provisionally to *Hormotoma* and leave it to the future to determine whether

* *Goniostropha* might be retained as a subgenus under *Hormotoma*, Salter, or possibly as a distinct generic designation for the Devonian group of species which we would otherwise refer to *Hormotoma* as the *Desiderata* section; providing that the slit-band in Œhlert's type, *M.* (*Goniostropha*) *bachelieri* Ronault sp., terminates in a short slit. That such a slit is present in the *bachelieri* we believe highly probable, and our investigations so far lead us to expect its presence in the majority, if not in all, of the Devonian shells agreeing otherwise strictly with *Hormotoma*. Still, in the absence of positive knowledge on the point, we do not consider ourselves justified in accepting *Goniostropha* for the group of shells in question. However the investigation of the species *bachelieri* may turn out, we are convinced that less than half of the twenty species referred to his subgenus by Œhlert really belong there. With some of the species we are not sufficiently acquainted to pass judgment upon them. Of the others we would say that *M. cingulata* Hisinger, and *M. moniliformis* and *M. obtusangula* of Lindström, are not at present distinguishable from *Hormotoma*; that *M. cochleata* Lindström, *M. extenuata* Conrad, *M. angulata* d'Arch. and Vern., and *M.* (*G.*) *chalmasi* Œhlert, belong to various sections of *Lophospira*; and that *M. micula* Hall, and *M. larcomi* McCoy, belong to an easily recognized and long-lived type which we propose to name *Solenospira*.

they have or have not been derived from elongated species of *Lophospira* like *L. bowdeni* Safford.

Besides the five Trenton and Cincinnati species about to be described, we refer here *Murchisonia anna*, *M. simulatrix* and *M. vesta*, three species described by Billings as occurring in the Calciferous in Canada; *M. gracilens* Whitfield from the same horizon in Vermont; *M. procris* Billings, from the Black River group of Canada; *M. moniliformis*, *M. obtusangula* and *M. subplicata*, Gothland species described by Lindström; and *M. hebe* Billings, Gaspé of Canada. *M. cingulata* Hisinger (as figured by Lindström) and *M. egregia* Billings, have the band too low to be counted as typical members of the genus, yet, it is probably best to place them here. We have already mentioned *M. attenuata* Hisinger, and *M. artemesia* Billings. *M. agilis* Billings, Quebec group, Canada, as is the case with other species described as *Murchisonia*, may belong here but is not sufficiently known to permit us to say that it does. *M. teretiformis*, of the same author, provided the Manitoba specimens identified by Whiteaves with this species are really the same as Billings' original types, has all the characters of *Hormotoma*, despite the great size which this shell attains.* Œhlert describes two species from the Devonian of France as *M.* (*Hormotoma*) *lebescontei* and *M.* (*H.*) *clavicula*. The same author proposes *Goniostropha* as a section of *Murchisonia* and includes in it several of the species that we refer to *Hormotoma*. If *Goniostropha* is to be recognized it must be for the reason given on page 1012.' If these are not sufficient then the American species *M. desiderata*, *M. maia* and *M. leda* of Hall, together with some of the European shells which Œhlert places in his proposed section, must be regarded as congeneric with the Silurian species of *Hormotoma*. As defined by Œhlert, *Goniostropha* is clearly an incongruous assemblage.

Hormotoma gracilis *Hall, and varieties.*

PLATE LXX, FIGS. 18–36 and ?42–43.

Murchisonia gracilis Hall, 1847, Pal. New York, vol. i, p. 181 (not Salter, 1859, Can. Org. Rem., Dec 1, p. 22.)

Murchisonia angustata Hall, 1847, Pal. New York, vol. i, p. 41.*

Comp. *Murchisonia gracilens* Whitfield, 1889, Bull. Amer. Mus. Nat. Hist., vol. ii, p. 53, pl. viii, fig. 14.

* We are strongly inclined to doubt that the Manitoba specimens, which are from the Trenton limestone (Fusispira or Maclurea bed), are specifically the same as the Hudson River group, Anticosti, originals of *M. teretiformis*. The apical angle in the former is 35° or more, while Billings gives the angle for the Anticosti types at 27°. Since the foregoing was placed in the printer's hands, Mr. J. F. Whiteaves has kindly sent us the two best specimens of these Manitoba and Anticosti forms in the museum of the Canadian survey. As a result of our comparison, we are now firmly convinced that the two forms are specifically distinct, differing from each other in the same manner as *H. bellicincta* and *H. trentonensis*. The Manitoba species resembles the former, having more whorls, especially in the upper half of the spire, than the true *H. teretiformis*.

† As will be noticed, the description of *M. angustata* occurs on an earlier page in the work cited than that of *M. gracilis*, and if we followed the usual custom in such cases the first name would have been adopted for the species instead of the second. But as the date and authority for the two names is the same, and as the name *angustata* has been scarcely recognized while *M. gracilis* has been described and quoted perhaps hundreds of times since 1847, it is evident that the latter has the better right to be retained for the species.

Typical form.

PLATE LXX, FIGS. 18-21; ? 22.

Hight 20 to 33 mm., apical angle very constantly about 18°. Shell small, slender; volutions about fourteen in a length of 30 mm.; rounded, generally with a slight angulation, on which lies the band, a little beneath the middle; band seldom preserved, when perfect, rather narrow, smooth, flat or faintly concave and margined on each side by a delicate raised line; suture simple, deep; lines of growth fine, bending strongly backward from the suture to the band, and beneath this curving very strongly forward again, the whole indicating a deeply notched mouth; aperture a little higher than wide, rounded except below where it is somewhat produced; inner lip reflected, forming a slightly twisted and thickened columella.

The original of fig. 22, which was found with many specimens like figs. 20 and 21, in the Richmond group near Spring Valley, has the whorls too angular. Perhaps it would be better to place it with the var. *goodhuensis*.

Variety ANGUSTATA *Hall.*

PLATE LXX, FIGS. 30-36.

Has more uniformly rounded whorls and slightly wider band than the typical form. So far as observed, this variety never reaches a length of 25 mm., the majority of specimens varying between 17 and 20 mm.

Variety SUBLAXA, *n. var.*

PLATE LXX, FIGS. 23-25.

This form is distinguished by its rather loosely coiled volutions, deep oblique suture, and wide band.

Variety MULTIVOLVIS, *n zar.*

PLATE LXX, FIGS. 26-29.

Distinguished from the foregoing varieties by its closely wound, vertically depressed volutions.

? Variety GOODHUENSIS, *n. var.*

PLATE LXX, FIGS. 42—43.

In this form the whorls are unusually high and angular, almost rivalling, in the latter feature, the next species, with which, moreover, it was found. But the apical angle is only about 18 degrees, and this agrees with *H. gracilis*, while it is too narrow for *H. subangulata*. We have only two specimens and therefore do not like to say anything positive about the form. A larger supply of specimens may show it to be more distinct than it now appears. At any rate, it seems worthy of recognition as a variety. On plate LXX, fig. 22 gives a view of a similar specimen which occurred with *H. gracilis* and the var. *multivolvis* in the Richmond group at Spring Valley. Possibly this represents a later appearance of var. *goodhuensis*.

One or the other variety of *H. gracilis* occurs in greater or lesser abundance at most localities in the the eastern half of the United States and Canada exposing the rocks of the Trenton and Hudson River periods. Really satisfactory specimens, however, are rare, especially such as preserve the shell and surface markings. The var. *angustata* is scarcely distinguishable in the condition of casts of the interior, in which it is usually found, from the typical form of the species, but it is probably safe to say that all the specimens of the species found in the Stones River group belong to this variety, since none of the other varieties have so far been identified in rocks beneath the Black River group. The variety *angustata* seems to occur as far down as the Calciferous sandstone, since we can see no difference whatever between the Stones River form and *Murchisonia gracilens* of Whitfield. The other varieties are sometimes associated with the typical form of the species, but they are readily enough distinguished, either as casts or shells, by the peculiarities above mentioned.

Formation and locality.—Var. *angustata* occurs rather rarely in the Vanuxemia bed of the Stones River group at Cannon Falls, Minnesota, and in equivalent strata in Wisconsin, Illinois, Kentucky, Tennessee, New Yo k and Canada; also in the shales of the Black River group at Minneapolis and near Cannon Falls, and in the Utica group at Cincinnati, Ohio. The typical form is found from the Black River group on up to the top of the Richmond group at many localities. Good specimens occur in the Maquoketa or Utica shales at Graf, Iowa. Var. *sublaxa* is so far known only from the Trenton group at Auburn, Missouri. var. *multivolvis* in the Richmond group near Spring Valley, Minnesota, and var. *goodhuensis* in the Phylloporina bed of the Black River group in Goodhue county, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 7337.

HORMOTOMA SUBANGULATA, *n. sp.*

PLATE LXX, FIGS. 37–41.

Length 20 to 30 mm., apical angle about 25°, band flat, median in position on the angular whorls.

The apical angle is wider and the volutions much more angular than in any of the varieties of *H. gracilis*. The upper slope of the whorls is generally flat or very slightly convex, but occasionally it may be a trifle concave. In none of nine specimens is the apical angle less than 24°, and in one it is 26°. The two specimens represented on the same plate by figures 42 and 43 resemble this species in the angularity of their whorls, but as the apical angle is only about 18° in these specimens it is perhaps advisable to refer them provisionally to *H. gracilis*. (See preceding page.)

Formation and locality.—Ctenodonta bed of the Black River group, Chatfield and near Cannon Falls, Minnesota. At the latter locality a cast of the interior apparently of this species was found in the Clitambonites bed of the Trenton group.

Collection.—E. O. Ulrich.

HORMOTOMA SALTERI, *n. sp.* (*Ulrich.*)

PLATE LXX, FIGS. 44–51.

Murchisonia (*Hormotoma*) *gracilis* SALTER, 1859, Can. Org. Rem., Dec. 1, p. 22. (Not HALL's species.)

Hight 25 to 40 mm.; apical angle 20° to 24° in typical form (figs. 44-48), about 25° in var. *canadensis* and 20° in var. *tennesseensis* (figs. 49-51); volutions nine or ten, rounded, more or less distinctly thickened above at the suture and flat or concave just beneath; band rather wide, flat or slightly concave, median in the var. *canadensis*, a trifle beneath the center in the typical form and a little above the center in the var. *tennesseensis;* lines of growth unequal, rather fine, never sharp.

This is a larger shell and has a wider apical angle than *H. gracilis*. In the typical form the thickening of the upper edge of the whorls is usually a well-marked feature, but it is less constant in both of the Black River group varieties, and often wanting or quite inconspicuous in the Canadian form. Evidently, the peculiarity increased with the evolution of the species.

Another variety may be distinguished as var. *nitida*. This occurs rarely near the top of the Trenton group in association with the typical form, from which, however, it is readily separated by its larger size, relatively plump form and much wider apical angle. The latter is about 30°, while the hight of a large specimen was nearly 50 mm. The concavity beneath the suture is not very distinct on the lower two or three whorls, but in all other respects their markings are precisely as in the typical form of the species.

Formation and locality.—Var. *canadensis* occurs abundantly in the Black River rocks at Pauquettes rapids on the Ottawa river, and, more rarely, together with the var. *tennesseensis*, in equivalent or somewhat younger strata between Nashville and Lebanon, Tennessee. The typical form was found in abundance, var. *nitida* rarely, in the upper part of the Trenton group between Burgin and Danville, Kentucky.

Collection.—E. O. Ulrich.

HORMOTOMA BELLICINCTA *Hall.*

PLATE LXX, FIGS. 15–17.

Murchisonia bellicincta HALL, 1847, Pal. New York, vol. i, p. 179, pl. XXXIX, figs. 1*a* and 1*b*, ? 1c and 1*d*, not 1*e*.

Hight 20 to 45 mm., apical angle 42° to 50°, generally about 44°; volutions neatly rounded, sometimes appearing a little flattened in the upper half, rather closely wound, depressed so that the hight and width is respectively as one is to two, about six or seven in number, casts, however, rarely preserving more than four; band wide, flat, clearly defined on shells, just above or exactly in the middle of the whorls of the spire; lines of growth strongly recurved to the band, regular, comparatively strong and distant, rarely visible on casts of the interior; a small, sometimes sharply defined umbilicus; aperture rounded, except at the lower angle, which is somewhat extended.

At least two species were united under the name *Murchisonia bellicincta* by Hall and most subsequent authors who have had occasion to write about the species, while collectors have used the name in a very loose and shifty manner. That Hall's original figures (*loc. cit.*) embrace at least two species must be evident to all who will take the trouble to compare his 1*a* and 1*e*. How could the former, representing a small testiferous specimen, possibly be the apical portion of an example of the same species as the original of the latter, which is said to be an incomplete "cast of a large specimen"? In the first place, the apical angle of 1*a* is about 50°, while that of 1*e* is only about 32°. So great a difference, especially in a genus of shells in which the apical angle is unusually constant, almost certainly indicates specific variation. When we add that in corresponding parts of the two figures the one has four whorls where the other has but three, we may well wonder how the fact has so long escaped observation. Both forms occur in Minnesota, and our only difficulty has been to decide as to which is the better entitled to retain the name *bellicincta*.

So far as known, neither occurs in any disvision of the Cincinnati period, and both appear to be confined strictly to the Trenton proper. The larger form, however, seems to be the more common of the two and therefore probably the form that has been the more frequently referred to by authors. On the other hand, the smaller species precedes the larger on the plate, and, as the specimens figured of it are in a better state of preservation than the other, it is reasonable to assume that they furnished the greater part of the characters brought out in Hall's description. We have therefore concluded to restrict the application of the name *bellicincta* to forms of the type of Hall's figs. 1*a* and 1*b*, and propose a new designation for the species represented by his fig. 1*e*.

Formation and locality.—Not uncommon in the Trenton limestone in New York and Canada. In Minnesota we have collected a total of eleven specimens, all from the lower part of the Fusispira bed at various points in Goodhue county.

Collections.—E. O. Ulrich; W. H. Scofield.

HORMOTOMA TRENTONENSIS, *n. sp.*

PLATE LXX, FIGS. 13 and 14.

Murchisonia bellicincta (part.) HALL, 1847, Pal. N. Y., vol. 1, pl. XXXIX, fig. 1*e* (not 1*a*-1*d*); OWEN, 1852, Geol. Rep. Wis., Iowa and Minn., pl. II, fig. 8.

Murchisonia major WHITFIELD, 1882, Geol. Wis., vol. iv, p. 244, pl. IX, fig. 4 (not *M. major* HALL).

Hight 30 to 100 mm., apical angle 32° to 37°, generally about 35°; volutions seven or eight, almost uniformly convex from suture to suture, not very closely wound, with the hight and width respectively as 2 is to 3 or 3 to 5; band median, wide, flat, the lunulæ very moderately curved; lines of growth regular, fine, somewhat thread-like, averaging about eight in 5 mm., with the usual backward curve; notch deep and wide; mouth greatly produced and turned backward below; inner lip thin, reflected, above partly covering a small umbilical perforation.

This beautiful shell has been for many years confused with *H. bellicincta* Hall sp. On the preceding page we give our reasons for restricting *Murchisonia bellicincta* to the smaller of the two species figured by

Hall under that name. The course adopted having necessitated a new name for the larger form, we propose to call it *trentonensis*, since the species is one of the most characteristic fossils of the Trenton group. The respective peculiarities of the two species are perhaps sufficiently brought out by our carefully drawn illustrations on plate LXX. The principal differences are that the apical angle is considerably wider and the whorls relatively much more depressed in *H. bellicincta* than in *H. trentonensis*. These differences, considering that they are repeated with an unusual degree of constancy in specimen after specimen, and maintained from Vermont and Canada to Minnesota, surely deserve specific recognition. We have not seen the aperture of *H. bellicincta* entire, but in our judgment it is not so much produced below as in *H. trentonensis.*

Several large species occur in the Trenton that are often extremely difficult to distinguish when, as almost invariably happens, nothing but casts of the interior are available; and when these are not good the task is in many cases hopeless. However, when some of the outer surface of the shell is preserved the difficulties vanish generally at once. Thus we have a form which we have identified with Hall's *Murchisonia major.* The shell of this species is readily distinguished by the character of its suture, the upper part of the whorls, instead of sinking in gradually as in *H. trentonensis,* being flattened and prolonged upward at the edge over the preceding whorl so as to form a kind of "enamelled" suture. In Manitoba there is another species (Whiteaves has identified it with *M. teretiformis* Billings) that, excepting that it grew to a much greater size (we have before us a specimen fully 8 inches in length), can scarcely be distinguished without the shell and surface markings. These show that the broad band lies lower on the whorls (its upper margin lies a trifle beneath the center), while the lines of growth are coarser and, especially those coming from below, more decidedly inclined backward in their course to the band. *Lophospira augustina* Billings sp. is another fossil that is likely to be confounded with these species of *Hormotoma* by careless collectors, but the obtuse angulation of the whorls cannot escape the practised eye.

Formation and locality.—While testiferous specimens of *H. trentonensis* are everywhere extremely rare, casts are common enough in the Trenton limestone of Canada and New York. Specimens of any sort are rare in Kentucky and Tennessee. In Minnesota the species occurs rather frequently in the Fusispira bed and occasionally in the Maclurea bed. When the strata are shaly the specimens are beneath the average in size.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 305.

HORMOTOMA (?) MAJOR *Hall.*

PLATE LXXI, FIGS. 5-7.

Murchisonia major HALL, 1851, Geol. Lake Superior Land District, vol. ii, p. 209.

Not *M. major* WHITFIELD, 1882, Geol. Wis., vol. iv, p. 244, pl. IX, fig. 4. (=*Hormotoma trentonensis* of this work.)

Shell large, 80 to 150 mm. in hight, rather slender, composed of about nine whorls; apical angle of first four or five turns, which are usually broken or dissolved away, about 37°, of the following four or five only 25° to 27°. In a specimen having a maximum width of 65 mm., the last three whorls reach a hight of fully 110 mm., while the hight of the aperture, measuring from its lower extremity to the anterior end of the suture line, does not exceed 44 mm. In casts of the interior there is a rather large umbilical perforation, the whorls are distinctly separated by an intervening space, the upper edge of the whorls more or less sharply angular, and their sides strongly convex in the lower and almost flat in the upper half. In the shell itself the umbilicus is very small, the suture shallow and indistinct, the whorls of the spire but slightly convex in the lower and middle thirds and gently concave in the upper, the thin upper edge of each being turned upward so as to lap over a part of the convex base of the preceding whorl. Aperture angular above, only very moderately produced below, on the whole somewhat rhomboidal in outline. Notch deep and wide, the deepest part lying about midway between the extremities of the outer lip or a little beneath the center. Neither the surface markings nor the band have been observed, but the latter, judging from the apertural notch, must lie but a short distance above the suture line.

Concerning the identity of the species just described and Hall's *Murchisonia major*, we can only say that after as careful an investigation as was possible without having an opportunity of studying the original types, we are fairly well satisfied that our shells are really the same as the one figured by Hall. Very likely his original lot of specimens included other forms of these large shells, but if the present species is, as we believe, among them, then it would be well to retain the name *major* for it and throw out the others. This course is to be commended if only for the reason that it will greatly simplify matters in the way of synonomy.

It is often asserted that *H. major* is but a large form of *H. bellicincta*, while Whiteaves would make it the same as Billings' *M. teretiformis*. However, and providing that we have correctly identified these species, the totally different suture of *H. major* shows conclusively that it is not even closely related to either of the two other species mentioned.

The unusual character of the sutural region, which is well shown in our fig. 7, is of itself sufficient to distinguish this shell from all associated gastropods. Casts are separated from those of *H. trentonensis* by their narrower apical angle (taking the whole shell into consideration), by the less uniform convexity of the whorls, and the rectangular instead of rounded junction of the upper and outer sides of the whorls. The last difference is very striking when transverse sections of the whorls are compared. The lower extremity of the mouth also is much less produced and therefore blunter. Casts of *Lophospira augustina* Billings sp., are sometimes found in the same layers with *H. major*, but the wider apical angle and obtusely angulated whorls of the former renders confusion in this case highly improbable. If perfect shells of these various species could be compared, we are convinced that the merest tyro in the science would separate them at once.

Formation and locality.—Though widely distributed, this species appears not to be abundant at any locality. It is restricted to the Trenton group, and in Minnesota occurs in both the Fusispira and Maclurea beds at Lime City, Stewartsville, Mantorville, Hader, and other localities. The original types were obtained in Wisconsin, and the species is said to occur at many points in that state. Good casts have been found in Pike county, Missouri.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, Nos. 7345, 7485, 7842.

Genus CŒLOCAULUS, Œhlert.

Murchisonia (part.) of LINDSTRÖM, BILLINGS, and other authors.
Cœlocaulus ŒHLERT (as subgenus of *Murchisonia*), 1888, Extr. Bull. Soc. d'Etud. Scientif. d'Angers, p. 20.

For generic characters see page 959. The date of this genus should be 1888 instead of 1887.

This type of shells is not as closely related to *Hormotoma* as may appear on a hasty comparison. To the practised eye there is something peculiar about their general aspect that at once causes them to be set aside as a group by themselves. With few exceptions they are all very slender many-whorled shells, with a continuous narrow umbilical perforation, the inner lip straight and the lower angle of the aperture comparatively very little produced. The whorls are depressed, in two instances our (*C. neglectus* and *C. barroisi* Œhlert) probably not more than twelve in number, generally exceeding fifteen, and in some cases as many as thirty. The band in all observed cases is wide and flat and lies beneath the middle of the whorls of the spire. In at least some of the species a considerable number of the apical whorls are filled with an organic deposit.

Species whose known characters are in accord with this diagnosis of *Cœlocaulus* occur in most of the principal formations from the Calciferous on to well up into the Devonian system. Of these *Murchisonia linearis* Billings, is the oldest. Then followed our *C. œhlerti* and *C. neglectus,* both Trenton forms, *M. compressa* Lindström, from Upper Silurian strata in Gothland, *M. bivittata, M. longispira, M. logani* and *M. turritiformis,* four Guelph species described by Hall, and *C. davidsoni, C. barroisi* and *C. procerus,* three species described from the Devonian of France by Œhlert. And there are others which probably belong here, but they are as yet too little known to justify their removal to *Cœlocaulus.* However, without them, the ten species mentioned make a sufficiently respectable showing to establish the genus in the classification of the Paleozoic Gastropoda.

Cœlocaulus œhlerti, *n. sp.*

PLATE LXX, FIGS. 61–63.

This species is known only from fragmentary casts of the interior, but as it is an interesting and striking form we deem it well worth a description. The apical angle is about 12°, and, if the taper of the spire is uniform an entire specimen must consist of at least thirty whorls, and have a length of about 60 mm. The largest specimen, having a maximum diameter of 12 mm., has eight whorls in a length of 30 mm.; another, 9 mm. in diameter, has twelve whorls in the same distance. The hight of the whorls is to their width as 2 is to 5 or 3 to 8. The whorls are very little separated and decidedly convex in casts but in the shell itself, which evidently was very thin except at the sutures, the convexity must be considerably less. Transverse section of whorls rounded quadranglar. Band and surface markings not observed, probably obscure, since no trace of them is visible on a mould of the exterior.

We know of no other shell in the Lower Silurian deposits of the Mississippi valley that could for a moment be confounded with *C. œhlerti.* The next species is smaller and has a much wider apical angle, with fewer whorls.

Formation and locality.—A rare fossil of the Trenton group (Galena limestone), and so far known only from Jo Daviess county, Illinois.

Collection.—E. O. Ulrich.

Cœlocaulus neglectus, *n. sp.*

PLATE LXXXII, FIGS. 29–31.

Hight about 18 mm., apical angle about 25°. The only specimen seen is a slightly distorted cast of the interior, consisting of only four whorls, the uppermost of which has an obtusely rounded termination, indicating that the apical whorls were filled with an organic deposit. These four whorls have a hight of about 12 mm., the last a diameter of 7 mm., the first of about 3 mm. The whorls are rounded in transverse section, the sutures deep, the umbilical perforation small, yet very obvious.

This small species might be confused with *Hormotoma subangulata* or with certain varieties of *H. gracilis,* but if the observer will bear in mind that the umbilicus is very small and quite inconspicuous in casts even of those shells, that their whorls are not so much depressed nor subcircular in section, and that the upper turns are never lacking except through accident, he should not have much trouble in disting uishing the *Cœlocaulus.*

Formation and locality.—Clitambonites bed of the Trenton group, near Cannon Falls, Minnesota.

Collection.—E. O. Ulrich.

Genus SOLENOSPIRA, n. gen.

Eunema (part.) of SALTER and BILLINGS.
Murchisonia (part.) of WHITFIELD and other authors.

For generic characters see page 959.

This is a long-lived group of species that can always be recognized by the broad saliently margined concave band which occupies the greater part of the middle third of the whorls. In their general appearance they remind one of *Turritellidæ* rather than pleurotomaroids, and so far as we can see there is no serious objection to considering them as the ancestors of that graceful family of shells.

So far as known the notch or sinus in the outer lip was never prolonged into a slit. This of itself is a suspicious circumstance when we consider the usual progress of development pertaining to nearly all of the various types of the *Pleurotomariidæ*. The proportionally great width of the band, together with the fact that its transverse markings are of the same character as the fine recurved lines of growth—indeed they are mere connecting continuations of them—strengthens this suspicion almost to conviction that *Solenospira* represents the root of a line of development that later on (in Carboniferous and subsequent times) diverged widely from ordinary pleurotomarians. And what family is a more likely continuation of the line than the *Turritellidæ*?

We place the genus with the *Pleurotomariidæ*, in the immediate vicinity of *Hormotoma*, chiefly because we know of no other stock from which it might have been derived. The depth of the apertural sinus and the fact that its deepest part is marked off in such a manner that with continued growth of the shell it formed a sharply margined spiral band, are both highly characteristic conditions of the *Pleurotomariidæ*, while the features mentioned in the preceding paragraph are such only as might very well have occurred in the separation of a line culminating in *Turritella*.

The oldest of the species which we place here is the *Eunema prisca* Billings of the Calciferous formation of Canada. An apparently undistinguishable form, occurring in the Stones River group in Minnesota, Wisconsin, Illinois and Tennessee, is described and figured in this work. The Quebec group furnishes two other species, *Murchisonia adelina* and *M. missisquoi* of Billings. The latter of these two species possibly may, when better known, prove to have other affinities. In the Black River group we have the type of the genus, *Eunema ? pagoda* Salter. We know of no other good representatives of the genus, in American deposits, at any rate, until we reach the Hamilton group, from which Hall has described one as *Murchisonia turricula*, or as it is now known, *M. micula*, the specific name having been changed because the first had been used previously under *Murchisonia.* The next American species occur in the St. Louis group of the Subcarboniferous system, from which Hall has described three species, *M. attenuata*, *M. turritella* and *M. vermicula*, every known character of which allies them with *Solenospira.* Of European species probably belonging here, we may mention the Devonian *M. tricincta* d'Arch. and Vern., and the Carboniferous *M. quadricarinata* McCoy, *M. larcomi* McCoy, *M. gracilis* Goldf., and *M. nana* and *M. tenuis* of DeKoninck. There are some new species also, and no doubt others have been described, but it is difficult to decide from illustrations alone whether they belong here or not. Some of the latter having more than four revolving carinæ may belong to *Aclisina.*

SOLENOSPIRA PRISCA *Billings.*

PLATE LXX, FIGS. 52–55.

Eunema prisca BILLINGS, 1859, Can. Nat. and Geol., vol. iv, p. 360.
Murchisonia (Eunema?) pagoda WHITFIELD, 1883, Geol. of Wis., vol. iv, p. 218. (Not *Eunema? pagoda* SALTER.)

We have eight more or less imperfect specimens, three of them casts, the rest testiferous, one from Minneapolis, two from Wisconsin, three from Dixon, Illinois, and two from Murfreesboro, Tennessee, of a species of this genus, that after repeated efforts we have failed to distinguish from the Calciferous shell which Billings called *Eunema prisca.* In all these specimens, the largest indicating a total length of between 40 and 50 mm., the apical angle is constantly about 14°. Our figures 53 and 55 (Plate LXX) are so clear and satisfactory that a detailed description is unnecessary. Besides these we have another lot of seven specimens that is not exactly like the first lot. The specimens of the second lot, namely, while agreeing precisely with the northwestern form as far down the spire as the eighth or tenth whorl, from here on reduce the apical angle to only about 10°. At the same time the relative hight of the whorls is increased. These peculiarities are shown very well in figures 52 and 54. If a subordinate name is desired for this peculiar Tennessee form, it may be called var. *extenuata.*

Compared with *S. pagoda* Salter sp., the only difference of any consequence is that while each whorl in that shell has four carinæ—two in the middle, one below and one above, the latter two being almost in contact at the suture—*S. prisca* has but three, the upper one being absent, while the lower one is visible on the base of the last whorl only.

Formation and locality.—Billings' types came from the "Calciferous sandrock, Mingan Islands." The specimens used by us are all from the Stones River group at the localities mentioned above.

Collection.—E. O. Ulrich.

SOLENOSPIRA PAGODA *Salter.*

PLATE LXX, FIGS. 56–60.

Eunema? pagoda SALTER, 1859, Canadian Organic Remains, Dec. 1, p. 30, pl. VII, fig. 5.
Not *Murchisonia (Eunema?) pagoda* WHITFIELD, 1883, Geology of Wisconsin, vol. iv, p. 218. (=*Solenospira prisca* BILLINGS sp.)

Hight generally 25 to 30 mm., probably not exceeding 40 mm.; apical angle 14° or 15°; volutions ten to fifteen, furnished each with two prominent keels which divide the surface into three approximately equal concave spaces or furrows; a third but smaller carina above at the sutural edge, while a fourth is visible generally only on the base of the body whorl; surface markings, aside from the strong revolving keels, consisting of extremely fine lines of growth which are directed rather strongly backward from both above and below to the median keels, passing apparently over these and then across the concave central space with a slight backward curvature (see fig. 56, pl. LXX); aperture subquadrate, very slightly produced below; umbilical perforation extremely minute or wanting.

The small carina just beneath the suture line distinguishes this species from *S. prisca*.

If Salter's figure (*loc. cit*) is correct, then the Canadian types of the species must have a wider apical angle than the Minnesota and Wisconsin specimens above described. The angle of the illustration in question is about 22°, while it is not over 15° in our examples. We are, however, inclined to doubt the accuracy of the Canadian illustration, especially since Billings, after giving the apical angle of his *Eunema prisca* at "about 12°," says that his species is distinguished from *E. pagoda only* by the absence of the upper carina.

Formation and locality.—Black River group, Pauquettes rapids, Ottawa river, Canada; Phylloporina bed, near Cannon Falls, Minnesota; "Upper Buff limestone," near Beloit, Wisconsin.

Collections.—University of Wisconsin; E. O. Ulrich.

Family EUOMPHALIDÆ.

This important family, according to our opinion, is to be viewed as an off-shoot from the same early type in which both the *Raphistomidæ* and *Pleurotomariidæ* also originated. It is to be expected, therefore, that, although some of the earliest forms of the family underwent very rapid and strongly marked changes, the majority are decidedly like their contemporaneous cousins. For the same reason it is evident that for some of the "majority" it is difficult to decide whether they had best be regarded as *Euomphalidæ* or as members of one of the other families. With our present limited knowledge of their progenitors, it is perhaps impossible to arrive at positive conclusions.

Already in the Calciferous and Quebec groups, which contain the earliest fully known representatives of the present subclass, we find unequivocal members of the family. Of them we may mention *Eccyliomphalus intortus, distans* and *canadensis* of Billings, *E. (Caularops) lituiformis* Whitfield, *Straparollus quebecensis* Billings, and *Euomphalus calciferus* Whitfield. The Eccyliomphali are clearly of the line of development which found its continuance in *E. angelini* Lindström, of the Swedish Lower Silurian, *E. undulatus* Hall, of the Stones River group, and our Trenton species, *E. subrotundus;* and possibly its culmination in the Upper Silurian shells from the island of Gothland, described by Lindström as *Euomphalus triquetrus* and *E. gotlandicus.** Concerning this line of development, we are fully convinced that it stands in only very remote genetic relationship to the large group of Upper Silurian Carboniferous species which is typified by *Euomphalus pentangulatus,* the derivation of the latter group from the equally ancient types of *Ophileta*, being, as we shall show presently, very easily demonstrated.

The immediate progenitor of the Calciferous Eccyliomphali, we conceive to have been a form like our *Ec. contiguus* with contiguous, though perhaps narrower,

* Walcott's *Eccyliomphalus devonicus* (Monog. U. S. Geol. Sur., vol. viii, p. 187; 1885) may represent a continuation of this type, but his specimen is so imperfect that it is impossible to arrive at satisfactory conclusions respecting it.

whorls, rounded or obtusely angular upon the upper side, the angle marking the bottom of a broad sinus in the lip; the first departure from this type consisted in the loosening and straightening of the last whorl (*Eccyliomphalus*, or as Whitfield would have it, *Caularops canadensis* Bill. sp.); next all the volutions became disjoined as in *Ec. intortus* and the later *Ec. undulatus.* We have no evidence to show that one or the other of these stages was not strictly maintained as a specific peculiarity by each of the early forms—it certainly was so with the Trenton species—but, according to Lindström, the whorls in his *E. gotlandicus* vary from closely coiled to perfectly evolute. All these species have a broad sinus in the upper lip and, so far as traced, we have found no evidence to show that the later (Devonian and Carboniferous) shells commonly referred to *Straparollus* (*i. e.* euomphaloid shells having rounded whorls and nearly or quite straight transverse lines of growth) were developed from them. On the contrary *Straparollus* or *Straparollus*-like shells seem to us to have been evolved probably at several successive times from true Euomphali. Still, we are not prepared to say that some of them may not have been derived from the Lower Silurian species which Billings called *Straparollina.* However, though with nothing but Billings' figures to base our judgment upon, we are strongly inclined to regard *Straparollina* as closely related to *Holopea* and consequently as widely distinct from the *Euomphalidæ.*

In our opinion, therefore, *Eccyliomphalus*, as this genus is defined and used by most American authors, deserves recognition as a well-marked and limited generic group, principally because it represents a distinct line of development. *Phanerotinus* Sowerby, which is similar in habit and sometimes considered as synonymous, is founded upon evolute Straparollus-Euomphali of the Devonian and Carboniferous rocks. As now used the genus is not a natural group, but it may well be retained, provisionally at least, as a designation of convenience for those Euomphali having rounded and more or less widely disjoined volutions and no apertural sinus. In America only three species fulfill these requirements, viz.: *P. parodoxus* Winchell (Burlington group), and *P. eboracensis* (Hamilton group), and *P. laxus* (Corniferous group) of Hall. The second is peculiar because its shell attaches to itself foreign objects. *Eccyliomphalus undulatus* Hall had a similar habit, and its frequent occurrence in several European Devonian *Euomphalidæ* has been observed by Deslongchamps, Koken and others, and quite recently has led Kayser to propose the new generic term *Philoxene* (Zeitschr. d. deutsch. geol. Gesellsch., Jahrg. 1889.) This peculiar feature reminds one of the recent genus *Phorus*, but we agree fully with Hall and Koken in attaching very little significance to its presence in these otherwise clearly Euomphaloid shells.

As far as we can go back in geological history, the developmental line of

Euomphalus began in *Ophileta*. Typically, this genus is probably restricted to rocks of the age of the Calciferous, and consists of discoidal shells, with the spire concave and the base nearly flat. The whorls are narrow, in contact, all exposed, and flattened or gently convex beneath, angular at the lower part of the slightly convex or flattened periphery and more sharply angular on the upper side. The anterior extremity of the upper keel marks the bottom of a deep >-shaped apertural sinus or notch. The keel itself is homologous with the slit-band of the *Pleurotomariidæ* though of more simple structure. The outer lip extends forward a trifle farther or about as far as the innermost part of the upper, while the lower on the whole is nearly direct though slightly insinuated in the outer half.

From the typical forms of the genus like *O. complanata* we pass by rather easy gradations through forms like *O. ? bella* Billings and *Euomphalus uniangulatus* Hall, to *Helicotoma*, Salter, the change consisting in the raising of the spire till it projected slightly above the level of the last volution, in the deepening of the umbilicus and in the rounding of the outer and lower sides of the whorls. The course of the lines of growth and the >-shaped notch at the end of the upper carina remain about the same. But it is not from fully developed *Helicotoma*, which continued as an independent genus to the close of the Lower Silurian, that the later Euomphali were evolved. In our opinion they were derived from a second branch of the Calciferous *uniangulatus* section of *Ophileta*, the first resulting in *Helicotoma*, the farther development of which tended toward the early pleurotomarian rather than the euomphaloid type of structure. In *Helicotoma*, namely, the upper carina becomes very much like a slit-band, and that is precisely the opposite of what was necessary to produce an *Euomphalus*, in which the apertural notch is reduced to the minimum.

Now, if the student will compare species like *O. bella* Billings, *O. (Eu.) uniangulatus* Hall, *Eu. obtusangulus* Lindström, *E. præcursor* Lindström and *E. walmstedi* Lindström, the last two Upper Silurian species, we think he will be prepared to admit the correctness of our views, since with our present knowledge it is quite out of the question to arrange the last of the species mentioned in any other position than in the immediate vicinity of the original Carboniferous types of *Euomphalus*.

During Devonian times a side branch from *Euomphalus*, for the best species of which Hall proposed the generic name *Pleuronotus*, became very abundant in individuals if not in species also. It is interesting to note that *Pleuronotus* represents a very striking return to characters pertaining to *Ophileta*, there being the same flat base, carinate upper side, and deep apertural notch which previously had been the main characteristics of that primitive genus. It might be contended that *Ophileta* enjoyed a continuous existence from the Calciferous to the Devonian and that

Pleuronotus therefore is really nothing more than a continuation of the original type. Such a view, however, is rendered untenable, so far as negative evidence can do so, by the fact that we have no knowledge whatever of the presence of the *Ophileta* type in the rocks lying between the base of the Trenton and the top of the Upper Silurian. *Pleuronotus* appears to have diverged rather suddenly during early Devonian times from the true *Euomphalus* line, but we do not now feel justified in designating the particular species which gave it origin. As to the length of time that it existed, we are inclined to believe that it became extinct before the close of the Devonian.

Following the development of *Euomphalus* into the Carboniferous rocks we find three types of shells: one, including *E. subrugosus* M. and W., *E. subquadratus* M. and W., and others, in which the spire is concave, the volutions quadrangular in section, and the upper and lower boundaries of the broad, nearly vertical and flat or gently convex periphery are marked by more or less sharp angles over which the lines of growth pass without being much recurved. On the peripheral side these lines are straighter than usual, and sometimes even curved very slightly backward. This group reminds one greatly of the Jurassic *Discohelix*, and probably is to be viewed as the stock from which that genus sprang. The second group includes the original types of the genus, *E. pentangulatus* and *E. catillus* of Sowerby, and a number of other European species whose volutions have an upper and usually also a lower keel or angulation, with the periphery, on which the growth lines are more or less bowed forward, strongly convex, and the spire flat or concave. A slight sinus in the upper lip is common. In its typical expression this group is unknown to us in American deposits save through a single small species from the Upper Carboniferous of Missouri, which seems to be new. The third group on the other hand is well represented here, we being acquainted with, besides several undescribed forms, the following five species: *E. latus* Hall, Burlington gr., *E. similis* Meek and Worthen, St. Louis gr., *E. planidorsatus* M. and W., and *E. subumbilicatus* Worthen, Chester gr., and *E. umbilicatus* M. and W., Coal Meas. In all these shells the spire rises above the plane of the last volution, and in some of them to an unusual extent. The whorls are rounded on the outer and sometimes also on the lower side, but generally the boundary of the umbilicus is angular. The upper keel is always present and situated much nearer the periphery than the suture; between the latter and the keel the surface is flat or gently concave. The general aspect of the shells is greatly like that of the prevailing forms of the Lower Silurian genus *Helicotoma*. In some this resemblance extends even to the possession of a number of obscure revolving lines on the peripheral region like those seen in *H. planulata*. There is, however, a very decided difference in the course of the lines of growth marking the surface of the outer layer. Thus, while the upper keel terminates anteriorly in a deep notch and the growth lines curve backward strongly both from above and below in approaching the keel in *Helicotoma*, they pass almost directly across the whorls in these Euomphali. In passing over the keel they are but little, if at all, deflected, but a broad backward sweep on the lower side of the whorls produces a slight obliquity of the aperture.

In stating the differences in the direction of the lines of growth of the Carboniferous and Lower Silurian shells just compared, we were careful to say, "the surface of the outer layer," because we have reason to believe that the markings of the inner layer are not the same as those of the outer. We have before us a remarkable specimen of an undescribed *Euomphalus* from the oolitic limestone of the Upper Coal Measures at Kansas City, Missouri. The species is closely related to and perhaps not specifically distinguishable from the Chester group shell to which Meek and Worthen have given the name *E. planidorsatus.* There is no doubt then about its genetic relations. The specimen in question has the external layer of the shell peeled off in patches so as to expose the inner layer. Both layers show lines of growth very distinctly, and it was in comparing their respective directions in the region of the upper keel that we met with a surprise. On the outer layer, namely, the striæ pass almost straight from the suture to the keel, beyond which they turn first very gently forward and then more strongly backward into the broad basal sinus. The inner layer seems to be composed of short overlapping laminæ, the edges of which impressed themselves upon the internal cast as closely arranged parallel grooves. The latter, instead of being direct like the lines of the outer layer, curve backward strongly in passing over the region of the keel, thus indicating a very decided >-shaped notch in the lip, which must, however, have been confined to the inner layer of the shell. Immediately beneath the keel the test is thick enough to produce a faintly concave instead of convex band on the interior cast.

After seeing this specimen, the important question arises, do not the same conditions pertain to all the similarly carinate Euomphali? Unfortunately we have no positive data bearing upon the question, although we have seen specimens of other species in a similar state of preservation; but the specimen described is the only one showing any sign of transverse markings on the inner surface of the shell, the casts in every other instance being quite smooth. Still, the Kansas City specimen proves that a notched aperture may really exist in species of *Euomphalus* exhibiting no external sign of its presence, and this fact is, to say the least, worthy of being remembered.

In addition to the euomphaloid types discussed on the foregoing pages, we distinguish three others, two of them under new names, the third described and named *Eccyliopterus* by Remele.

Ophiletina is a new generic or subgeneric name proposed by us for the reception of two or three peculiar yet obviously euomphaloid shells occurring in the Stones River, Black River and Trenton groups in Minnesota and elsewhere. Compared with other types of the family, we find that they resemble certain Carboniferous species of *Euomphalus* (the *E. subquadratus* section) more closely than any others found in Paleozoic rocks. Nearer even than these is a Triassic species which Koken figures and describes as *E. cassianus*, (*op. cit.*, p. 416). Now, we consider it quite out of the question that either the Carboniferous or the Triassic species are descended from the Lower Silurian shells under consideration. What we do believe is that *Ophiletina* is a rapidly evolved side branch from *Ophileta* that became extinct before or with the close of the Lower Silurian age. The principal reason for this opinion lies in the fact that no shell of this type is known from the Upper Silurian, nor from the Devonian, unless *Pleuronotus* be so considered. The latter, however, is more like *Ophileta* than *Ophiletina*.

Hisingeria is proposed for the reception of *Inachus planorbis* His., a well known fossil of the Upper Silurian strata of the island of Gotland, that, since 1828, when Hisinger first identified it with Wahlenberg's *Turbinites centrifugus*, has been referred to under no less than seven different generic names. Until the appearance of Lindström's grand work on the "Gastropoda of Gotland," in which it is referred to *Pleurotomaria*, most authors called it an *Euomphalus*. In 1837 Hisinger proposed the generic name *Inachus* for it, but as this had been used many years before by Fabricius, it could not be retained.* Believing that Hisinger was fully justified in separating his species *planorbis* (or *sulcatus*, as he often called it) from previously established genera, it seems to us only a just recognition of his acumen to substitute *Hisingeria* for his *Inachus*. We may add that Koken (*op. cit.*, p. 419) also regards the species *planorbis* as "the representative of an independent genus."

Hisingeria planorbis is most certainly not a true *Pleurotomaria*, nor is it, if our views are correct, even a member of that family. Lindström admits that there are "some features which remind of *Euomphalus*." We should say *many* instead of *some*, and add that we have not found a single character that may be justly set against them. That *Hisingeria* has a deeply notched aperture and a kind of slit-band is no more indicative of pleurotomarian than euomphaloid affinities, and when we consider that the detail of the band, together with every other feature of the shell, is more in accordance with the latter than the former, a little surprise at Dr. Lindström's positive reference of *H. planorbis* to *Pleurotomaria* may be pardoned. The form of the shell is decidedly euomphaloid, as is also the position of the band on

*It seems that DeKoninck (Faune Carbonif., 1881.) intended to replace *Inachus*, Hisinger, with *Polytropis*, but as he mentions *Euomphalus discors* Sowerby, as the typical species, which is at least generically distinct from *Inachus sulcatus* (*planorbis*), it is evident that *Hisingeria* does not conflict with *Polytropis*.

the upper side of the whorls, the band, in low-spired pleurotomarians, being almost invariably situated on the periphery. Again, the rounded character of the whorls of the interior casts, which necessitated a strong deposit of shell beneath the external keels, the lower especially, recalls a common condition among species of *Ophileta, Euomphalus* and *Pleuronotus,* but not of any of the *Pleurotomariidæ.*

According to our view, *Hisingeria* is a strongly marked descendant of the *Helicotoma* or *Ophileta* type. Though the general aspect is widely different, the real differences are not so great as they appear on first sight, and, what is more important, they are rather easily accounted for. In *Hisingeria* the slit-band or keel has been reduced in prominence and moved inward from the outer edge of the upper side of the whorl to near the suture line, while the revolving striæ, which as a rule are but ill developed in *Helicotoma,* have been strengthened and the outer basal angle somewhat extravagantly thickened. The last feature is perhaps the most striking peculiarity when compared with, for instance, *Helicotoma planulata* Salter, but in our *H. subquadrata* the outer basal angle is somewhat prominent, while in our *H. marginata,* a new species from the extreme top of the Lower Silurian, a similar feature is even more abruptly developed. Still, we doubt very much that the latter is in any wise an ancestor of *Hisingeria planorbis,* the real line of descent from *Ophileta* being, in our opinion, as yet undiscovered or unrecognized as such.

Eccyliopterus, Remele, which we place in this family, has already been discussed in connection with *Raphistoma* on pages 935 to 938. The genus is a good one and includes shells with contiguous whorls similar in most respects to those of *Helicotoma,* and others in which they are more or less completely disconnected. The latter have usually been confounded with *Eccyliomphalus,* but as we have endeavored to show, the true position of the genus is nearer *Ophileta* and *Helicotoma* than *Eccyliomphalus.* The distinguishing character of *Eccyliopterus* lies in the remarkable development of the upper keel which projects beyond the surface of the whorls like a high collar.

Genus OPHILETINA, n. gen.

For remarks on this genus see page 1028.

Only two or possibly three small species of this interesting genus are known. In these the whorls are rather slender, contiguous or partly free, coiled almost in the same plane, and either hexagonal or subquadrate in section. On the upper side and forming the outer edge there is a sharply elevated convex—or flat-topped—ridge which looks very much like a true slit-band, being covered with strongly recurved lines (lunulæ) and terminating anteriorly in a well-marked notch. On the vertical outer side the lines of growth are bowed forward in the middle, on the lower side broadly backward. Of the following two species, *O. sublaxa* may be regarded as the type.

The principal, or perhaps we should say only feature relied on in distinguishing this new generic group from *Ophileta* on the one side and *Euomphalus* on the other, is the slit-band. Both of those genera may often have an apertural notch at the terminus of the ridge corresponding to the "band," but there is never anything like a definite band, the lines of growth passing over the ridge without interruption further than is occasioned by changing their direction from obliquely backward to obliquely forward. In *Ophiletina,* however, as is shown in figures 41 and 47 on plate LXXIV, the ridge is as much of a "slit-band" as in the majority of the Lower Silurian *Pleurotomariidæ.* In *Helicotoma,* certain species of which are considerably like our *Ophiletina angularis,* the summit of the corresponding ridge, though never flat nor bearing lunulæ, is occasionally margined on each side by a delicate raised line, the result being a "band" that is not greatly different from the kind pertaining to species of *Lophospira* like *L. acuminata* (compare fig. 8, plate LXXIII, and fig. 24, plate LXXIV). Another constant and easily recognized difference between *Ophiletina* and *Helicotoma* is furnished by the course of the lines of growth across the vertical outer surface of the shell. In the former the lines curve forward in the upper half and just as much backward in the lower, the direction on the whole, therefore, being essentially vertical. In the latter the forward direction continues to the basal angle (compare plate LXXIV, fig. 46 with 15, 16, 22, 33 and 37).

OPHILETINA SUBLAXA, *n. sp.*, and varieties.

PLATE LXXIV. FIGS. 40—42 and 47.

Shell small, 13 to 16 mm. in diameter, coiled approximately in one plane, the upper side flat, the lower gently concave; volutions slender, three in number, without the more or less prominent nucleus, hexagonal in transverse section, a little wider than high, the greater part of the last free. Of the six angles the strongest bears the band and lies at the outer edge of the upper side. Within this the space to the suture line is divided into halves, the outer concave, the inner a flat slope, by a second carina. The third is prominent and thin and lies considerably beneath the middle of the outer surface of which the fourth carina forms the base. The fifth and sixth angles are more obtuse, and lie one about the middle of the inner side, the other at the junction of the inner and lower sides. Lines of growth strong, equal, somewhat imbricating, averaging about seven in 2 mm., making a slight retral bend (it is often stronger than in our engraving) in crossing the central angle of the upper face, a very strong and sharp retral bend or loop on the sides and summit of the band-ridge, a slight forward curve on the outer and a retral curve on the lower surface. The band itself is convex and sharply defined, the lunulæ strong.

The above description is strictly of the northwestern form of the species. Of this we have three specimens, one from each of the three states of Minnesota, Wisconsin and Illinois. We have a fourth specimen (original of fig. 42), found by one of the authors in the lower part of the Stones River group in Tennessee, which differs slightly in several particulars. In the first place the whorls are more slender when viewed from above; next the hight and width of the volutions are more equal; then the inner face of the whorls is steeper and rounded rather than angular; finally, the upper side of the shell is concave and the lower flat instead of the reverse. Possibly this Tennessee specimen, which, although a silicified shell, retains no trace of surface markings, represents a distinct species, but the material at hand is scarcely sufficient to justify specific separation. A subordinate designation, however, may be allowable and we therefore suggest that it be known provisionally as var. *depressa*.

Another variety or closely related species occurs in the Fusispira bed of the Trenton group. We have seen but a single example, a cast of the interior attached to a piece of stone so that only the upper side is visible. As far as can be seen it agrees with *O. sublaxa* in all respects except that the last whorl is scarcely separated from the inner turns. Considering that the Lower Silurian euomphaloids are all very restricted in their vertical ranges, it is highly improbable that perfect shells of the later form would agree in all respects with the Stones River group types of the species. We venture therefore to separate the Fusispira bed form as var. *sequens*.

Formation and locality.—The typical form occurs in the limestones of the Stones River group at Minneapolis, Minnesota, Mineral Point, Wisconsin, and Dixon, Illinois; var. *depressa* in the lower division ("Central limestone") of the same group at Murfreesboro, Tennessee; var. *sequens* in the Fusispira bed of the Trenton group at Wykoff, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota (two specimens of typical form); E. O. Ulrich (one specimen of typical form and both varieties).

Museum Register, Nos. 6869, 7302.

OPHILETINA ANGULARIS, *n. sp.*

PLATE LXXIV, FIGS. 43–46.

Shell small, 8 mm. wide; 2.3 mm. high; planorbiform; spire flat, under side concave from the peripheral edge on; whorls in contact, quadrangular or subpentagonal in section; outer side vertical, nearly flat, with a small carina near its middle; upper side concave between the elevated band, which is flat and lies at the outer edge, and a low ridge two-thirds across the whorl, beyond which the surface descends rapidly into the sutural channel. The lines of growth, except that they are somewhat finer, are very much as in *O. sublaxa*. Four or five lines occur in 1 mm. With the aid of a glass of low power the direction of the lines can be made out very clearly on our engravings, special care having been given to this feature.

We know of no shell found in the Lower Silurian rocks of America that is at all likely to be confused with either this or the preceding species. In the Coal Measures and in the Triassic of Europe there are several small forms of *Euomphalus* that, aside from the fact that they have no defined band, greatly resemble *O. angularis*.

Formation and locality.—Phylloporina bed, Black River group, near Cannon Falls, Minnesota.

Collection.—E. O. Ulrich.

Genus ECCYLIOPTERUS, Remele.

In part *Eccyliomphalus*, *Euomphalus*, *Ophileta*, *Maclurea* and *Raphistoma* of authors.
Eccyliopterus, REMELE, 1888, Zeitschr. d. deutsch. geol. Ges., Band xl.

For generic characters and general remarks see pages 935 to 938, and page 1029.

To give a better idea of this genus than is furnished by the two Trenton species next described, and particularly to show the evolute character pertaining to some of the species, we have added figures, on plate LXXIV, of two Calciferous forms which have been erroneously referred to *Eccyliomphalus* by Whitfield. Otherwise *E. owenanus* presents an excellent general idea of the present genus. The "collar" is always a notable feature and especially high in the species mentioned. We have a species from the Shakopee formation of Minnesota agreeing very closely in all respects with *E. triangulus,* excepting that its whorls are all contiguous save a part of the last.

ECCYLIOPTERUS BELOITENSIS, *n. sp.*

PLATE LXII, FIG. 70; PLATE LXXIV, FIGS. 1–4.

Width 30 to 45 mm., greatest hight nearly half the width; whorls enlarging rather rapidly, three or three and one-half in number, coiled very nearly in the same plane; upper side of shell broadly concave; umbilicus large, half the diameter of the shell; under side of whorls strongly convex, outer side vertical, upper side concave in the outer half, convex in the inner; suture deep, collar only moderately high, well indicated, however, even on casts of the interior; mouth somewhat acuminate-ovate, very oblique. Lines of growth obscure, directed backward, on the upper side with a slightly sigmoid curve.

Formation and locality.—Stones River group, Beloit, Wisconsin; High Bridge, Kentucky.

ECCYLIOPTERUS OWENANUS *Meek* and *Worthen.*

PLATE LXXIV, FIGS. 10–14.

Ophileta owenana MEEK and WORTHEN, 1868, Geol. Sur. Ill., vol. iii, p. 313.

This is a smaller shell than *E. beloitensis,* the width of the largest seen being only about 26 mm., while the average for fourteen specimens is about 22 mm. The whorls are more slender, being four in number, and the collar, which is scarcely indicated on casts, is relatively much higher and thinner than in the larger species. Indeed, the collar is nearly as high as the cavity of the whorl. While the upper sides of casts are nearly as much depressed, the whorls themselves are much less concave in the outer half, this part being almost flat. The inner half generally slopes rather rapidly inward and downward, in some cases forming an obtuse median angulation. The collar of the inner turns may stand up free or be joined in part to the inner slope of the next whorl.

The *E. ottawaensis* Billings sp., from the Trenton limestone of Canada, seems to have even more slender whorls and a flatter spire. The whole shell also appears to be more depressed.

Formation and locality.—Fusispira bed of the Trenton group, Wykoff, and various localities in Goodhue county, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 7376.

Genus HELICOTOMA, Salter.

Helicotoma, SALTER, 1859, Can. Org. Rem., Decade 1, p. 13.

If in separating the *Euomphalidæ* and *Pleruotomariidæ* we placed all our dependence on the presence or absence of a slit-band as distinguished from a simple retral curve of the lines of growth, *Helicotoma,* as well as *Ophiletina,* also *Pleuronotus,* would be arranged with the latter instead of the former family. But we cannot assume one character as absolute in assigning position. No, every feature and circumstance must be compared and weighed if we would arive at anything approaching a natural classification. Particularly important matters to be determined fall under the term of chronogenesis. In the discussion of the family beginning on page 1023, we follow up the development of *Helicotoma* and conclude that it was derived from *Ophileta*—further, that the *Helicotoma* line terminated with itself and that *Euomphalus*, which it resembles in many respects, was not derived from it but directly from *Ophileta*. The connection with *Ophileta* must determine the position of *Helicotoma* since that genus is most certainly not a member of the *Pleurotomariidæ*, while we are fully satisfied of its affinities with typical *Euomphalidæ*.

The Calciferous formation furnishes at least one unquestionable species of *Helicotoma*, viz.: *H. perstriata* Billings. There is a small species (less than one-half an inch in diameter) in the Shakopee of Minnesota, that seems to differ very little except in size from our *H. umbilicata* of the Stones River group. Other species of the Stones River group are *H. tennesseensis* Safford, *H. declivis* Safford, *H. planulata* var. *robusta* U. and S., *H. planulatoides* Ulr., *H. verticalis* Ulr., and *H. granosa* Ulr. The Black River group has *H. planulata* Salter, the type of the genus, and *H. muricata*, *H. spinosa* and *H. larvata* of the same author. From the Quebec group of Canada Billings described five species (*eucharis, gorgonia, misera, proserpina* and *tritonia*) with characters apparently in strict accordance with *Helicotoma*. Only *H. marginata* Ulr. is known to us from strata of the Cincinnati period. H. *naresi* Etheridge, an Upper Silurian shell, and the Devonian *H. serotina* of Nicholson, probably belong to some other genus.

HELICOTOMA PLANULATA *Salter*, and var. ROBUSTA, *n. var.*

PLATE LXXIV, FIGS. 15–17.

Helicotoma planulata SALTER, 1859, Can. Org. Rem., Decade I, p. 14.

H. planulata is distinguished from nearly all other species of the genus by having from three to six strong, simple or double, revolving lines on the outer side of the whorls. Beneath the marginal notch-ridge the outer side is more or less distinctly concave. The summit of the ridge may be on the same plane in all the whorls, but, as a rule, on each it is a little lower than on the preceding turn. Within the ridge, which is sharply elevated and marked on its outer side by an impressed line, the depressed upper side of the whorls is quite flat. The under side of the whorls may be regularly convex or an obscure angle may form the boundary of the umbilicus. A full grown individual has five whorls. On plate LXXIV, figs. 16 and 17, are two views of what we consider as a typical example of the species.

Var. ROBUSTA, *n. var.*

PLATE LXXIV, FIG. 15.

This variety is founded on a single imperfect specimen. It has revolving lines like *H. planulata*, but differs in certain respects too obviously to be referred to that species without question. In the first place its whorls enlarge more rapidly both in hight and width. The inner whorls are missing, but we are well satisfied that the specimen consisted originally of no more than four whorls. Next the concavity of the upper part of the outer side of the whorls is scarcely noticeable. Finally the lines of growth cross this side more obliquely.

Formation and locality.—The typical form of this species, excepting a single example from an undetermined Trenton horizon in Lincoln county, Missouri, is only known from the Black River limestone at Pauquettes rapids of the Ottawa river, in Canada. The type of our var. *robusta* is from the Stones River group in Jo Daviess county, Illinois.

Collection.—E. O. Ulrich.

HELICOTOMA PLANULATOIDES, *n. sp.* (*Ulrich.*)

PLATE LXXIV, FIGS. 28—30.

Specimens of this species range in width generally between 15 and 25 mm. The form is closely related to *H. planulata* Salter, but there are only about four whorls instead of five, and each descends slightly beneath the level of the preceding. Compared further with the Canadian species, we find that the umbilicus is somewhat narrower. A more striking difference, however, is the total absence of revolving lines. See *H. tennesseensis* for comparisons with that species.

Formation and locality.—Ten specimens were obtained in the vicinity of High Bridge, Kentucky, where they occurred at the top of the Stones River group or base of the Black River limestone. Two others, from the Black River group of middle Tennessee, occurred in a lot of fossils received from Prof. Jas. M. Safford.

Collection.—E. O. Ulrich.

HELICOTOMA TENNESSEENSIS *Safford.*

PLATE LXXIV, FIGS. 20—24.

Helicotoma tennesseensis SAFFORD, 1869, Geol. of Tenn., p. 288. (Neither defined nor illustrated.)

This abundant shell holds about the same size and is closely allied to *H. planulata* and *H. planulatoides.* A constant peculiarity is a narrow downward slope along the suture line. Aside from this and the absence of revolving lines, we fail to see any difference between the Tennessee and Canadian species. The Kentucky species, however, attains a larger size with the same number of whorls.

Formation and locality.—Very abundant in the lower division ("Central limestone") of the Stones River group at Murfreesboro, Tennessee.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

HELICOTOMA SUBQUADRATA, *n. sp.* (*Ulrich.*)

PLATE LXXIV, FIGS. 31—33.

Although closely related to all three of the preceding species, the present form is readily distinguished by the subquadrate section of its whorls, the junction of the outer and lower sides of the whorls, which are both flattened, being rather strongly angulated. The notch-carina is not much elevated, and the surface of the whorl within it is perfectly flat to the suture line.

Formation and locality.—Same as the preceding. Only two specimens have been observed, and these were both received from Prof. Jas. M. Safford.

HELICOTOMA UMBILICATA, *n. sp.*

PLATE LXII, FIG. 68; PLATE LXXIV, FIGS. 25—27.

This species has been quite generally confused with *H. planulata*, but after seeing a number of specimens of both forms we are prepared to assert, with much confidence, that they are not the same. It is true *H. umbilicata* has, like the Canadian form, revolving lines on the outer side of the whorls, but these are never very strong and in most cases so weak that they cannot be distinguished on even good moulds of the exterior. Comparing other features, it will be found that the shell of *H. umbilicata* is more depressed, the width of the whorls being constantly somewhat greater than the hight, while in *H. planulata* the two dimensions are equal. But the differences principally relied upon in distinguishing the two forms are (1) that the apertural notch is much deeper and, consequently, the lines of growth more strongly recurved, and (2) the umbilicus is wider and shallower in our species than in the Canadian shell. In nine specimens of the latter before us the umbilicus in no case exposes quite half of the width of each of the nine whorls. On the other hand, in eleven specimens of *H. umbilicata* the amount exposed varies from fully two-thirds to nine-tenths of the width, and in most cases exceeds three-fourths. *H. tennesseensis* Safford is probably nearer than any of the other species, but has constantly a higher spire and narrower umbilicus. On the exterior of the shell, the lower part of the outer side of the whorls is sometimes quite prominent.

Formation and locality.—Stones River group, Minneapolis and St. Paul, Minnesota; Beloit, Janesville and Mineral Point, Wisconsin, and Dixon, Dunleith, La Salle and Rockton, Illinois. Though widely distributed it seems not to be common at any point.

Collections.—University of Wisconsin; E. O. Ulrich.

HELICOTOMA VERTICALIS, *n. sp.* (*Ulrich.*)

PLATE LXII, FIG. 69; PLATE LXXIV, FIGS. 18 and 19.

This species is known from casts of the interior only, but they are readily distinguished from all of the preceding forms by the rectangular form of the outer and upper surfaces of the whorls. The latter are not more than four in number, enlarge rapidly, are strongly convex below and leave a deep and relatively narrow umbilicus. On the under side the cast resembles the shell of *H. planulatoides* very closely, but in other respects is quite different, the outer side of the whorls in that species being concave and inclined inwards above instead of convex or flat and vertical. The upper surface of the whorls, in accordance with the differences just mentioned, is considerably wider in *H. verticalis.*

Koken figures a Russian shell which he calls *Raphistoma damesi* (N. Jahrbuch f. Mineralogie, etc., 1889, Beilageband vi, pl. XI, figs. 4, 4*a*) that reminds one greatly of *H. verticalis.* If he is right in calling his species a *Raphistoma*, then it is evident that it cannot be very closely related to our shell. If, on the other hand, it is, like ours, a *Helicotoma*, then it might be difficult to distinguish it from the American form. Still, the outer side of the whorls in Koken's species is not quite vertical, but begins to slope inward at the upper angle.

Formation and locality.—Upper part of Stones River group, High Bridge, Kentucky, where it occurs associated with *H. planulatoides* and *H. granosa.*

Collection.—E. O. Ulrich.

HELICOTOMA GRANOSA, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 32–44.

Shell small, generally 7 to 9 mm. in diameter, probably not exceeding 12 mm; hight equaling about a third of the width; notch-carina prominent, thin, its summit carrying a row of small nodes; whorls three and a half or four, the inner ones raised, the outer two coiled nearly in the same plane; upper surface of whorls depressed, nearly flat and sloping slightly downward toward the suture; umbilicus large, exposing about three-fourths of each of the inner turns; outer side of whorls strongly convex in the lower half and distinctly concave in the upper; entire outer side of whorls, when perfect, covered with irregularly distributed or retrally curved rows of granules or small nodes; a series of similar nodes along the center of the upper side of the first two and a half volutions.

When the sculpture bearing layer is removed, the shell is smooth, and in this condition it is most difficult to distinguish from the young of *H. umbilicata.* Perfect specimens, however, with their peculiar granulose markings, could not possibly be confused with any other species known.

Formation and locality.—Upper part of Stones River group, High Bridge, Kentucky.

Collection.—E. O. Ulrich.

HELICOTOMA DECLIVIS *Safford.*

PLATE LXXIV, FIGS. 34–38.

Helicotoma declivis SAFFORD, 1869, Geol. of Tenn., p. 288. (Neither defined nor illustrated.)

This species is remarkable especially for two reasons: first, the umbilical cavity, which is rather wide, has even slopes on which the inner whorls are more or less obscurely or quite indistinctly defined; second, the upper surface of the whorls is raised so as to form a broad, obtuse, median angulation or ridge. The inner whorls of the spire are depressed slightly beneath the level of the outer one while the notch-carina is so small that it fails to rise to the level of the median ridge.

Formation and locality.—Associated with *H. tennesseensis* in the lower part of the Stones River group at Murfreesboro, Tennessee.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

HELICOTOMA MARGINATA, *n. sp.* (*Ulrich.*)

PLATE LXXIV, FIG. 39.

Of this species we have seen but the unique example of which a view of the upper side is given on plate LXXIV. It is remarkable chiefly because the lower part of the outer side of its whorls is so prominently developed that it projects like a broad flange.

Formation and locality.—Found at the extreme top of the Richmond group, Elkhorn falls, near Richmond, Indiana.

Collection.—E. O. Ulrich.

Genus ECCYLIOMPHALUS, Portlock.

Eccyliomphalus, PORTLOCK, 1843, Geol. Rep. Lond., p. 411.

For remarks on this genus see pages 1024 and 1029.

ECCYLIOMPHALUS UNDULATUS *Hall.*

PLATE LXXV, FIGS. 19–23.

Ecculiomphalus undulatus HALL, 1861, Geol. Rep. Wis., p. 37; WHITFIED, 1895, Mem. Am. Mus. Nat. Hist., vol. i, pt. 2, p. 63, plate VIII, figs. 1—3.

Original description.—"Shell consisting of one or two volutions, spirally coiled, but distantly separated from each other, rapidly increasing in size from the apex, and of a subtriangular or ovate-triangular form, the upper side being convex and curving to the ventral margin; the dorsum is somewhat flattened, and the lower side sloping with a gentle curve from the lower lateral angle to the ventral side, which is narrow and sharply rounded. Along the ventral side and a little below the center there is a narrow, abruptly depressed groove, which extends the entire length of the shell.

"Surface of the shell marked by obscure undulations, which are most distinct on the lower lateral angle, also on the lower side by two or three revolving ridges.* Fine transverse lines of growth parallel to the margin of the aperture are visible over the greater part of the surface of the specimen, which is essentially a cast of the interior."

To the above description we may add that there is a broad sinus in the upper part of the mouth, and that the depressions on the outer side of the shell are due to agglutinated foreign objects like fragments

* We do not understand what is meant by the "two or three revolving ridges" on the lower side, since we have not observed anything of the kind on our specimens. That the latter are specifically identical with Hall's species we are confident after seeing Whitfield's figures of the original type (*loc. cit.*).

of *Orthis*. Also that the inner whorl is cut off from the remainder of the spiral tube by imperforate concave partitions.

Formation and locality.—Stones River group, Minneapolis, Minnesota; Beloit, Wisconsin; La Salle Illinois; and Lebanon, Tennessee.

Collection.—E. O. Ulrich.

ECCYLIOMPHALUS SUBROTUNDUS, *n. sp.*

PLATE LXXV, FIGS. 17 and 18.

This shell differs from *E. undulatus* in that it forms little more than a single volution, that the shell expands more slowly, that it is almost circular in cross-section, that it is coiled in the same plane, and has the ridge on the inner side placed lower. The ridge is also more sharply defined and thinner. *E. intortus* Billings, of the Point Lévis limestone in Canada, is in many respects a similar shell, yet is more closely involute, expands more rapidly, and is without the ridge on the inner side.

Formation and locality.—Fusispira bed of the Trenton group, Wykoff, Minnesota.

Collection.—E. O. Ulrich.

ECCYLIOMPHALUS CONTIGUUS, *n. sp.* (*Ulrich.*)

PLATE LXXV, FIGS. 48–52.

Shell 12 to 30 mm. in diameter; 7 to 16 mm. in hight, consisting of three or four rapidly enlarging contiguous whorls, coiled so as to leave a deep umbilicus in which from a third to a half of each of the inner whorls is visible; whorls subovate in section, higher than wide, somewhat narrowly rounded in the outer half of the upper surface. On the upper side the inner whorls may be sunken slightly beneath or raised above the level of the last; innermost whorl with a free termination. Mouth obliquely subovate, the margin rather deeply notched above, broadly curved forward on the outer side and gently sinuate below. Surface markings somewhat irregular and coarse, parallel with the edge of the mouth

That the whorls in this shell are contiguous, we cannot consider as a serious objection to classifying it with *Eccyliomphalus*. A sufficient justification of our arrangement is found in Lindström's *Euomphalus gotlandicus* which clearly belongs to this genus, and in which the whorls may be quite indifferently totally evolute or closely joined.*

Formation and locality.—Lower part of the Stones River group, Murfreesboro, Tennessee.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

Family MACLURIIDÆ, Woodward.

We have not been able to satisfy ourselves that this is a valid family and its acceptance here is chiefly in deference to the views of previous authors. We are, however, convinced that the natural affinities of the majority of the types usually referred here are with the *Euomphalidæ*. About twenty-four American species have been described, and all of these, though exhibiting considerable variation, have heretofore been placed into the single genus *Maclurea*.

Considering the great differences exhibited by the opercula of some of these species, it seems to us that their arrangement in one genus can only be justified as

*There may be some doubt concerning the specific identity of all the various forms referred by Lindström to his *Euomphalus gotlandicus*, but there can be none when it comes to their generic alliances.

a provisional measure. We admit that the time has not yet arrived when it will be possible to divide the whole genus into natural groups, but convenience demands that at least one section should be distinguished now. All definitions of *Maclurea* give, as perhaps the most essential feature, one character that is known to be absent in several species, which nevertheless are always classified without question under the *Maclurea*. Namely, two more or less prominent muscular scars or processes upon inner side of the operculum. As the absence of these projections in certain species certainly deserves some recognition in our classification, we propose to separate them as a distinct genus, under the new name *Maclurina*, which we have selected in order to facilitate recollection of their previous generic association. In breaking up the genus we deem it advisable to proceed with extreme caution, since the opercula, upon which the division rests, are fully known in only a few cases. We shall, therefore, change the generic designation at the present time in only three instances, and leave the arrangement of the remainder for future investigation.

Genus MACLUREA, (Lesueur.) Woodward.

Maclurites, LESUEUR, 1818, Jour. Acad. Nat. Sci., vol. i, p. 312.
Maclurea, WOODWARD, Manual of Shells, p. 202; EMMONS, 1842, Geol. Rept., p. 276; SALTER, 1859, Can. Org. Rem., Decade 1, p 7.

Shell thick, discoidal, few whorled, reversed, the under side flat or nearly so and exposing all the whorls, the upper side convex and deeply perforated in the center instead of raised into a spire; surface with lines of growth crossing the whorls almost directly, the peripheral portions not infrequently exhibiting a revolving set of lines also. Operculum more or less curved in a front view, set somewhat obliquely into the aperture, and made up of concentric laminæ with the nucleus, which is in the middle or near the outer angle of its lower part, projecting more or less forward, sometimes like a great vertically compressed horn; inner side excavated, with a prominent projection for the attachment of a muscle in the lower inner fourth of the excavation and a large muscular scar, little or not at all elevated, in the upper inner fourth. Type: *Maclurea magna* Lesueur.

It may be that the shells of this genus are, as supposed by Billings and others, really sinistral, in which case the flat side would be the spire and the umbilicated side the base, but we prefer for the present, to regard the ridge which usually surrounds the umbilicus as corresponding to the notch-keel of the *Euomphalidæ*. This view is supported by the fact that the lines of growth on the flat side of the whorls, are usually sinuated, while a somewhat similar form of shell is characteristic of *Ophileta*. Besides *M. magna*, we regard *M. bigsbyi* Hall, *M. logani* Salter, and *M. crenulata* Billings, as thoroughly in accordance with the requirements of the genus.

Maclurea bigsbyi *Hall.*

PLATE LXXV, FIGS. 5–10.

Maclurea bigsbyi Hall, 1861, Geol. Rep. Wis., p. 37; Whitfield, 1882, Geol. of Wis., vol iv, p. 222, pl. vi, figs. 17 and 18; also 1895, Mem. Am. Mus. Nat. Hist., vol. i, p. 62, pl. viii, figs. 14 and 15 (not 12 and 13).

Shell of medium size, ranging in diameter from 25 to 80 mm., usually 50 to 60 mm.; normal hight varying from five-twelfths to one-half of the width. Lower surface flat, the outer angle subacute; in casts more or less obtuse, and with the inner whorls somewhat rounded and the sutures generally much more distinct than on the shell itself. Umbilicus deep, rather abrupt, exposing half or more of each of the inner whorls, its width always greater than one-third of, and sometimes exceeding half the width of the entire shell; margin of umbilicus angular in shells, abruptly rounded in casts, the slopes convex on each whorl. Casts rarely retain traces of the surface markings. These consist of more or less obscure and irregular transverse lines and undulations, crossed on the peripheral region only by revolving lines a mm. or less apart. Operculum much as in *M. logani*, except that the nucleus is at the lower inner angle instead of in the center of the lower side.

The original localities for this species afford two closely allied species, a small one that is about 25 mm. in diameter, and a larger form that commonly is more than twice as wide. These two forms differ further in the relative size of the umbilicus, its width in the smaller form being in no observed case more than one-third of the width of the shell, while in the larger form it generally equals one-half. Under the circumstances it is highly probable that both forms were included by Hall in his *M. bigsbyi*, and it is a matter of considerable difficulty to decide as to which of the two is the better entitled to retain his name. The larger species being the more common and widely distributed, and undoubtedly the same as the best preserved and largest of the original types of the species figured by Whitfield in 1895, we have decided to restrict the application of the specific name *bigsbyi* to it, and to propose the new name *nitida* for the other.

Formation and locality.—Stones River group, Beloit, Janesville, Mineral Point, and other localities in southern Wisconsin; Dixon and La Salle, in Illinois; Lebanon and near Knoxville, Tennessee. Dr. F. W. Sardeson catalogues the species as occurring in the Vanuxemia bed in Minnesota, but we have not been able to verify its occurrence in the state.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, Nos. 7308, 7349.

Maclurea bigsbyi var. dixonensis n. var., and Maclurea knoxvillensis *n. sp. (Ulrich.)*

(Not figured.)

Two other species of this type, both three inches or more in diameter, are known to us, in the one case from rocks holding *M. bigsbyi*, in the other in strata supposed to be equivalent or nearly so. The first, which was collected at Dixon, Illinois, is more depressed and has the margin of the umbilicus, which takes up about one-third of the diameter of the shell, moved farther inward so that its walls are almost vertical. As the form is easily recognized, we suggest the provisional designation *M. bigsbyi* var. *dixonensis*. The other was received from Prof. J. M. Safford, who collected the shell and opercula in the vicinity of Knoxville, Tennessee. As it deserves to rank as a distinct species, we propose the name *Maclurea knoxvillensis*. With a general aspect like *M. bigsbyi*, it differs decidedly in having less angular whorls and deep sutures on the flat side. The operculum, so far as the position of the nucleus is concerned, is more like that of *M. logani* than *M. bigsbyi*, but differs strongly from both in the fact that the nucleus is extremely prominent and twisted, recalling, somewhat feebly, a small ram's horn.

Maclurea nitida, *n. sp.*

(Perhaps a small variety of *M. bigsbyi* Hall.)

PLATE LXXV, FIG. 11.

Maclurea bigsbyi (part) Hall, and Whitfield. (See description of that shell on page 1039.)

Shell rather small, 20 to 30 mm. wide, half as high, and resembling the young of *M. bigsbyi* in all respects save that (1) the umbilicus is narrower, in no case exceeding a third of the width of the shell, (2) less sharply defined, the turn into the umbilicus being abruptly rounded but never angular, (3) the transverse striæ between the umbilicus and periphery more regular and sharper, and (4) the transverse section of the whorls (see plate LXXV, fig. 9) a little different, the hight being relatively a trifle greater, and the section less obviously triangular. Remains of three or four revolving lines occur on the periphery of one specimen, but nothing of the kind is visible on any of the others.

Formation and locality.—Stones River group, Mineral Point and Beloit, Wisconsin; Dixon, Illinois, and Murfreesboro, Tennessee.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 7356.

Maclurea depressa, *n. sp.*

PLATE LXXV, FIGS. 1–4.

Shell of medium size, depressed, about 55 mm. wide, and 18 mm. high at the aperture; under side of whorls more or less distinctly concave, the outer and inner edges being somewhat elevated; inner edge forming a sharp ridge in casts of the interior; umbilical perforation abrupt, comparatively small though showing all the inner whorls, its width equalling less than a third of the diameter of the shell. Surface markings apparently as in *M. bigsbyi* Hall.

The concave under surface of the whorls, more depressed form, and smaller and more abruptly descending umbilicus are the differences relied on in distinguishing this species from *M. bigsbyi.* Variety *dixonenis* of that species, which might perhaps with better propriety be classed either as an intermediate species or as a variety of *M. depressa*, differs chiefly, if not solely, in the form of the under side of the whorls, these being flat or gently convex, as in *M. bigsbyi*, instead of concave.

Formation and locality.– Stones River group, Minneapolis, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 6858.

Maclurea crassa, *n. sp.*, and var. macra, *n. var.*

PLATE LXXV, FIGS. 12–16.

Externally this species resembles *M. bigsbyi*, but, aside from the fact that it is a much heavier shell (on the outer and under sides of the last whorl it varies in thickness between the extremes of 3 mm. and 6 mm.), it differs in having the inner whorls convex and slightly elevated on the under side, the outer or peripheral angle more obtuse, and the umbilical depression wider. The width of the latter is to the diameter of the shell as 32 is to 58, the numbers representing the respective dimensions in millemeters of a testiferous example. Comparing casts of the interior of the two species, the differences are more obvious, the whorls of *M. crassa* being more slender and more rounded in section on the lower side especially, and the umbilicus open to such an extent that nearly the whole width of the inner whorl is exposed to view. Because of the extreme thickness of the shell, the suture, though very close on the exterior, is unusually deep in casts, while the mouth expands somewhat like a trumpet. Casts of the interior look very much like the exterior of the shell of *M knoxvillensis;* yet even with this unequal comparison it will be observed that the umbilicus does not descend as abruptly as in that species, the convex slope being much more inclined giving a relatively greater width to the umbilicus at its narrowly rounded margin.

Var MACRA, *n. var.*

PLATE LXXV, FIGS. 15 and 16.

The cast upon which this variety is based, was found at a lower horizon than that which holds the typical form. So far as we can see it differs only in being more depressed, the transverse and vertical diameters of the last whorl near the aperture being to each other respectively as four is to three. In the typical form the same dimensions are as four is to five. Part of this difference may be due to distortion—indeed we think it is, since at the inner end of the outer whorl the two dimensions are almost equal.

Formation and locality.—Of the typical form we have four specimens, from the Maclurea bed of the Trenton group, of which one was obtained from each of the following localities in Minnesota: Lime City, Stewartville, Pleasant Grove and Wykoff. One of these belongs to the Survey museum, the others to E. O. Ulrich. Var. *macra* was collected by the latter in the Fusispira bed at Hader.

Museum Register, No. 8442.

Genus MACLURINA, n. gen.

This genus is proposed in accordance with our remarks on page 1038, for the reception of shells heretofore classed as *Maclurea*, but differing from the typical form of the genus in wanting the projections for the attachment of muscles on the inner side of the operculum. *Maclurea manitobensis* Whiteaves, the operculum of which is figured and described by Whiteaves in the Canadian Record of Science for April, 1893, is regarded as the type of the new genus. In this species the nucleus is at the junction of the lower and inner margin of the operculum, and we believe the same is true of *M. cuneata* and *M. subrotunda* of Whitfield, which with Whiteaves' species, are all that at the present time it seems safe to refer to *Maclurina*. Billings says of the operculum of his *M. oceana* that it has no muscular process, and he also figures the opercula of two otherwise unknown species which likewise are without such projections. But these opercula differ so widely from that of *M. manitobensis* that it seems highly improbable that they can belong to shells of the same genus.

MACLURINA MANITOBENSIS *Whiteaves.*

PLATE LXXVI, FIGS. 4 and 5; PLATE LXXXII, FIG. 45.

Maclurea manitobensis WHITEAVES, 1890, Trans. Roy. Soc. Can., vol. vii, Sect. 4, p. 75; also 1893, Canadian Record of Science, p. 324.

Original description.—"Shell large, attaining to a maximum diameter of eight inches and a half, and consisting of about five somewhat slender volutions which increase rather slowly in size; outer volution nearly always distinctly angulated at the periphery. Left (under) side almost flat, but faintly depressed in the center in some specimens and as faintly raised in others; volution, as viewed on the flat side, very shallowly concave in the center and slightly raised on the outer margins; suture lightly impressed. Right (upper) side moderately convex (the greatest thickness or depth varying in different examples from two-fifths to one-third the maximum diameter); somewhat conical or subhemispherical, the outer volution obliquely flattened and narrowing very rapidly, but in a few specimens somewhat convexly, from the periphery to the umbilical margin; umbilicus deep, conical, and apparently about equal in breadth to one-fourth of the maximum diameter, though in all the specimens collected, the test is either imperfect or absent at the umbilical margin; aperture obliquely and rather narrowly subtrapeziform; outer lip apparently simple; test thick.

"Surface of the test on the left or flat side marked with irregularly disposed, but for the most part distant, transverse linear grooves or periodic arrests of growth, each of which curve gently backward in a very shallowly convex curve, and occasionally with a few striations which run parallel to them. In one of the specimens figured which is a little less than four inches in its greatest diameter, and in which the whole of the test is preserved on the flat side, there are six of these periodic arrests of growth on the outer volution, while the inner whorls are perfectly smooth. In larger but similarly preserved specimens, these arrests of growth which are not sufficiently deep to produce any impression on the casts, are somewhat more numerous and disposed at still more unequal intervals. On the right or convex side the test is ornamented with rounded spiral ribs of nearly equal size, and these are crossed by similarly shaped, straight and transverse costæ, in such a way as to present a somewhat nodulous appearance. The spiral ribs, however, seem to be rather broader than the narrow furrows between them while the transverse costæ are apparently equal in breadth to the regularly concave grooves which alternate with them."

The Minnesota specimens referred to this species are all, save one, mere casts of the interior, but they agree so well with Whiteaves' figures and descriptions that there is little room for doubt concerning their identity with the Manitoba types of the species. The excepted specimen preserves the shell on the inner whorls only, and shows that the first three or four turns are very small and rounded on the lower side. The specimen has a width of about four inches, and consists of nearly six whorls, at which rate the largest example should make about seven complete volutions. None of the examples seen retain any of the test of the convex side of the shell, nor have we seen good moulds of the exterior, hence we cannot say that they had revolving lines like those found on one of the specimens described by Whiteaves.

Formation and locality.—Maclurea bed of the Trenton group. Whiteaves (*loc. cit.*) mentions numerous localities in Manitoba. In Minnesota the species is not as abundant as the associated *M. cuneata*, but may be found at most localities in Goodhue, Dodge, Olmsted and Fillmore counties, where its particular horizon is exposed.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 4105.

Maclurina cuneata *Whitfield.*

PLATE LXXVI, FIGS. 1–3; PLATE LXXXII, FIG. 46.

Maclurea cuneata Whitfield, 1878, Ann. Rep. Geol. Sur. Wis., p. 75; and 1882, Geol. Wis., vol. iv, p. 246, pl. IX, figs. 5–6.

The diameter in this species, as far as known, does not exceed three inches, while the umbilical perforation is very small; otherwise casts of the interior agree almost exactly with those of *M. manitobensis*. A single testiferous example belonging to Mr. Ulrich's collection has been observed. It is a very small specimen, being only 16 mm. in diameter, and embedded in the rock, but on being ground down so as to show a vertical section, it brings out as shown in fig. 46, pl. LXXXII, some interesting features. The specimen consists of three and a half whorls, all gently convex on the lower side but differing considerably in other respects. The first two and a half turns are coiled nearly in the same plane, so that they are almost entirely exposed on the upper or umbilical side. With the next turn, however, the umbilicus is greatly contracted and in the following half turn the normal or rather the specific characters of the shell are established.

Formation and locality.—Maclurea bed of the Trenton group. Casts are more or less abundant at Wykoff, Stewartville, Lime City and many other localities in the southern part of the state; Whitewater, Wisconsin; Dubuque, Iowa.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 8440, 8441.

MACLURINA SUBROTUNDA *Whitfield.*

(Not figured.)

Maclurea subrotunda WHITFIELD, 1878, Ann. Rep. Geol. Sur. Wis. for 1877, p. 75; and 1882, Geol. Wis., vol. iv, p. 246.

Two small casts, too imperfect for illustration, yet retaining enough characters to render their identification with this species almost certain, were found by Mr. Ulrich in the Maclurea bed at Stewartville, Minnesota. Evidently the species is not far removed from *M. cuneata*, but is a smaller shell, attaining, according to Whitfield, "a diameter of only about one and a half inches." The casts are proportionally higher than *M. cuneata* and the periphery much less acute, being almost vertical and rounded below where it joins the flat base. At Whitewater, Wisconsin, as in Minnesota, the species is associated with *M. cuneata*.

Family TROCHONEMATIDÆ, n. fam.

Shells trochoid, turbiniform or somewhat planorbiform, perforate or imperforate; margin of aperture entire, simple, rarely trumpet-shaped, sometimes with a wide angled notch and carina in the upper or outer part; no slit nor distinguishable band; surface with several strong revolving ridges or more numerous spiral striæ; test very slightly or not at all nacreous. Operculum unknown, probably incapable of preservation.

While it is impossible at the present time to give a fair estimate of the probable limits of this family, we may yet say with confidence that it is connected on the one hand through *Trochonema* with the *Pleurotomariidæ* and *Euomphalidæ*, and on the other, through *Cyclonema*, with the *Turbinidæ*. We may say further that the *Trochidæ*, if we admit that the Gotland shells described by Lindstöm as of *Trochus* are really referable to that family, were derived from *Trochonema*. *Polytrophis*, DeKoninck, which because of its remarkable operculum deserves to rank as a separate family, also most probably was derived from certain members of the same genus. But as we will refer to these alliances in greater detail in our remarks on *Trochonema* and *Cyclonema*, it may suffice to say that to the best of our knowledge the *Trochonematidæ* may appropriately follow the *Pleurotomariidæ* and *Euomphalidæ* and precede the *Trochidæ*, *Polytrophidæ* and *Turbinidæ*.

Of described genera we place here *Trochonema* and the perhaps indistinguishable *Eunema* of Salter, *Cyclonema* and the closely related *Strophostylus* of Hall, and, with some doubt, *Holopea* of the same author; also *Craspedostoma*, Lindström. Besides these Mr. Ulrich proposes to establish and add two new genera which he regards as related to *Cyclonema*. The first of these he names DYERIA, in memory of the late C. B. Dyer, a former well-known collector at Cincinnati; the other BUCANOSPIRA, in allusion to the trumpet-like expansion of the aperture. Both of these genera may prove to have closer relations to *Platyceras* than we now believe.*

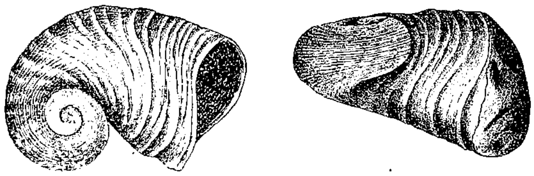

FIG. 8.—Two views of a large specimen of *Dyeria costata* James sp. from the upper half of the Lorraine group at Cincinnati, Ohio. Collection of E. O. Ulrich.

Dyeria is founded on a Cincinnati fossil originally described by Mr. U. P. James, as *Cyrtolites costatus*,† but since 1875 known to collectors as *Bucania costata*. Heretofore it was supposed that its whorls were coiled in the same plane, but, as may be seen from the accompanying illustrations of a full-grown specimen, this is not the case. Still, the coiling of the whorls may be more nearly in one plane than in the figured specimen—indeed, in one case before us the last whorl turns upward instead of downward According to our opinion *Dyeria costata*, as it should now be called, is in no wise related to any member of the *Bellerophontacea*, but on the contrary is not far removed from *Cyclonema*. The surface sculpture is of a type pertaining quite generally to that genus, even to the matter of the transverse wrinkles or undulations on the last whorl of old examples. It is true the margin of the lip and, therefore, the lines of growth, take a more undulating course in circling the whorls than in any *Cyclonema* known to us, but when a sinus does occur in the lip of a *Cyclonema* it is in a corresponding region or regions. However, *Dyeria* differs widely from that genus in the depressed—almost involute—form of its shell, in having a considerable part of the last whorl vagrant and nearly straight, and in the simple unthickened character of the inner lip. It remains to be seen whether the vagrant character of the last whorl is essential or not. If it is not then the genus may justly include forms like Lindström's *Euomphalus tuba*.

a *c* *b*

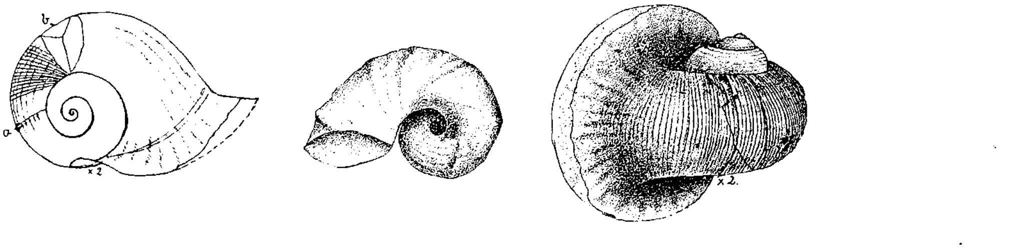

FIG. 9.—*Bucanospira expansa*, n. gen. et sp. (Ulrich), Niagara group, Wayne county, Tennessee. *a* and *b*, slightly restored views, X2, of a silicified shell, showing the expanded aperture, remains of preceding expansions (at *a* and *b* on fig. *a*), and surface markings; *c*, under side of the interior cast of a larger specimen with indications of numerous successive apertural expansions. The umbilicus is relatively larger and the spire lower in this specimen than in the first. Collection of E. O. Ulrich.

Bucanospira is based on an undescribed Upper Silurian shell from western Tennessee, for which we

* The *Platyceridæ* are greatly in need of revision. While the majority are doubtless referable to the capulids, many others belong near *Cyclonema* and *Dyeria* among the *Trochonematidæ*. Or, if that arrangement is not acceptable, then the latter family will have to be restricted to *Trochonema* and *Cyclonema*, and *Strophostylus* (which we extend so that it includes shells commonly arranged under *Cyclonema*), together with *Holopea*, *Dyeria* and *Bucanospira* removed to the *Calyptræidæ*; or a new intermediate family must be instituted for their reception.

† Amer. Jour. Sci. and Arts, 3d ser., vol. iii, p. 26, 1872; see also Meek, 1873, Pal. Ohio, vol, i, p. 150, pl. XIII, figs. 1a, 1e.

propose the specific name *expansa*. As we understand it, *Bucanospira* is a later modification of the type represented by *Dyeria costata*, differing mainly in this, that the aperture is abruptly and greatly expanded at intervals as growth proceeds. The old expansions are either all broken away, or, as is more likely, reabsorbed, giving a condition precisely as in *Tremanotus*. Each expansion, however, left its mark on the interior of the shell as may be seen from the cast of the interior figured above (Fig. 9c). In *Craspedostoma*, Lindström, which also has an expanded mouth, the expansion or border differs in being thick, cut out on the inner side so as to leave two projecting spurs, and in being developed at one—the closing—period only.

Genus TROCHONEMA, Salter,

Trochonema and *Eunema* of SALTER, 1859, Can. Org. Rem., Dec. 1, p. 24.
? *Trochonemopsis*, MEEK, 1875, Pal. Ohio, vol. i, p. 219.
Cyclonema (part.) of HALL, SALTER and others.

Shell turbinate, umbilicated; spire varying in hight, base generally flattened yet sometimes quite ventricose; whorls not numerous (4—8), varying from strongly angular to rounded, always with two more or less prominent ridges or angles between which lies a broad vertical, usually flat or concave, peripheral space; a third ridge usually near the suture, while a fourth generally surrounds the umbilical cavity. Other, but smaller ridges may occur though chiefly on the basal half of the whorls. Lines of growth crossing the whorls from above obliquely backward, often vertical and not infrequently inclined in the opposite way on the peripheral band. In the last case the outer lip is broadly notched at the extremity of the upper peripheral angle. Aperture usually very oblique; peritreme complete; inner lip varying in thickness, not reflected. Type, *T. umbilicatum* Hall sp.

This excellent genus exhibits considerable variety in its contents. There is scarcely a single character that pertains strictly to all the species, yet, comparing one with the other, we find them so closely knit together that to separate them very far would mean nothing less than violence to natural classification. We do not mean to say that the genus may not be conveniently and yet naturally divided, or subdivided, if that is preferable. *Eunema*, Salter, the type species of which is scarcely more than a high and practically imperforate *Trochonema*, was established at the same time as *Trochonema*. As at present understood, *Eunema* is not a well-marked genus, while its employment even as a subgenus is attended with difficulties. It cannot be maintained on Salter's characterization, since in shells of this type the relative size of the umbilicus is a very unreliable generic character. However, if we will select another character of *E. strigillatum*, viz.: the very slight obliquity of its aperture, the group may have some value. A much better division may be instituted for the reception of the group of species typified by our *T. pulchellum* which eventually gave origin to *Cyclonema*. The separation of this group is certainly convenient since it leaves *Trochonema* (*s. s.*) as a more compact and sharply defined group. Brief definitions of these divisions follow:

TROCHONEMA (*s. s.*), Salter.—Shells turbinate and more or less widely umbilicated; whorls angular, with a wide vertical peripheral band, marked off above and below by a more or less sharp angle or carina; often with a third carina at the suture and a fourth around the umbilicus. Aperture generally very oblique, chiefly in its lower part. Type, *T. umbilicatum* Hall.

EUNEMA, Salter.—In every respect like *Trochonema* save that the shells are generally higher, the umbilicus very narrow or closed entirely and the aperture very little oblique. Type, *E. strigillatum* Salter.

GYRONEMA, n. subgen. or gen.—Whorls generally more ventricose than in *Trochonema*, mouth only moderately oblique, umbilicus small, the surface, on the lower half especially, with numerous spiral ridges among which those corresponding with the two which bound the vertical peripheral band in *Trochonema* are sometimes not easily recognized. Type, *T.* (*G.*) *pulchellum*, n. sp.

Meek (Pal. Ohio, vol. i, p. 219) suggested, "at least as a subgeneric designation," the name *Trochonemopsis* for the Devonian shell which he called *T. tricarinata*, providing that the peritreme in this shell was really not continuous. He says of the inner lip that above the umbilicus "it seems to be nearly or quite obsolete." We have no evidence on the point in question, and, therefore, cannot say what should be done in the matter.

The various forms of *Trochonema* suggest affinities with several more or less widely different genera and families. In the first place we pass by rather easy gradations through *Gyronema* to *Cyclonema*. Our *G. pulchellum*, for instance, retains many of the typical characteristics of true *Trochonema*. The vertical peripheral band, despite the fact that it is traversed by a submedian carina, is still quite easily recognized. In *G. liratum* it is less apparent, but in this case we have considerable of an umbilical cavity, so that its relations to *Cyclonema* are not very apparent. In *G. percarinatum*, however, in which the umbilicus is very small, if not entirely wanting, the general aspect is decidedly like *Cyclonema varicosum* Hall. The only difference of any consequence is that the inner lip is thin and not reflected nor excavated as it should be in a true *Cyclonema*. But we have most positive evidence, showing that the development of the excavation of the inner lip was gradual in a species of *Cyclonema* from the Stones River group in Tennessee, closely related to *C. varicosum*, in which the inner lip is much thinner than usual and very little excavated. In short, this and other evidence before us, is such that we are fully satisfied that the best representatives of *Cyclonema* were derived from *Gyronema*.

On pages 962 and 989 we have already expressed our conviction that *Trochonema* and certain species provisionally referred to *Lophospira* are in some wise connected. That this is a fact can scarcely escape any one who will compare our figures of

Lophospira trochonemoides and *L. knoxvillensis* on plate LXXII with almost any of the species of *Trochonema* figured on plate LXXVII. As best suiting the purpose we may recommend *Trochonema bellulum, T. retrorsum* and *T. madisonense.* It will be observed that the two sets of shells agree closely in all respects save one, viz.: the former has the continuity of the lines of growth interrupted by a true "band" on the upper peripheral carina, while in the latter the angle is simple and does not interrupt the continuity of the lines.

Taking another set of species, *Trochonema* is brought into the closest kind of connection with some of the Upper Silurian shells which Lindström has placed in the genus *Trochus.* For instance, we ask, what marked difference exists between our *Trochonema arctatum* and *T. obsoletum* and Lindström's *Trochus dalli* and *T. wisbyensis?* There is none of any consequence that we can discover, so we are constrained to say if the first pair falls strictly within the limits of *Trochonema* then the second must also. And what is there about all four of them that will justify their separation from *Trochonema? T. arctatum* differs from our *T. robbinsi* and *T. niota* Hall sp., in having a narrower peripheral band. All of these three forms differ from the majority of the species of *Trochonema* in wanting the carina near the suture. But this deviation is surely not of more than specific importance since the absent carina is developed in our *T. simile,* a shell that, with a general aspect like *T. robbinsi,* has the upper side of the whorls concave instead of regularly sloping and a carina beneath the suture. Lindström's *Trochus lamellosus* also belongs to *Trochonema.* None of these species seems very intimately related to any of the other shells referred to *Trochus* by Lindström save perhaps his *T. fulminatus* and *T. mollis,* the latter of which is a modified *Cyclonema* not far removed from *C. transversum.* As to whether these other species are true *Trochidæ* or not, we have no opinion to offer at present, but some of them (*e. g., T. lundgreni* and *T. stuxbergi*) doubtless stand in close genetic relationship with the Lower Silurian *Raphistomina.*

TROCHONEMA UMBILICATUM *Hall,* and varieties.

PLATE LXXVII, FIGS. 1–8.

Pleurotomaria umbilicata HALL, 1847, Pal. N. Y., vol. i, pp. 43 and 175.
Trochonema umbilicata SALTER, 1859, Can. Org. Rem., Dec. I, p. 27, pl. VI, fig. 3.

There are several forms or varieties of this widely distributed species. The one that occurs in the Trenton limestone is usually regarded as the most typical of the species. It has rather low volutions, with a shoulder-like flat space bordering the suture and taking up about one-third of the width of the upper side, the remaining two-thirds being a concave slope to the peripheral band. This is almost exactly vertical and barely concave. The under surface from the lower peripheral angle to the subcentral ridge or angularity enclosing the umbilicus is a nearly flat slope. The shell is rather thin and the apertural margin in casts is much less expanded than in the similar *T. beachi.* Lower and inner portions of peritreme comparatively thin and not much reflected. Aperture very oblique. The surface markings are obscure on all save the last whorl, and here even they are never coarse, though often somewhat irregular. The lines are not quite vertical on the outer or peripheral face crossing it from above somewhat obliquely backward. On the lower side they sweep very strongly backward and grow stronger as they curve over the median angularity into the umbilicus. In the latter the surface is first flat, then convex. Specimens are usually not as large as the one shown in our fig. 2.

Many of the Stones River group specimens cannot be distinguished from the Trenton form, but occasionally we meet, in Tennessee especially, with a larger variety (see pl. LXXVII, figs. 7 and 8) which may be distinguished as var. *latum*. Its whorls are less concave on the upper slope and enlarge more rapidly than in the ordinary variety.

In Canada, at Pauquettes rapids, a variety occurs abundantly in the Black River limestone differing from the others in being relatively a little higher, very thin, with the lines of growth finer and more regular, and the umbilical carina sharper. Figures 4—6 are of a good, though rather young example of this variety. The same form was figured by Salter. It may be called var *canadensis*.

Formation and locality.—This species is found in the three beds of the Trenton group at many localities in Goodhue and Fillmore counties. We have not noticed it among the numerous Trochonemas of the Stones River group at Minneapolis and other points in the state, but it occurs in this formation in Wisconsin and Illinois; also in Kentucky, Tennessee, New York and Canada. While it is rather a common fossil through the greater part of the Trenton, and perhaps the Cincinnati period also, *good* specimens, of either casts or shells, must be counted as very rare. There is some doubt about the casts found at Cincinnati. They may or may not belong to this species.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, Nos. 7301, 8727.

TROCHONEMA BEACHI ? *Whitfield.*

PLATE LXXVII, FIGS. 9—12.

? *Trochonema beachi* WHITFIELD, 1878, Ann. Rep. Geol. Sur. Wis., p. 74; also 1882, Geol. Wis., vol. iv, p. 213.

We have not been able to satisfy ourselves concerning the species intended by Prof. Whitfield to bear this name. It must be very closely related to *T. umbilicatum*, the only differences to be made out from the single view (dorsal) given by him being a thicker shell (producing the abrupt apertural expansion in the cast) and a slightly greater proportional hight of the volutions. The umbilicus is said to be much narrower and more abrupt, the spire higher and the shell smaller. On plate LXXVII, figure 11 represents a section of a small specimen from Dixon, Illinois, having apparently all the characters ascribed to *T. beachi*. The umbilicus, perhaps, is a trifle too large and the shell matter enclosing it somewhat thinner than in several other specimens that we refer here. The hight of the spire and general appearance of the shell is decidedly like the Canadian Black River variety of *T. umbilicatum* (see plate LXXVII, figures 4—6), but the lips are much thinner in that form. Except when the specimens are unusually good, it must always be a difficult matter to recognize *T. beachi*.

Formation and locality.—Stones River group, Minneapolis, Minnesota; Janesville and Beloit, Wisconsin, and Dixon, Illinois. A single example, apparently of the same form, from the Black River group at Curdsville, Kentucky.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

TROCHONEMA BELOITENSE *Whitfield.*

PLATE LXXVIII, FIGS. 1—9.

Trochonema beloitense WHITFIELD, 1878, Ann. Rep. Geol. Sur. Wis., p. 74; and 1882, Geol. Wis., vol. iv, p. 212.

Though closely related to *T. umbilicatum*, this fine species is easily distinguished by its much more rapidly expanding and higher volutions, giving to the last whorl a much more ventricose appearance.

The test also is much thicker, the surface markings coarser, the angles more prominent, and the umbilicus smaller. The last whorl often shows a tendency to become disjoined, but this feature is never so pronounced as in our *T. vagrans.* Casts of the interior, because of the thick shell, have unusually rounded whorls, and these are even more readily distinguished from *T. umbilicatum* than are the shells. The upper of the two peripheral carinæ is always clearly indicated by a rounded ridge with minor revolving undulations as shown in our fig. 3. The lower carina, however, seems always to be but obscurely reproduced on casts. The umbilical ridge, on the other hand, is more distinct on casts than on the shell itself. As may be seen in fig. 4, it becomes quite obsolete with age. In the Minnesota form of the species the whorls seem always to be more slender than in specimens from Wisconsin.

Formation and locality.—Stones River group, Minneapolis and St. Paul, Minnesota; Mineral Point and Beloit, Wisconsin, and Dixon, Illinois.

Collection.—E. O. Ulrich.

TROCHONEMA VAGRANS, *n. sp.*

PLATE LXXVII, FIG. 46; PLATE LXXVIII, FIGS. 10–13.

This form is closely related to *T. beloitense*—perhaps merely a variety of that species. It has more slender volutions, a thinner shell and, considering the size of the specimens, stronger surface markings. The shell being of only moderate thickness, the whorls of casts are also more angular. The last whorl is over half free and drops rapidly.

Formation and locality.—Stones River group, Vanuxemia bed, Minneapolis, Minnesota. Apparently a rare fossil.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 6865.

TROCHONEMA RUGOSUM, *n. sp.*

PLATE LXXVII, FIGS. 19–22.

Shells of this species have a much smaller umbilical perforation than *T. umbilicatum.* This is due chiefly to the much thicker shell, the size of the umbilicus in casts of the two species being more nearly equal. For the same reason the mouth of *T. rugosum*, as seen on casts, appears to be abruptly expanded, especially upon the lower and outer sides. The upper side of the whorls (in casts) is also more strongly convex (not angular) in the inner half and more deeply concave in the outer. On both the cast and shell the two peripheral carinæ are more prominent, causing the space between to be more excavated. The surface markings are very coarse, turned backward on the upper side of the whorls, vertical on the concave peripheral face and again turned backward, though not as strongly as in *T. umbilicatum*, on the lower side. Here, particularly toward the aperture of adult examples, the striæ are often more numerous, sometimes two to one, than on the peripheral band.

Formation and locality.—Stones River group, Vanuxemia bed, Minneapolis and St. Paul, Minnesota; Beloit, Wisconsin.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

TROCHONEMA ECCENTRICUM, *n. sp.* (*Ulrich.*)

PLATE LXXVII, FIGS. 17 and 18.

Young examples of this species must be almost indistinguishable from *T. umbilicatum*, the general aspect and surface markings being practically the same in both. Fully grown examples, however, are separated at once by the basal or umbilical ridge which, instead of maintaining a submedian position, is swung outward gradually in the latter half of the last turn until it is immediately beneath the periphery. This peculiarity results in well-marked differences in the shape of the mouth, the latter appearing more triangular than quadrangular in a ventral view though decidedly quadrangular in a basal view. The inner and lower lips also are more strongly reflected and thicker than in any other species of the genus known. And yet, the shell is not much thicker than in *T. umbilicatum.*

Formation and locality.—Upper division ("Glade limestone") of the Stones River group, near Lebanon, Tennessee.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

TROCHONEMA BELLULUM, *n. sp.* (*Ulrich.*)

PLATE LXXVII, FIGS. 26–29.

At first we were inclined to unite this species with *T. eccentricum*, but a more careful comparison revealed differences of sufficient importance to deserve recognition. In the first place the adult shell is much smaller, the width of the largest specimens being less than 25 mm. (in five out of six it is less than 20 mm.), while it is from 35 to 40 mm. in adult shells of *T. eccentricum.* Next, the apical angle is usually a trifle narrower, giving a proportionally higher spire. Finally, the lines of growth are finer and turn slightly forward instead of backward in crossing the concave peripheral space, thereby producing, with the retrally curved striæ of the upper side, a slight notch at the upper peripheral carina. Such a wide-angled notch occurs in three other species, viz.: *T. retrorsum*, *T. subcrassum* and *T. madisonense* of this report, but they are all readily distinguished from the present species by other characters. Compared with *T. umbilicatum*, *T. fragile* and other similar species, *T. bellulum* is distinguished at once by the eccentric sweep of the umbilical ridge and the subtriangular shape of the aperture resulting from it.

Formation and locality.—Lower division ot the Stones River group, Murfreesboro, Tennessee.

Collections.—Prof. J. M. Safford; E. O. Ulrich.

TROCHONEMA FRAGILE, *n. sp.*

PLATE LXXVII, FIGS. 13–16.

This is a small form, the greatest diameter averaging about 15 mm., the largest seen being only about 22 mm. wide. The specimens closely resemble young testiferous examples of *T. umbilicatum*, but it is to be noted that it is the internal cast that agrees in its general appearance with the exterior of that shell. We have not seen the exterior of *T. fragile*, but the unusual sharpness of the angles indicates a very thin fragile shell, probably similar, even to the surface markings, remains of very delicate equal lines of growth being retained by one of the specimens, to the variety of *T. umbilicatum* which we distinguish as var. *canadense.* The lower or umbilical side must be almost exactly as in that variety, but, judging from the differences exhibited between the interior and exterior of other species of the genus, the lower boundary of the vertical peripheral face must be even more prominent than in var. *canadense.* Further comparison brings to light another difference that we believe will serve to separate the species at all times from that variety. Namely, the uppermost of the four carinæ is proportionally much nearer the suture in *T. fragile*, being removed from it but little more than one-fifth of the width of the upper surface of the whorl, whereas in all the varieties of *T. umbilicatum* the distance equals at least a third. In this feature the speci s agrees with *T. subcrassum* and *T. retrorsum*, which see for comparisons. It is scarcely possible that *T. fragile* can be confounded with any of the other species here described.

Formation and locality.—Clitambonites and Fusispira beds of the Trenton group at various localities in Goodhue county, Minnesota. Also in beds equivalent to the latter horizon in Carroll county, Illinois.

Collections.—Geological and Natural History Survey of Minnesota (2 specimens); W. H. Scofield (3 specimens); E. O. Ulrich (7 specimens).

Museum Register, No. 8735.

Trochonema subcrassum, *n. sp.*

PLATE LXXVII, FIGS. 30-34.

The exterior of this form is in nearly all respects very similar to the internal casts of *T. fragile*, and the specimens were at first regarded as testiferous examples of that species. However, on removing the shell, it became evident that it is much thicker, especially at the angles, than it can possibly be in *T. fragile*, and that the internal cast is much less angular than are the casts of that species. Indeed, as is shown in fig. 33, the sharp external carinæ are only obscurely indicated on the interior cast. An equally important difference, and one that removes the species rather widely from all of the preceding species save *T. bellulum*, is the fact that the lines of growth, instead of continuing their general backward direction on the peripheral face, are here turned forward to form a wide-angled notch as in many species of *Lophospira*. The lines of growth are very fine on the whole with many that are readily discernible to the unassisted eye. On the base they are not as strongly turned backward as in *T. fragile* and most other species of the genus, so that the aperture is not as oblique as usual (compare plate LXXVII, figs. 15 and 30). The upper carina is very near the suture and sometimes scarcely removed from it.

The comparatively slight obliquity of the aperture in this and the next species (*T. retrorsum*) allies them with the forms included in the subgenus *Eunema*.

Formation and locality.—The types of this species are from the upper part of the Trenton group in Mercer and Boyle counties, Kentucky. A single cast of the interior, apparently belonging here, was found in the Fusispira bed near Cannon Falls, Minnesota.

Collection.—E. O. Ulrich (12 specimens).

Trochonema retrorsum, *n. sp.*

PLATE LXXVII, FIGS. 35—38.

In most respects like *T. subcrassum*, but the mouth is even less oblique, the umbilicus narrower and much more abrupt, the shell thinner, the inner lip straighter, and the lines of growth even finer and more regular. The almost vertical wall of the umbilicus and the very slight backward curve of the lines of growth on the base of the shell are two very striking features when the species is compared with *T. umbilicatum* and other species of that type. The mouth is pentagonal, the upper carina very near the suture.

Formation and locality.—Ctenodonda bed, Black River group, Goodhue county, Minnesota.

Collection.—E. O. Ulrich.

Trochonema madisonense, *n. sp.* (*Ulrich.*)

PLATE LXXVII, FIGS. 23—25.

A large shell agreeing in most particulars with *T. umbilicatum*, but having relatively higher and more ventricose whorls, while the ridge, which generally surrounds the umbilical depression in this genus, is quite obsolete. The shell is thicker, the surface markings stronger, the mouth very oblique and with thicker lips. Casts of the interior of the two species are more alike than their exteriors, yet those of the present may be distinguished by the greater separation of the whorls due to the removal of a greater thickness of shell. There is a wide notch in the outer and upper portions of the peritreme which, with the somewhat triangular form of the aperture in a ventral view, suggests relations with *T. eccentricum*. Figures of that shell are given on the same plate with those of this species, so it is scarcely necessary to compare them further.

Formation and locality.—Richmond group, Madison, Indiana.

Collection.—E. O. Ulrich.

TROCHONEMA NIOTA *Hall.*

PLATE LXXVI. FIGS. 16–18.

Pleurotomaria niota HALL, 1861, Geol. Sur. Wis. Rep. Prog., p. 33; WHITFIELD, 1895, Mem. Amer. Mus. Nat. Hist., vol. i, pt. ii, p. 60, plate VII, fig. 11.

Original description.—"Shell large, broadly subconical, the diameter through the last volution equal to about four-fifths of the hight, consisting of six volutions, which are flattened on the periphery, with a very slightly concave space upon the upper side, extending to the suture; lower side rounded into the moderately large umbilicus, the last volution large and ventricose.

"Surface character unknown, except a few undefined undulations near the extremity of the last volution, which are more distinct below than above."

The above description is not very clear, and as Hall compares the species with his *Pleurotomaria subconica* and *P. bicincta*, saying that it is intermediate in form between them, we naturally failed to recognize the form until Whitfield (*loc. cit.*) figured the original type The specimen illustrated by us evidently is in better condition than the type, and shows clearly that it has no affinities with the two species with which Hall compares his specimen. It is nothing more nor less than a high-spired *Trochonema*, with a very small umbilicus for this genus. The upper slope of the whorls is more concave than shown in Whitfield's figure. The lower lip was broadly sinuated, the inner almost vertical, while the shell appears to have been thin and the surface markings not very strong.

Formation and locality.—Buff limestone (? Stones River group), Beloit, Wisconsin, where the specimen here used was collected by Mr. H. C. Powers.

Collection.—E. O. Ulrich.

TROCHONEMA ALTUM, *n. sp.*

PLATE LXXVII, FIGS. 39–41.

The cast of the interior figured on plate LXXVII is all we have seen of this species. It evidently represents a *Trochonema* with an unusually high spire, minute umbilicus, wide peripheral band and slightly convex rather than concave upper slope. In some respects it reminds one of *T. niota* Hall sp., but has a wider peripheral band, more rounded whorls, and seems to have been a much smaller shell. We know of no other species near enough to require comparisons.

Both *T. altum* and *T. niota* form relatively high shells, and might therefore be referred to the subgenus *Eunema*, but as their mouths are oblique we think it best to leave them in the typical section of the genus.

Formation and locality.—Lower half of Fusispira bed, Trenton group, near Cannon Falls, Minnesota.

Collection.—E. O. Ulrich.

Subgenus EUNEMA, Salter.

Eunema, SALTER, 1859, Canadian Organic Remains, Dec. I, pp. 24 and 29.

This term may be employed provisionally as a subgeneric designation under *Trochonema*. As defined on p. 1046, it will include, besides the type, *E. strigillatum* Salter, the following six species. In none of the latter is the spire as high as in Salter's species, but all have about the same kind of mouth, and that we deem of more consequence than either the hight of the spire or the size of the umbilicus. *E. pagoda* Salter and *E. vrisca* Billings are widely different, being *Pleurotomariidæ* (see p. 1021).

TROCHONEMA (EUNEMA) SALTERI, *n. sp.*

PLATE LXXVII, FIGS. 42–43

Shell 20 to 30 mm. in hight; width across the body whorl about three-fourths of the hight; apical angle about 65°. Whorls four or five, angular, with a gently concave slope above nearly to the suture, and an equally wide vertical flat peripheral band; base moderately ventricose, umbilicus extremely small or wanting; close to the suture a slight angularity. Of the two peripheral angles the upper is the more prominent, the lower being comparatively obscure, especially near the aperture. Lines of growth fine, crossing the whorls somewhat obliquely backward and downward, the direction being almost uniform on all parts; slightly sinuate on the base. Aperture obscurely triangular in outline, somewhat effuse below, with the inner lip nearly straight.

Eunema strigillatum Salter is a higher shell, and differs more importantly in having the lines of growth turned forward instead of backward after crossing the upper of the two peripheral carinæ.

T. salteri resembles species of *Lophospira* very greatly, and collectors may find it difficult to recognize unless they are fortunate enough to meet with good specimens retaining either the mouth or some of the surface markings.

Formation and locality.—Lower half of Fusispira bed, Trenton group, Goodhue county, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota ; E. O. Ulrich.

Museum Register, No. 7375.

TROCHONEMA (EUNEMA) NITIDUM, *n. sp.* (*Ulrich.*)

PLATE LXXVII, FIGS. 44 and 45.

Related to *T. salteri,* but has a shorter and smaller spire, and proportionally larger and much more ventricose body whorl. The lower margin of the peripheral band also is more obscure, the upper slope more concave, the lines of growth very fine and more nearly vertical, the inner lip not so straight and the aperture less oblique and more ovate. The specimen illustrated may be said to be of the average size, though we have an interior cast of one that was fully twice as large.

Formation and locality.—Utica group, Cincinnati, Ohio, and localities in the vicinity of that city.

Collection.—E. O. Ulrich.

TROCHONEMA (EUNEMA) ROBBINSI, *n. sp.*

PLATE LXXVI, FIGS. 11–15.

This also is related to *T. salteri,* yet may be distinguished very easily by its more depressed, subconical, shape, much less ventricose base, perfectly even and longer upper slope, and more prominent and sharper lower angle. The umbilical perforation is very small and mostly covered by the reflexed inner lip.

The specific name is given in honor of Dr. C. H. Robbins, of Wykoff, who first brought the shell to our notice. We are indebted to this gentleman for many good specimens and courtesies while visiting his locality.

Formation and locality.—Fusispira bed, Wykoff, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 7516.

TROCHONEMA (EUNEMA) SIMILE, *n. sp.*

(Not figured.)

This form is in some respects intermediate between *T. salteri* and *T. robbinsi,* being more depressed than the former and not as much as the latter. The angles are slightly more prominent than in either, and the peripheral band is somewhat concave, while the upper slope shows a swelling in the upper half or a blunt ridge close to the suture and is concave for the rest. Care is required in distinguishing casts of this and several species of *Lophospira.*

Formation and locality.—Fusispira bed of the Trenton group, Wykoff, Minnesota.

Collection.—E. O. Ulrich.

TROCHONEMA (EUNEMA) ARCTATUM, *n. sp.* (*Ulrich.*)

PLATE LXXVI, FIGS 9 and 10.

Shell small, about 9 mm. in hight, narrow, subconical, the apical angle about 58°; peripheral band unusually narrow, about half as wide as the upper slope, pitching inward, the upper margin being more prominently angular or keeled than the lower; upper slope slightly concave in the lower half and convex in the upper; base depressed convex, umbilical perforation small but distinct; aperture not very oblique, subovate, rounded on the inner side, higher than wide. The lines of growth are very fine. As near as they can be made out, they cross the whorls at about the same angle as in *T. robbinsi.*

The peripheral band is so narrow that the shell is very apt to be mistaken for one of the *Pleurotomariidæ.* Sardeson describes a *Pleurotomaria clivosa* from the Black River shales at Minneapolis that looks so much like *T. arctatum* that we suspect it belongs to this genus.

Formation and locality.—Upper part of Trenton group, near Burgin, Kentucky.

Collection.—E. O. Ulrich.

TROCHONEMA (EUNEMA) OBSOLETUM, *n. sp.* (*Ulrich.*)

PLATE LXXVI, FIGS. 6–8.

Excepting the body whorl, this small shell would differ from *T. arctatum* only in being a trifle wider but with the last whorl it assumes a very different expression. The last whorl namely is relatively quite rounded, the upper slope being inflated and the base somewhat ventricose, while between the two the peripheral band is scarcely distinguishable. The lines of growth, while extremely delicate on the upper whorls and still fine on the last, are nevertheless much stronger here, with now and then a wrinkle that is distinctly visible to the naked eye. The axis seems not to be perforated, the central part of the base being merely sunken in.

Formation and locality.—Upper part of Trenton group, near Burgin, Kentucky.

Collection.—E. O. Ulrich.

Subgenus (?genus) GYRONEMA, Ulrich.

This group of species occupies an intermediate position between the true *Trochonemas* and *Cyclonema.* (See remarks and definition pp. 1045 to 1047.) As we believe the division is important and well founded in nature, we shall employ it here in the sense of a full genus.

GYRONEMA PULCHELLUM, *n. sp.*

PLATE LXXVIII, FIGS. 19–21.

Shell small, 9 to 17 mm. in hight; greatest width of body whorl, which constitutes much the greater part of the shell, equalling about three-fourths of the hight; apical angle about 85°. Whorls six and a half in an entire shell, the first two minute, rounded, glassy, and perfectly smooth, the third gradually assuming the angles of the following turns. Body whorl divided into three subequal regions; first, the upper slope, of which the inner third is almost horizontal and the outer two-thirds a strongly concave slope, a sharp angle or ridge dividing the two parts; second, the peripheral band, which is nearly vertical, margined on each side by a sharp carina and rendered somewhat bi-concave by a smaller carina, which first makes its appearance on the fifth whorl, lying slightly beneath the middle of the space; and third the basal part of the whorl is flattened rather than ventricose and traversed by five or six small revolving ridges and furrows, the last of which marks off the boundary of the small umbilical perforation. Surface showing very fine and rather regular lines of growth which cross the whorls from above somewhat obliquely backward. On one beautifully preserved example the whole surface, when highly magnified, is seen to be covered with a crowded set of extremely delicate revolving lines. Aperture subovate or somewhat hexagonal, its hight slightly exceeding the width; peritreme thin, the inner lip reflected partly over the umbilicus.

Formation and locality.—Ctenodonta bed of the shales of the Black River group, Minneapolis, Chatfield and near Cannon Falls, Minnesota; also in the limestones of this group in Mercer county, Kentucky.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 6854.

GYRONEMA SEMICARINATUM *Salter.*

PLATE LXXVIII, FIGS. 17 and 18.

Cyclonema semicarinata SALTER, 1859, Can. Org. Rem., Dec. I, p. 27, pl. VI, figs. 2 and 2*a*, not 2*b*.

This species is distinguished from *G. pulchellum* by its stronger lines of growth, and the much greater prominence of the carina which corresponds with the upper boundary of the vertical peripheral band in that species. The lower boundary is only very slightly more prominent than the rest of the six or seven revolving carinæ which lie beneath the principal keel. The upper slope of the whorls also is somewhat wider than in *G. pulchellum*, and, furthermore, may be, as in the specimen figured, divided on the last whorl by an extra small median carina. This extra carina is probably not of much consequence since it occurs only on a part of the last whorl in our specimen, and is neither mentioned nor illustrated by Salter.

We have not the least doubt concerning the specific identity of the Minnesota specimen and the shell represented by Salter's figures 2 and 2*a* (*loc. cit.*), but we cannot say as much for his fig. 2*b*. The last might pass very well for our *G. pulchellum* since it gives the peripheral band as nearly vertical, the carina which forms its lower boundary being nearly or quite as prominent as the upper. The upper slope, however, is not as concave as it should be in our species.

Formation and locality.—Phylloporina bed of the shales of the Black River group, near Cannon Falls, Minnesota.

Collection.—E. O. Ulrich.

GYRONEMA DUPLICATUM, *n. sp.*

PLATE LXXVIII, FIGS. 22–25.

Comp. *Pleurotomaria percarinata* HALL, 1847, Pal. N. Y., vol. i, p. 177, pl. XXXVIII, fig. 4.

This is distinguished from *G. pulchellum*, which it resembles in a general way much more closely than it does *G. semicarinatum* Salter sp., by its larger size, entirely closed umbilicus, and less angular whorls. The carina on the upper slope of the whorls is less prominent and smaller (in casts of the interior it looks more like a thick swelling than a carina), and on the last whorl it is apparently always divided into two thin lines. Between these and the upper peripheral angle, which is the strongest but not the most prominent on the whorl, the surface is concave, but not as deeply so as in *G. pulchellum*. The lower keel of the peripheral band is not always readily distinguished since it is followed on the slightly ventricose base by six or seven similar though generally somewhat smaller carinæ, while above it there is at least one prominent keel in the middle of the peripheral band. Occasionally this median keel is double, as in fig. 22, or there may be a smaller carina between it and the lower peripheral keel, as in figs. 23 and 24. The lines of growth are rather obscure on our specimens, but apparently they are not as fine nor as regular as in *G. pulchellum.* The duplication of some of the carinæ is a peculiar feature.

This species is generally identified with Hall's *Pleurotomaria percarinata*, an upper Trenton shell from New York that is now commonly referred to *Cyclonema.* Assuming that Hall's figure of his type specimen (*loc. cit.*) is correct, we would say that the northwestern form above described cannot possibly be the same species.

Formation and locality.—Stones River group, possibly also Black River group, at Beloit and other localities in Wisconsin, and Dixon, Illinois. We are informed that it occurs at Minneapolis and St. Paul, but have not succeeded in obtaining it from any point in Minnesota.

Collections.—University of Wisconsin; E. O. Ulrich.

GYRONEMA LIRATUM, *n. sp.*

PLATE LXXVIII, FIGS. 14–16.

The peculiarities of this fine species are very well shown in our illustrations. It is related to *G. pulchellum* and *G. duplicatum*, but is distinguished at once from both by its much larger umbilicus and more rapidly spreading and rounder volutions. The specimen is a cast, partly of the exterior and partly interior. The former shows about fourteen revolving carinæ and thick lines on the last volution, among which the two which correspond with the upper and lower boundaries of the peripheral band in other species are distinguished with some difficulty. They are a little stronger than the others excepting one equally strong and a trifle more prominent which lies midway between them. Only these three are indicated on the interior of the body whorl.

Formation and locality.—Stones River group, Beloit, Wisconsin.

Collection.—E. O. Ulrich.

Genus CYCLONEMA, Hall.

In part *Pleurotomaria* of CONRAD and HALL.

Cyclonema, HALL, 1852, Pal. of N. Y., vol. ii, p. 89; SALTER, 1859, Can Org. Rem., Dec. 1, p. 23. Not *Cyclonema*, (HALL) LINDSTRÖM, 1884, Sil. Gast. and Pter. of Gotland, p. 174

Shell turbinate or conical, never thick, composed of few more or less ventricose whorls; no umbilicus; surface sculpture consisting of numerous revolving lines and small ridges crossed obliquely by sharp lines of growth; aperture oblique, varying from rounded to subquadrate; inner lip more or less thickened, reflected, always excavated. Types, *C. bilix* Conrad and *C. mediale* Ulrich.

The principal characteristic of this genus is the excavation of the inner or columellar lip. This peculiarity distinguishes the genus at once from *Gyronema* which includes some otherwise not very different shells. In *Strophostylus* there is a fold on the inner lip, forming a similar excavation, but it is generally so much twisted that its upper end is not visible in a direct view of the mouth. As a rule also the inner lip is much thicker than in *Cyclonema.* It seems a little strange that the relations of *Cyclonema* and *Strophostylus* have not been recognized heretofore. They are certainly very closely related and in practice it is often difficult to distinguish them. But if we are correct in deriving *Cyclonema* from *Gyronema* then the two groups must have different roots. The oldest known shells (Stones River group) that are strictly referable to *Cyclonema* have relatively coarse revolving ridges. In our *Strophostylus textilis*, on the other hand, the revolving lines are very delicate. The difference is so marked that we cannot believe that *Strophostylus* came from the same immediate root as *Cyclonema*. In our opinion they represent two independent lines.

The composition of the shell of *Cyclonema* must be different from that of the majority of Lower Silurian Gastropoda. On the hills about Cincinnati, where thousands of specimens have been collected, the test is preserved when all the other shells occur as casts of the interior only. Indeed, we have never seen a natural cast of *Cyclonema*. Another point worthy of notice is the extreme rarity of specimens retaining the apical nucleus. Out of considerably over one thousand good shells before us only six retain the apex entirely. In nearly all of the other cases the evidence at hand seems to show that these minute whorls were lost during the life of the shell, or, at any rate, before fossilization, while in four of the six specimens preserving them they were covered and protected by an encrusting bryozoan.

The nuclei seen belong to four species, *C. bilix* var. *fluctuatum*, *C. gracile*, *C. mediale* and *C. inflatum*, the last of which may be but a well-marked variety of the third. In all the nucleus has a glassy appearance, with the first two whorls perfectly smooth, the third with distinct transverse lines only, and all three round and coiled so as to form a blunt apex to the shell. The generic and specific characters begin with the fourth whorl. In *C. bilix* and *C. gracile* the whorls decrease very gradually to the first two, but in *C. inflatum* the third and fourth whorls, with a part of the fifth, are wound into a subcylindrical coil on top of the rapidly expanding succeeding volutions. In *C. mediale* the conditions may be described as intermediate. Considering the character of the nucleus in these four representative species, it appears that the original stock from which *Cyclonema* sprang was a low-spired *Holopea*-like shell.

So far, but a single true *Cyclonema* is known to us from Minnesota. Other Minnesota shells have been placed in the genus, but in our opinion they do not belong here. In order that the reader may get an adequate and just idea of the genus, and also that the genus may be properly established, we have decided to include a number of species that have not yet been found in the upper Mississippi region.

Many species have been placed in *Cyclonema* that do not belong there. Some belong to *Gyronema*, as for instance, *C. percarinatum* Hall sp., *C. semicarinatum* Salter, *C. nodulosum* Lindström and *C. carinatum* (Sowerby) Lindström; others, like *C.*

cancellatum Lindström (not Hall's sp.), to *Strophostylus* as here understood. We have not had an opportunity to examine any of the Devonian species that are referred to *Cyclonema* by various authors, but judging from the literature alone we feel satisfied that not one has a sufficient right to maintain its position in the genus. Lindstöm's description of *Cyclonema* is incorrect since it is based principally or solely upon the Gotlandic species described by him. He places the genus into the immediate vicinity of *Polytropis* (*Oriostoma*) because he has found an operculum similar to the type prevailing in that genus in Hisinger's *Turbo striatus* which he places, together with several similar and other very different shells from Gotland, under *Cyclonema*. Though we have collected thousands of specimens of typical species of *Cyclonema*, not a single operculum of any kind has ever occurred in connection with them. We conclude, therefore, that *Cyclonema* had no operculum, at any rate none that could be preserved as a fossil.

CYCLONEMA BILIX *Conrad.*

PLATE LXXVIII, FIGS. 35–42.

Pleurotomaria bilix CONRAD, 1842, Jour. Acad. Nat. Sci. Phila., vol. viii, p. 271; (part.) HALL, 1847, Pal. N. Y., vol. i, p. 305.
Cyclonema bilix HALL, 1852, Pal. N. Y., vol. ii, p. 89.
Cyclonema bilix (part.) HALL, MEEK, MILLER, and others.

Shell subconical, the hight and width equal, or the hight may exceed the width by as much as one-fifth or in rare cases even one-fourth; apical angle varying from 55° to 75°. Whorls generally three or four in number, the nucleus, consisting of three more, being absent in nearly every instance. In the typical form the whorls are depressed convex, flat or even a trifle concave in the central part of the exposed slope while at the top there is nearly always a small shoulder-like convexity which, with a similar convexity at the bottom, produces a distinctly impressed suture. Base of body whorl more or less flattened, narrowly rounded at the periphery; no umbilicus. Aperture oblique, somewhat triangular in a view of the base-subquadrate in a ventral view, the upper and inner sides of about the same length, and each about two, thirds as long as the lower side, while the outer side equals in length both the inner and upper sides; inner lip excavated, the excavated portion narrowly crescentic in shape, gently concave or straight on the inner side and strongly convex on the outer, usually 1.5 mm. across its widest part, rarely 2.0 mm. or more in old shells; inner margin of excavation sharp below, becoming more and more rounded toward the upper extremity where it turns sharply into the mouth. Surface marked by numerous, small, more or less regular revolving ridges and by much finer, sharply elevated, lines crossing the whorls from above obliquely downward and backward. On the outer surface of the upper whorls the revolving lines are mostly of the same size with from nine to twelve on each. On the body whorl where a new set is interpolated they generally alternate in size, with an average of ten or eleven in 5 mm. Of the oblique transverse lines, which run parallel with the margin of the aperture and are more closely arranged in this species than usual for the genus, the number in 5 mm. on the last whorl averages about thirty but varies between the extremes of twenty-five and forty. The last whorl of old examples usually exhibits more or less numerous irregula undulations and wrinkles of growth which generally cause some irregularity in the surface ornamentation.

The hight of specimens usually varies between 15 and 20 mm ; occasionally it may reach 30 mm.

We could not satisfy ourselves that *Cyclonema fluctuatum* James is more than a good variety of *C. bilix*. Mr. James included in his species some specimens that do not deserve to be distinguished even as a variety, but we believe the majority of his types are of an abundant variety that is generally quite easily distinguished from the typical form of the species,as above described, by having much finer surface markings and the outer surface of the whorls almost constantly concave. The undulations of the surface, though occurring more commonly in this form than in any other, are not considered of much importance. As the more delicately sculptured variety deserves some recognition we propose to retain Mr. James' name in a reduced sense for it, so it may be known hereafter as *C. bilix* var. *fluctuatum.*

Meek's *C. bilix* var. *lata* (Pal. Ohio, vol. i, p. 152) seems to rest on nothing more than an unusually depressed and somewhat abnormally coiled old shell of the typical form of the species. What *he* calls the typical form of the species is something quite different, being one of the forms of our *C. mediale*, while the high shell represented by his fig. 5*g* on plate XIII, which is the type of Miller's var. *conicum*, really belongs to the species as restricted by us. The spire in the last being higher than usual, the name *conicum* might be retained for it, but after an exhaustive study of a large number of specimens we are forced to the conviction that the relative hight of the spire is a very unreliable character, each species and variety exhibiting great variability in this respect. The form of the whorls is a better character, but of all the surface markings have served us best in separating the various species.

In the great confusion prevailing among collectors and authors concerning the species of *Cyclonema* occurring in the region about Cincinnati, we have found it no small task to select the particular form which has the best right to bear Conrad's original name, *bilix.* The significant points about Conrad's brief description are: (1) that the sides of the volutions are "suddenly contracted at the suture," (2) the periphery is abruptly rounded, (3) the base flattened and (4) the locality, Richmond, Indiana.*

We have a number of good specimens (about sixty, exclusive of an even greater number of the var *fluctuatum*) from Richmond and Versailles in Indiana, and localities in Ohio exposing equivalent horizons, agreeing in all essential respects with the specimen illustrated on plate LXXVIII, and which, to the best of our knowledge, are of the same species as the one figured by Conrad. A rare variety with more convex whorls occurs in the Lorraine group at Cincinnati, but this is not the same as either of the two from that locality which have been sent to all parts of the world as *C. bilix.* The typical form of the species was lost sight of and the more easily obtained Cincinnati forms, which careless or interested observers had said were the same, took its place. Excepting the variety mentioned, *C. bilix* is restricted to the Richmond group and, therefore, does not occur at Cincinnati.

We cannot agree with the practices of certain paleontologists who, either because they are incapable of separating the forms, or unwilling to take the trouble, would have us classify all the *Cyclonema* of the Cincinnati and Trenton periods as one species. The following forms are as good "species" as any, and as each represents a recognizable and sufficiently permanent stage in the evolution of the genus, each with its own set of varieties or mutations, they deserve the notice of the systematist. The more experienced and careful collectors long ago separated the common forms, not only because they were different but because they found them at different horizons.

Formation and locality.—Richmond group, Richmond, Versailles, and Madison, Indiana; Oxford Waynesville, Blanchester and numerous other points in Ohio. Fragments apparently of this species were seen at Sterling and Savannah, Illinois, and there is no reason known why it may not occur also in southern Minnesota.

Collection.—E. O. Ulrich.

CYCLONEMA MEDIALE, *n. sp.* (*Ulrich.*)

PLATE LXXVIII, FIGS. 29 and 30.

Cyclonema bilix (part.) HALL, MEEK and other authors; not CONRAD.

Distinguished from *C. bilix* Conrad, by its more ventricose whorls and stronger revolving carinæ. The under side of the whorls is fuller and the outer side (seen in the spire) is always distinctly and uniformly convex, there being no sign of a shoulder at the suture, nor of the median concavity, both of

*The original description reads as follows:—

P. bilix, Pl. XVI, fig. 10.—Spire conical; volutions four; sides subrectilinear at base, suddenly contracted at the suture; surface with spiral raised striæ alternated in size; large volution abruptly rounded in its greatest circumference, base flattened and striated.

Locality.—Richmond, Indiana, in limestone of the age of the rocks of Salmon River series, New York. Lower Silurian which occur quite generally in Conrad's species. The suture is comparatively shallow. There are two common varieties, one having three widely separated strong carinæ on the upper slope followed below by smaller and gradually decreasing and crowding ridges or lines, the last occurring usually about the middle of the base. Much thinner revolving lines generally occur between the larger. In the other variety (see figures) the revolving ridges are more equal in size and distribution, and at least three more in number. On the body whorl they number between fifteen and twenty, but not more than eight or ten of these show on the next whorl above, while in the first variety but four are shown. The apical angle for the whole shell varies greatly but always is narrower for the upper turns than it is for the last two or three.

The strongly carinated variety resembles and probably was derived from *C. varicosum* Hall, but its whorls are less convex and the upper part of the spire more slender, the entire shell of *C. mediale* consisting of six or seven whorls, while *C. varicosum* probably never has more than five volutions. The columellar lip also is straighter and both the revolving and transverse ridges and lines stronger in Hall's species.

Formation and locality.—This is an abundant and highly characteristic fossil of the lower half of the Lorraine group in Ohio, Kentucky and Indiana. We have over two hundred specimens from the vicinity of Cincinnati.

Collection.—E. O. Ulrich.

Cyclonema inflatum, *n. sp.* (*Ulrich.*)

PLATE LXXVIII. FIGS. 31 and 32.

Shell of medium size, consisting, as usually found, of about four rounded whorls; with the apex entire there are in all about seven whorls, the first four forming a narrow truncated cone, the two turns at the apex being coiled in a very wide angle; succeeding whorls spreading more rapidly, the angle increasing in some extreme cases from 40° to 90°; mouth rounded, quadrangular; surface strongly carinated spirally, the carinæ on the upper half of the whorls more distant than those on the lower, fifteen to twenty in all on the body whorl.

This species agrees closely in its surface markings with certain varieties of *C. mediale;* and perhaps it also should be regarded as an extreme variety of that species. Generally it is readily distinguished by its more convex whorls.

Formation and locality.—Lower half of the Lorraine group Cincinnati and vicinitv

Collection.—E. O. Ulrich. (25 specimens.)

Cyclonema varicosum *Hall.*

PLATE LXXVIII, FIGS. 27 and 28.

Cyclonema (*ventricosa* in error for) *varicosa* HALL, 1870, Twenty-fourth Rep. N. Y. St. Mus. Nat. Hist., pl. VIII. (Not defined.)
Cyclonema cincinnatiense MILLER, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 230.

Though closely related to *C. mediale* this shell is still easily distinguished by its straighter columellar lip, fewer, stronger and sharper revolving and tranverse surface markings, deeper suture and more convex whorls. The revolving ridges, especially those on the outer side of the whorls, are very strong and prominent. Between each two there are usually several much thinner lines. Of the principal carinæ the body whorl has only nine or ten, and of these only five or six are shown on the whorls above the last.

Cyclonema cincinnatiense Miller is founded on small examples of this species obtained from the upper beds of the Trenton group opposite the city of Cincinnati.

Formation and locality—Two imperfect specimens of this species were collected at Wykoff, Minnesota, where they were found in the upper part of the Fusispira bed. The original type was obtained from the upper part of the Trenton group at Nashville, Tennessee. The species occupies the same position at Colby, Kentucky, and in the vicinity of Cincinnati.

Collection.—E. O. Ulrich. (15 specimens.)

Cyclonema humerosum, *n. sp.* (*Ulrich.*)

PLATE LXXVIII, FIGS. 43–46.

The average size in this species is somewhat greater than in either of the preceding forms, while the apical angle is generally wider and more constant, the majority of the specimens varying comparatively but little either way from 85°. The principal feature, however, is a strongly developed shoulder, giving a deeper suture than in any other species of the genus. This shoulder may be rounded or, especially in the Richmond group form, quite angular. In the latter the slope of the outer side of the last whorl is very often distinctly concave, and not infrequently undulated in the direction of the lines of growth. The same conditions occur less frequently though quite as well marked in the Lorraine form. The surface markings are fairly constant. About ten principal subequal carinæ occur on the outer slope of the body whorl, and about the same number of smaller ones on the periphery and base. The larger ones usually alternate with a much thinner set.

Formation and locality.—Very abundant in the upper half of the Lorraine group at Cincinnati, and not rare at several horizons in the Richmond group, at Waynesville, Clarksville, Oxford and other localities in Ohio. Also at Richmond, Versailles and other points in Indiana.

Collection.—E. O. Ulrich.

Cyclonema pyramidatum *James.*

PLATE LXXVIII, FIGS. 33 and 34.

Cyclonema pyramidata James, 1874, Cin. Quar. Jour. Sci., vol. i., p. 152.

In its typical form it is scarcely possible to confound this species with any other known, but there are varieties, one of which shows its derivation from *C. mediale*—the starting point for most of the Cincinnati species of *Cyclonema*—while another develops a shoulder at the top of the whorls, causing it to resemble *C. humerosum.* One of the best characters is the extension of the spiral striation over the entire base. In most of the other forms the spiral lines extend only about half across the base, the inner part having transverse striæ only.

Formation and locality.—Lorraine group, Cincinnati and vicinity.

Collection.—E. O. Ulrich.

Cyclonema simulans, *n. sp.* (*Ulrich.*

PLATE LXXVIII, FIG. 47.

Of this species we have about fifty specimens. These show that the shell is of medium size, with a general form about intermediate between *C. humerosum* and *C. mediale,* though rather nearer the former, there being usually a small shoulder and a flattening or even a slight concavity of the outer slope of the last whorl. It is distinguished from both by its surface markings. These consist as usual of revolving and obliquely transverse lines, but the former are much weaker on the last two whorls and often quite obsolete near the mouth, while the latter are more distant excepting in the last third of the body whorl of old examples. In the latter the mouth is sometimes irregularly expanded and thrown upward along the suture.

Formation and locality—Upper division of the Lorraine group at Cincinnati, Ohio.

Collection.—E. O. Ulrich.

CYCLONEMA SUBLÆVE, *n. sp.* (*Ulrich.*)

PLATE LXXVIII, FIGS. 48 and 49.

The form of the shell and whorls in this species and the variations in the hight of the spire and in the expansion of the whorls, is precisely as in *C. mediale*, from which it is distinguished by its occasionally obsolete and always much thinner revolving striæ. In many specimens the upper half or more of the outer slope of the whorls is quite free of spiral lines, in others they are obscurely indicated. On the lower half the lines become gradually more distinct (occasionally the first beneath the smooth space is the strongest of all), but they are never very prominent or sharp. On the body whorl, where they are from one-third to one-half a millimeter apart, a partial alternation in size is usually apparent. *C. simulans* has more abruptly impressed sutures and more distant revolving lines.

Formation and locality—Not uncommon in the lower half of the Lorraine group at several localities in the vicinity of Cincinnati.

Collection.—E. O. Ulrich. (About 70 specimens.)

CYCLONEMA TRANSVERSUM, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 65–67.

This may be an extreme variety of *C. sublæve*, but the six specimens which we refer here look so much alike and so different from the prevailing varieties of that species, that very few if any would hesitate in pronouncing them distinct. The specimens vary in width from 17 to 30 mm. The spire is imperfect in all, but, judging from what remains, the total hight cannot have equalled the width. Apparently it was about a sixth less. The apical angle is about 85°. The last whorl expands very rapidly, is gently convex in the upper slope and on the base, and abruptly rounded at the periphery. The aperture is very oblique and unusually large in a basal view, the excavated inner lip very wide. The surface is more or less strongly marked with oblique lines and wrinkles of growth without a trace of revolving lines except on the smallest specimen. In this the inner half of the last whorl presents several very obscure revolving lines on the lower half of the outer slope.

Aside from the almost total absence of revolving lines, the rapid expansion of the last whorl and shallow suture will distinguish *C. transversum* from most of the preceding species of the genus.

Formation and locality.—Lower half of the Lorraine group, Covington, Kentucky, and Cincinnati, Ohio.

Collection.—E. O. Ulrich.

CYCLONEMA GRACILE, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 55–61.

Shell scarcely attaining medium size, perfect specimens consisting of five or six, more or less slender, rounded whorls; excepting the minute apical turns, the whorls increase regularly in size; either the whole or only the lower part of the whorls may be covered with fine revolving striæ, or these may be wanting entirely; when present a glass is usually necessary to show them clearly; lines of growth having the usual direction, very fine, scarcely distinguishable except on the last whorl; mouth rounded, oblique, inner lip comparatively thin and in many cases not distinctly excavated.

This neat and interesting shell is probably nearer *C. sublæve* than any of the others, but is readily distinguished by its more slender as well as more rounded whorls. It is also a smaller shell. We have before us five or six specimens of what appears to be a variety of *C. gracile*. They agree with the types, with which they were also found, in every respect save that the revolving striæ are much stronger and readily apparent to the unassisted eye. Specimens of this kind may be known as var. *striatulum*.

Formation and locality.—Lorraine group, Cincinnati, Ohio, and vicinity; not uncommon.

Collection.—E. O. Ulrich. (40 specimens.)

CYCLONEMA (? HOLOPEA) LIMATUM, *n. sp.* (*Ulrich.*)

PLATE LXXXII, FIGS. 62–64.

Shell 25 to 30 mm. in hight, the greatest width generally about a fifth less, consisting, without the nucleus which is unknown, of about four rapidly enlarging ventricose whorls; suture distinctly impressed though not deeper than necessitated by the uniform convexity of the whorls; aperture large, higher than wide, rounded below, somewhat acuminate ovate in outline; inner lip nearly straight, not as thick as usual in *Cyclonema*, while as a rule it is merely flattened instead of excavated, and turned inward so that the flat portion is not fully visible in a ventral view; surface smooth, sometimes polished, the lines of growth obscure; of revolving lines not a trace is to be seen except on two specimens where the surface is glossy as though they retained patches of epidermis that is generally not preserved.

In its general aspect this fine species reminds one strongly of *Holopea*, and it is possible that it would be more naturally placed in that genus. It has seemed to us, however, that the characters of the inner lip, which *is* sometimes excavated as in *Cyclonema*, would not permit its reference to *Holopea*, in which, as the genus is now understood, the inner lip is thin and simple. Perhaps *C. limatum* indicates a partial reversion to ancestral characters—in other words, a form in which larval characters are retained through adult stages.

Formation and locality.—Lower division of the Lorraine group, Cincinnati, Ohio.

Collection.—E. O. Ulrich.

Genus STROPHOSTYLUS, Hall.

Strophostylus, HALL, 1859, Pal. N. Y., vol. iii, p. 303

Shell turbinate to subglobose, consisting of three to six rounded and more or less ventricose whorls, with the spire elevated or low and the body whorl often very large; mouth rounded, outer lip thin, sharp, columellar lip not very thick, very little reflected, generally twisted and spirally grooved within; surface finely cancellated, with either the revolving or the oblique growth lines the stronger. Type, *S. elegans* Hall.

The earlier Lower Silurian species of this generic type have all comparatively slender whorls, and forms of the same kind continue on at least to the close of the Upper Silurian. These slender-whorled forms may at first sight look very different from those rapidly expanding subglobose species for whose reception Hall proposed the genus. But, that the latter were evolved from the former is, we think, sufficiently indicated by the range of variation occurring in a single species like *S. cyclostomus* Hall, of the Niagara. Specimens of this species before us approach our widest *S. textilis* very closely. As a rule the spiral element of the surface sculpture is the stronger in the slender-whorled forms, while the lines of growth predominate in the broader types.

Comparing the genus with *Cyclonema* we find that the inner lip is thinner and the fold on it more twisted, the whorls are more rounded and generally coiled with less constancy, most of the species exhibiting greater variation in the hight of the spire than occurs in *Cyclonema*. But, as we have already stated under *Cyclonema*, our principal reason for distinguishing the two groups of species lies in the conviction that they represent two separate lines of development.

Most authors place *Strophostylus* in the immediate vicinity of *Platyceras* and *Platystoma*. In a measure this arrangement is quite correct, but Lindström surely was not justified in reducing *Strophostylus* to synonomy under *Platyceras*. He quite ignores the close relations of the genus to *Cyclonema*—indeed it is evident that he did not recognize the most essential feature of either *Cyclonema* or *Strophostylus*, since he places at least one undeniable member of the present genus under *Cyclonema*. We refer to his *Cyclonema cancellatum*. Even his *C. delicatulum* and *C. adstrictum*, which do not belong to *Cyclonema*, may very well go under *Strophostylus*.

STROPHOSTYLUS TEXTILIS, *n. sp.*

PLATE LXXXII, FIGS. 49–54.

Shell rather small, 12 to 25 mm. high, 11 to 20 mm. wide, obliquely conical; apical angle 60° to 70°; whorls, in casts, three or four, in entire shells, six or seven, increasing quite regularly in size from the acute apex, almost uniformly rounded, often with several widely separated, deep, oblique constrictions; suture deep; aperture subovate, oblique; inner lip appearing thin in a ventral view, but when a part of the outer wall is removed it is seen that it forms a moderately thick columella with a spiral fold beginning near the lower angle. In young examples neither the fold nor a spiral furrow just above it is very distinct, while in some cases the whole inner lip appears to be simple and thin as in *Holopea*. Surface beautifully cancellated by subequal, fine, sharp, revolving and obliquely transverse lines, the network growing strong enough on the last whorl to be distinctly visible to the naked eye.

This graceful and beautifully marked shell cannot be confused with any other known to us from the Lower Silurian rocks of America. There are several Upper Silurian forms that resemble it, but in all of these either the transverse or the revolving set of striæ is stronger than the other. *Cyclonema gracile* has about the same shape, but its inner lip and surface markings are quite different. The apex also is different, being conical in the *Strophostylus* and somewhat truncated in the *Cyclonema*.

Formation and locality.—Shales of the Black River group (Ctenodonta bed chiefly), Minneapolis, St. Paul, Cannon Falls, Chatfield and Fountain, Minnesota. Also, though very rarely, in the Clitambonites bed of the Trenton group, at St. Paul. In Kentucky it occurs near Burgin in the upper part of the Trenton.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 233.

Genus HOLOPEA, Hall.

Holopea, HALL, 1847, Pal. N. Y., vol. i, p. 169.

Though we have given considerable study to the matter, we prefer not to commit ourselves at present to a description of the generic characters. We may say, however, that *Holopea*, as now used, embraces much that does not belong here. Indeed, some of the following species doubtless will be removed when the contents of the genus are finally revised. Most diverse affinities are indicated by different sets of species, some evidently being true *Littorinidæ*, others are related to *Cyclonema* and *Strophostylus*, another set to *Platystoma*, while a few are difficult to place.

HOLOPEA INSIGNIS, *n. sp.*

PLATE LXXIX, FIGS. 1–5.

Shell thin, attaining a width of 40 mm.; average width about 32 mm.; hight about 28 mm.; hight in young examples relatively greater, nearly or quite equalling the width; spire low; volutions about four, casts of the interior usually consisting of two or two and a half, very rapidly expanding, ventricose, the vertical diameter greater than the transverse, subelliptical in cross-section, narrowly rounded above so as to form a deeply impressed suture, and perhaps even more abruptly rounded on the under side where the contour enters a small but distinct umbilical perforation; mouth very moderately oblique, subelliptical; inner lip thin, produced so that it turns partly around the umbilicus; exterior surface marked by rather regular lines, generally less than a mm. apart, crossing the whorls from above almost vertically, a tendency to turn slightly backward being apparent in most specimens; parallel with these, at intervals increasing with age, numerous more or less obscure undulations; indistinct revolving lines, one or two mm. apart, may be observed on the outer surface of good specimens, but on casts of the interior faint impressions of the wrinkles of growth only are visible.

This fine species is distinguished from most of its congeners by its low spire, relatively high and rapidly expanding volutions, and deeply impressed suture.

Formation and locality.—Stones River group, Minneapolis, Cannon Falls and Faribault, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, Nos. 5042, 5554.

HOLOPEA APPRESSA, *n. sp.*

PLATE LXXIX, FIGS. 7–10.

This resembles *H. insignis* but has more slender whorls, a wider umbilical slope, more oblique and differently shaped aperture and more abruptly impressed suture. The whorls also are not nearly so full in the upper part of the outer side.

Formation and locality.—Clitambonites bed of the Trenton group, Goodhue county, Minnesota. A variety with more convex whorls occurs in the lower part of the Trenton group at Burgin, Kentucky.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 6765.

HOLOPEA AMPLA, *n. sp.*

PLATE LXXIX, FIGS. 22–25.

This is a large shell resembling in many respects both *H. insignis* and *H. appressa*. The spire is low but rises higher than in either of those species, the suture is less deeply impressed, the whorls on the whole more rounded in section and the surface undulations stronger. From the former it differs in addition in having a wider umbilicus and more oblique aperture, and from the latter in having the whorls much less sharply rounded on the upper side. *H. similis* is a smaller species and has a smoother surface.

Formation and locality.—Stones River group, Cannon Falls, Minnesota; Mineral Point and Beloit, Wisconsin. The Wisconsin specimens are smaller than those from Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; University of Wisconsin; E. O. Ulrich; W. H. Scofield.

Museum Register, Nos. 5836, 7355.

HOLOPEA SIMILIS, *n. sp.*

PLATE LXXIX, FIG. 26

This shell might be described as a miniature *H. ampla*, were it not that its apical whorls rise higher above the last two, giving it a somewhat acute apex. Comparing it with young examples of that species we find that it has more slender whorls, a higher spire and smoother shell. There is a moderately wide umbilical depression in the base but the perforation is very small, the suture is distinct and sometimes slightly channelled, at other times the top of the whorls is merely flattened; the mouth is rounded and oblique, the exterior surface marked by fine lines of growth which curve rather strongly backward in crossing the whorls from the suture. The specimen figured is above the average in size.

At first we thought this species might be the same as Hall's *H. obliqua*, but after repeated and always fruitless efforts to identify that shell we have decided to give it a new name.

Formation and locality.—Ctenodonta bed of the shales of the Black River group, Minneapolis and St. Paul; also at localities in Goodhue and Fillmore counties. A similar form, but having a larger umbilicus, occurs in the Fusispira bed near Cannon Falls. We have also a specimen from the Lorraine group at Covington, Kentucky, which seems to agree exactly with the Black River form of the species.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 7381.

HOLOPEA ROTUNDA, *n. sp.*

PLATE LXXIX, FIGS. 20 and 21.

Shell thin, of medium to rather large size, with hight and width about equal, consisting of about four rather rapidly enlarging, strongly convex, ventricose whorls; umbilical perforation extremely small, probably closed in some specimens; suture distinct, sometimes faintly canaliculate on the last whorl; aperture somewhat oblique, subelliptical, the hight exceeding the width by about one-seventh; inner lip thin, curved, the edge reflected so as to almost cover the umbilical perforation; surface with obscure lines and an occasional faint wrinkle crossing the whorls from the suture with a slight backward direction.

The spire is not so high and the whorls more ventricose than in our *H. excelsa* and *H. concinnula*, while the umbilicus also is smaller and the aperture more oblique than in the latter. *H. similis* has less uniformly convex whorls and more of an umbilicus, while *H. paludiniformis* Hall seems to have a higher spire and to differ in other respects.

Formation and locality.—Stones River group, Dixon, Illinois; Trenton group, Hartsville, Tennessee.

Collection.—E. O. Ulrich.

HOLOPEA CONCINNULA, *n. sp.*

PLATE LXXIX, FIG. 6.

Hight about 24 mm., width 18 mm., apical angle 72°. Volutions about five, rounded, with a barely perceptible angularity near the middle of the upper part shown in casts of the interior; umbilicus small; very faint undulations and lines of growth, crossing the whorls almost vertically, may be seen on the last whorl.

Of this species we have seen only the cast of the interior figured on plate LXXIX. In its form it resembles *H. paludiniformis* Hall, a Trenton limestone shell in New York, very closely, yet we are fully satisfied that it will prove quite distinct. At present the possession of an umbilical perforation by our species is the only differential feature that our limited knowledge of the New York shell permits us to mention.

Formation and locality.—Stones River group, Beloit, Wisconsin.

Collection.—University of Wisconsin.

Holopea excelsa, *n. sp.*

PLATE LXXIX, FIGS. 11 and 12.

Similar to *H. concinnula* but larger and relatively higher in the spire, with the aperture more oblique (about as in *H. rotunda*), the whorls scarcely so ventricose, and the umbilicus much smaller and probably closed entirely in the shell. Perhaps it is not distinct from *H. paludiniformis* Hall, but if we may rely on Hall's figures of that shell, it differs, excepting the umbilicus, from *H. excelsa* about as *H. concinnula* does.

Formation and locality.—Fusispira bed of the Trenton group, Wykoff, Sumner and Hader, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 285. (A crushed specimen somewhat doubtfully referred to this species.)

Holopea paludiniformis *Hall.*

(Not figured.)

Holopea paludiniformis Hall, 1847, Pal. N. Y., vol. i, p. 171, pl. xxxvii, figs. 3*a*, 3*b*.

A small specimen, apparently of this species, was collected by Mr. E. O. Ulrich in the Clitambonites bed of the Trenton group near Cannon Falls, Minnesota. The specimen is imperfect at the mouth and shows clearly that it has a small umbilical perforation, so it may belong to some other species, unless the prevailing impression that *H. paludiniformis* has no perforation proves erroneous. With this specimen a larger one was found which possibly is the same. We think not, however, since it has a wider umbilicus and an impressed suture, reminding one in both features of *H. appressa.*

Holopea pyrene *Billings.*

PLATE LXXIX, FIGS. 13–18.

Holopea pyrene Billings, 1862, Pal. Foss., vol. i, p. 27.
Holopea perundosa Sardeson, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 336.

Shell obliquely turbinate, spire depressed conical, rising but little above the top of the last whorl; whorls three or four, the inner ones appearing slender, the last somewhat ventricose, subovate in cross section, the vertical diameter considerably greater than the transverse, the upper side of the outline more obtuse than the lower; umbilicus large; suture deeply impressed; aperture slightly oblique; whorls crossed by deep concave undulations separated by rather sharp ridges; lines of growth very obscure in the specimens studied, which seem to be, at least in part, casts of the exterior. Width 33 mm., hight about 27 mm.

It may be that Dr. Sardeson was justified in separating the Minnesota species here described from *H. pyrene*, especially since Billings says that his specimen, which does not show the under side, has a form "much like *H. obliqua* Hall," and comes from a lower geologic horizon than our specimens. It has, however, seemed so unlikely to us that such an extravagant character as the strong undulations of the whorls would appear in two distinct species of the same genus, that we have decided to refer the Minnesota specimens to Billings' species until the latter has been shown to be distinct.

Formation and locality.—Lower part of Fusispira bed, near Cannon Falls, Minnesota.

Collection.—E. O. Ulrich.

Holopea parvula, *n. sp.* (*Ulrich.*)

PLATE LXXIX, FIG. 19.

Shell small, 6 to 10 mm. in width, the hight equalling about three-fourths of the width; spire depressed conical; whorls four, including two very small ones at the apex, neatly rounded, subcircular in section; suture distinct, very slightly canaliculate; umbilicus large, equalling about one-fourth of the diameter of the shell; aperture moderately oblique, rounded, slightly modified above by the preceding whorl; surface with very fine, obscure lines of growth and on the latter half of the body whorl a number of more or less obscure undulations running parallel with the apertural margin.

This shell resembles the inner whorls of *H. pyrene*, but its whorls seem to be proportionally more slender and more nearly circular in section. Though small, the specimens are evidently mature.

Formation and locality.—Upper part of Trenton group, near Burgin, Kentucky.

Collection. —E. O. Ulrich.

HOLOPEA SUPRAPLANA, *n. sp.*

PLATE LXXIX, FIGS. 27 and 28.

Excepting that the whorls increase more rapidly in hight, the general appearance of this shell, especially in dorsal and ventral views, is greatly like *H. insignis*. However, in viewing the upper side, a marked difference will at once strike the observer. The upper side of the whorls, namely, instead of being rounded as in that species, is a sharply defined flat plane sloping gently downward to the suture and extending outward about half the width of the body whorl, as seen in the apical view. The spire is low, the outer side of the body whorl moderately convex, the base turning sharply into a small but undeniable umbilicus; inner lip very thin, reflected so as to form a semitubular prolongation from the umbilicus; aperture very little, if at all oblique; surface markings, excepting a few obscure vertical lines near the mouth, unknown.

We know of two other species of this type, one from the upper Trenton at Nashville, Tennessee, in which the upper plane is less sharply defined, the spire a little higher, and the umbilicus very small; the other from the Richmond group at Richmond, Indiana, and Oxford, Ohio, having the upper plane fully as well defined and wide, but not sloping downward, and the umbilicus much smaller or closed. In the latter the sutural edge of the plane is raised.*

Formation and locality.—Lower half of Fusispira bed, Trenton group, Kenyon, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, No. 7493.

Family CAPULIDÆ.

Genus PLATYCERAS, Conrad.

This genus is only provisionally employed for the following two capuloid shells, and as it includes a host of wonderfully diverse shells, upon which the opinions of paleontologists vary greatly, we have thought it best to use the genus without attempting to give either the synonomy or a diagnosis.

PLATYCERAS (?) WISCONSINENSIS, *n. sp.*

PLATE LXI, FIGS. 49–54.

Shell rather small, capuloid, obliquely subconical, with the hight and width nearly equal; apex obtuse, not spiral, turned slightly to the right or the left, and situated immediately over or curving slightly beyond the apertural margin; aperture more or less obliquely rounded-quadrate, or broadly subovate, the peristome horizontal or irregularly sinuate. Surface of cast smooth or with a few obscure

* As these are both interesting and important species and easily recognized, I propose to call the first *Holopea nashvillensis* and the second *Holopea oxfordensis*.
E. O. ULRICH.

wrinkles of growth; external surface unknown. Muscular scar horseshoe-shaped, situated a little above the midhight.

Formation and locality.—Stones River group, Vanuxemia bed, Beloit, Wisconsin. One of the authors believes he collected casts of this shell also in Minnesota, which is very probable, but as the specimens have been mislaid or lost, we cannot now verify the occurrence of the species in this state.

Collections.—University of Wisconsin; E. O. Ulrich.

PLATYCERAS DEPRESSUM, *n. sp.*

PLATE LXI, FIGS. 55 and 56.

This form may be only a variety of *P. wisconsinensis.* So far as the limited material at hand admits of judging, it differs chiefly in being smaller and relatively lower. It is scarcely probable that either of these species really belong to *Platyceras.* Perhaps they are related to the shells for which Kayser has proposed the genus *Hercynella.*

Formation and locality.—Black River group, Ctenodonta bed, six miles south of Cannon Falls, Minnesota.

Collection.—E. O. Ulrich.

Suborder SUBULITACEA.

Primarily this division is intended to include the Paleozoic *Subulitidæ* and *Loxonematidæ* and the more recent *Eulimidæ* and *Pseudomelaniidæ.* There are other Mesozoic and living shells that are more or less obviously related to the families mentioned and which might perhaps be advantageously classed with them, but it seems to us too early to attempt either a characterization of the suborder or an enumeration of its probable contents.

Family SUBULITIDÆ.

Shell more or less elongate, subulate or fusiform, nearly or quite smooth; aperture elongate, narrow, canaliculate below; no inner lip; columella involute.

Following Lindström's suggestions, we place in this family *Subulites,* Conrad, *Bulimorpha,* Whitfield, *Fusispira,* Hall, and *Euchrysalis,* Laube. To these we add *Cyrtospira,* a new genus, founded on species heretofore regarded as curved forms of *Subulites.*

Genus SUBULITES, Conrad.

Subulites, CONRAD, 1847, Pal. N. Y., vol. i, p. 182; LINDSTRÖM, 1884, Gastropoda of Gotland, p. 193.
? *Polyphemopsis,* PORTLOCK, 1843, Geol. Londonderry, p. 415.

Shell thin and unadorned, slender, subulate or somewhat fusiform in outline; whorls high, flat or very slightly convex on the outer side; suture linear, sometimes scarcely distinguishable, in no case greatly modifying the almost even slope of the slender spire; aperture elongate, narrow, acuminate above, widest and somewhat truncated below, much higher than wide, the width and hight about as one is to four;

outer lip thin, the edge straight above, and strongly recurved below, causing the lower extremity to be broadly arched in an end view; columella thin, involute, terminating abruptly below, above forming a small spiral axial canal; upper whorls of spire usually (?always) filled with organic deposit or shut off from the last three to five whorls by a deeply concave septum, in consequence of which casts of the interior are incomplete above. Type, *S. elongatus* Conrad.

As above described, *Subulites* cannot properly include species like *S. calciferus*, *S. psyche* and *S. daphne* of Billings, and *S. obesus* Whitfield. These agree much better with average forms of *Fusispira*. Of the remaining American species referred by authors to *Subulites*, we remove *S. parvulus* Billings, *S. abbreviatus* Hall, *S. notatus* Billings, *S. ventricosus* Hall, and *S. brevis* Winchell and Marcy, to our new genus *Cyrtospira*, which see. *S. richardsoni* Billings is not sufficiently known to us, but *S. inflatus* Meek and Worthen is a *Fusispira*, while *S. terebriformis* Hall and Whitfield, *S. gracilis* Miller, *S. directus* Fœrste, and *S. compactus* Whiteaves, evidently are good species of *Subulites*. Of European species, *S. attenuatus* Lindström belongs where its describer placed it, but *S. priscus* Eichwald, as figured by Koken, undoubtedly belongs to *Fusispira* and not to *Subulites*.

Of the following species, which, despite the close resemblances prevailing among them, are easily enough distinguished when the specimens are reasonably good, we are fully satisfied that all, with the possible exception of *S. nanus* and *S.* sp. undet., are strictly congeneric with *S. elongatus*. Testiferous examples are extremely rare, and good casts of the interior even are not by any means common. Under the circumstances it is to be regarded as very fortunate that we have succeeded in obtaining specimens showing the form of the aperture of nearly all of the species described. Without the aperture it is sometimes extremely difficult to decide whether a shell is to be called a *Subulites* or a slender, flat-whorled *Fusispira*. If the specimen is a cast and is obtusely terminated above as in figs. 1, 2 and 9, on plate LXXXI, the observer may be reasonably certain that it belongs to *Subulites* Another apparently constant, at any rate very reliable difference is found in the shape of the under side of the whorls. In *Fusispira*, namely, the lower part of the body whorl turns inward more rapidly, causing a stronger concavity in the columellar side of the aperture.

Concerning the systematic value of the characters relied on by us in separating the species, we wish to say merely this: if the value of a character is determined by the relative constancy of its repetition in individuals, and if it is allowable to assume that its value is about the same in all species of the same genus, then the following forms deserve to rank as good species. Of only one species have we more than fifteen good specimens, namely, *S. regularis*. These range in length from 40 to 100 mm., but in every other respect, as far as we can discover, they are absolutely identical. Moreover, the species is recognizable over a geographical range extending from Tennessee and Kentucky to Minnesota in one direction, and Ottawa, Canada, in another.

SUBULITES CONRADI, *n. sp.*

PLATE LXXXI, FIGS. 4 and 5.

Shell extremely elongate-fusiform; the spire slender, long, and tapering not much more gradually than the base, which is somewhat truncated; outline on each side gently arcuate, the lower part of the middle third of the length perfectly cylindrical; whorls flat, about four and a half in casts of the interior, the uppermost of these having an obtuse termination and a diameter of about 6 mm. in a specimen whose greatest diameter is about 15 mm.; whorls preceding this not observed; suture linear; aperture long, very narrow, expanding gradually from the suture, but contracting again near the base; body whorl tapering very gradually.

This agrees rather closely with all that can be made out of Hall's poor figure (Pal. N. Y., vol. i, pl. XXXIX, fig. 5*a*) of Conrad's original type of *S. elongatus*, but as it differs from the other specimens figured by Hall, as well as from specimens obtained from Watertown, N. Y., said to be of Conrad's species, we have hesitated to identify our species with *S. elongatus*.

Formation and locality.—Stones River group, Goodhue county, Minnesota. A specimen recently received from Mr. W. R. Billings, of Ottawa, Canada, who collected it in rocks of the Black River group, associated with *S. canadensis*, near Ottawa, appears to be of this species.

Collections.—E. O. Ulrich (4 specimens); W. H. Scofield (6 specimens).

SUBULITES CANADENSIS, *n. sp.* (*Ulrich.*)

PLATE LXXXI, FIG. 3.

Our figure of this species was made up from several fragments of a *Subulites* collected several years ago at Ottawa, Canada. At that time we supposed that the specimens belonged to *S. elongatus* Conrad, and the figure was prepared to show what we knew, or rather what we believed we knew, of that species. In going over the subject once more we concluded that it was certainly distinct from *S. elongatus*. Quite recently we received several specimens more of the same form from Mr. W. R. Billings, and learned that the species occurs at Ottawa, not in the Trenton limestone, as we supposed, but in the Black River group. As the species seems to be a well-marked form, and distinct from all others known to us, we propose to designate it as above. It is a more robust species than *S. conradi* (one of the fragments before us indicates a total hight of at least 120 mm.), with the aperture wider below, the whorls slightly convex in the spire, and the body whorl more ventricose and tapering more rapidly, while the spire tapers more regularly and more rapidly. The greatest diameter of the largest fragment is 22 mm.

Formation and locality.—Black River group, Lot 3, Con. 3 R., Gloucester, near Ottawa, Canada.

Collection.—E. O. Ulrich.

SUBULITES DIXONENSIS, *n. sp.*

PLATE LXXXI, FIGS. 6–8.

This form is distinguished from *S. conradi* by its wider aperture and more distinct basal truncation; also by the peculiar fullness near the middle of the body whorl, and the more rapid taper downward caused thereby. These differences are shown very clearly by our figures of the two species on plate LXXXI.

Formation and locality.—Three specimens were collected at Dixon, Illinois, where they occurred in the upper part of the Stones River group.

Collection.—E. O. Ulrich.

SUBULITES BELOITENSIS, *n. sp.*

PLATE LXXXI, FIGS. 9–11.

The sides of the spire in this form are not arcuate as in *S. conradi*, and the aperture is wider, while the taper of the body whorl, as seen in a ventral view, is more gradual than in *S. canadensis* and *S. dixonensis*. In one specimen the outer lip, instead of running straight up to the suture, as shown in fig. 10, is turned rather strongly backward in the upper fourth. The same specimen preserves a small patch of the external surface of the shell. This is somewhat glossy and perfectly smooth to the naked eye, but with a good glass some extremely faint lines of growth may be observed; also a revolving line a short distance above the suture.

Formation and locality.—Stones River group, Beloit, Wisconsin.

Collection.—E. O. Ulrich.

SUBULITES PERGRACILIS, *n. sp.*

PLATE LXXXI, FIGS. 12–15.

Of this form we have seen nothing but fragments, like those figured, which were broken out of a solid block of limestone. The shell evidently was extremely slender, with the central and lower parts almost cylindrical. The body whorl tapers very gradually, and the outer lip is strongly recurved, forming a wide and deep canal. The suture is distinctly banded.

Formation and locality.—Fusispira bed of the Trenton group, Wykoff, Minnesota.

Collection.—E. O. Ulrich.

SUBULITES PARVUS, *n. sp.* (*Ulrich.*)

PLATE LXXXI, FIGS. 16 and 17.

Shell small, scarcely 23 mm. in length and 6.5 mm. across the widest part, fusiform; spire tapering more rapidly than usual in the genus, consisting of three or four small, flat whorls; aperture large, comprising more than half the length of the whole shell.

Formation and locality.—Upper part of Stones River group, High Bridge, Kentucky.

Collection.—E. O. Ulrich.

SUBULITES NANUS, *n. sp.* (*Ulrich.*)

PLATE LXXXI, FIGS. 18 and 19.

Shell slender, smooth, fusiform, very small, the largest of three specimens having a hight of 15 mm. and a width of 3 mm.; whorls about five, the apex very acute; aperture elongate, very narrow, not quite half the length of the shell.

A smaller and more slender shell than *S. parvus.*

Formation and locality.—Stones River group ("Glade limestone"), Lebanon, Tennessee; High Bridge, Kentucky.

Collection.—E. O. Ulrich.

SUBULITES REGULARIS, *n. sp.*

PLATE LXXXI, FIGS. 35 and 36; PLATE LXXXII, FIGS. 47 and 48.

Shell 40 to 100 mm. in hight, 10 to 23 mm. in width; hight of aperture about one-third of entire hight of shell; spire tapering regularly, the apical angle 18° to 20°; whorls eight to ten, very gently convex, the hight and width, as shown in spire, about equal; body whorl contracting rapidly in the lower half, the columella relatively narrow; aperture comparatively wide, widest in the middle, the greatest width slightly exceeding a third of the length; outer lip sharp, nearly straight in the upper two-thirds, and strongly rounded, with also a moderate retral sweep, in the lower third; outer surface of shell perfectly smooth in the material at hand. On a fragment of the body whorl, which seems to preserve only the inner layer of the shell, some eight or ten revolving brown bands are shown.

This fine species is readily distinguished from most other species of the genus by its regularly tapering spire, and from others by the unusually abrupt contraction of the lower half of the body whorl. In the last feature, as well as in the resulting shape of the inner wall of the aperture, the species resembles *Fusispira*, particularly such species of that genus as *F. planulata* and *F. nobilis*.

Formation and locality.—Stones River group, Cannon Falls, Minnesota; Murfreesboro, Tennessee; and High Bridge, Kentucky. Also near Ottawa, Canada, where it is said to occur in the Black River limestone.

Collection.—E. O. Ulrich.

SUBULITES, *sp. undet.*

PLATE LXXXI, FIGS. 33, 34, 36 and 37.

Compare *Fusispira? spicula* SARDESON, 1892, Bull. Minn. Acad. Nat. Sci., vol. iii, p. 336, pl. VI, figs. 10 and 11.

We have several specimens of a small *Subulites* agreeing with *S. regularis* in having a regularly tapering spire and rapidly contracting body whorl. The specimens consist of interior casts and testiferous fragments, and at first we thought they belonged to that widely distributed species. A careful comparison, however, shows that the whorls are almost perfectly flat in the spire instead of slightly convex, while the shell has a band at the suture that is not apparent in any examples of *S. regularis.* This banded suture allies the form with *S. beloitensis* and *S. pergracilis,* from which it is distinguished by the shape of its body whorl. The specimens in question are peculiar in one feature when compared with all true species of the genus, namely, the filling of the apical whorls is extremely limited, the casts of the interior being almost as acute at the apex as is the shell itself.

Sardeson's *Fusispira? spicula,* which came from the same bed, may be founded on an imperfect cast of this species, but as he describes the aperture as "subquadrate" and speaks of oblique lines of growth, we hesitate to say that it is. Still, he may be mistaken.

Formation and locality.—Shales of the Black River group, Minneapolis, St. Paul, Chatfield and Fountain, Minnesota. Also at Beloit, Wisconsin, and in the upper part of the Stones River group at High Bridge, Kentucky.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 4050.

Genus CYRTOSPIRA, n. gen. (Ulrich.)

Like *Subulites* excepting (1) that the shells are shorter, especially in the spire, the length of the aperture generally exceeding half of the total hight of the shell; (2) that the shell is curved with one side of the outline straight, the other strongly arcuate, or the axis may be spirally turned so that the shell curves first in one direction and then in another; and (3) the truncation of the lower extremity of the aperture is not so apparent. Types, *C. tortilis* Ulrich and *Subulites ventricosus* Hall.

We have separated this type of shells from *Subulites,* to which it was hitherto referred, not only because it is strikingly different from the typical forms of that genus, but also for the reason that it proves to have been fully established as early as, if not before, the oldest known true *Subulites*;* also because it continues its peculiarities without material modification, and with no apparent tendency to pass into *Subulites*, from the base of the Stones River group to or near the top of the Upper Silurian. *C. tortilis* and *C. bicurvata* are from the first horizon, *C. parvula* Billings sp., from the Black River group, *C. wykoffensis* and *C. abbreviata* Hall sp., from the Trenton group, *C. notatus* Billings sp., from the Anticosti group, and *C. brevis* Winchell and Marcy sp., and *C. ventricosa* Hall sp., which may be the same, from the Niagara and Guelph formations. The vertical range indicated by this list of species having the characters required by *Cyrtospira* is precisely the same as for *Subulites*. Evidently the two groups of shells existed side by side as parallel but distinct genetic lines.

CYRTOSPIRA TORTILIS, *n. sp.* (*Ulrich.*)

PLATE LXXXI, FIGS. 24 and 25.

Shell 22 or 23 mm. in hight, about 10 mm. in width, straight on the side of the aperture and strongly curved on the opposite side, consisting of about four gently convex whorls, of which the apical three constitute but a small part of the whole shell; apical angle about 52°; aperture large, acuminate above, somewhat truncated below, widest in the middle, the length equalling about three times the greatest width and about two-thirds of the entire length of shell; columella rather strongly twisted, turning forward in its lower part.

The large size of the aperture, the strong twist of the columella, obtuse apical angle and slight convexity of the whorls, together form a shell that is readily distinguished from all other species referred to the genus.

Formation and locality.—Lower division of the Stones River group, Murfreesboro, Tennessee.

Collection.—E. O. Ulrich.

CYRTOSPIRA BICURVATA, *n. sp.* (*Ulrich.*)

PLATE LXXXI, FIGS. 21 and 22.

This is a more slender shell than *C. tortilis* and is peculiar in having the apical part turned in the usual direction while the last whorl is curved in the opposite way. The body whorl, as seen in a view of the aperture, tapers very gradually to the lower extremity of the columella.

Formation and locality.—Upper part of Stones River group, High Bridge, Kentucky.

Collection.—E. O. Ulrich.

CYRTOSPIRA WYKOFFENSIS, *n. sp.*

PLATE LXXXI, FIG. 23.

Although the apex is broken away in both of the specimens upon which this species is founded, enough remains to satisfy us that it was more acute than in either of the preceding species. The body whorl tapers gradually as in *C. bicurvata*, but the curve of the shell is all in one direction, while we are convinced that the spire consisted of one or two whorls more than we find in that species.

Formation and locality.—Fusispira bed of the Trenton group, Wykoff, Minnesota.

Collection.—E. O. Ulrich.

*As stated under the description of *Subulites*, *S. calciferus*, *S. daphne* and *S. psyche* of Billings, and *S. obesus* Whitfield, which are older than the Stones River group, are not, strictly speaking, good species of *Subulites*.

Genus FUSISPIRA, Hall.

In part *Murchisonia* and *Subulites* of several authors.
Fusispira, HALL, 1871, Twenty-fourth Rep. N. Y. St. Mus. Nat. Hist., p. 229.

Shell fusiform, spire elevated; whorls generally convex, with distinct sutures, at other times nearly flat with shallow—or enamelled—sutures; aperture longitudinal, elongate ovate or subelliptical, acuminate above, produced below, forming a subrimate canal; outer lip sharp, its edge straight from the suture almost to the involute extremity of the columella; columella nearly vertical, slightly twisted, simple, thin; test varying in thickness, sometimes heavy with indications of broad revolving bands (?color bands); exterior surface smooth, or with rows of minute punctures arranged in either revolving or longitudinal lines. Type, *F. ventricosa* Hall, which seems to be a variety of *F. inflata* Meek and Worthen sp.

The principal difference between this genus and *Subulites*, Conrad, lies in the basal part of the aperture. This is relatively wider and more truncated in that genus. On page 1070 we give other details that may aid the student in discriminating between the two genera. These may be supplemented with the remark that the shell is perhaps always heavier in *Fusispira*, giving deeper and open sutures in clean casts of the interior.

FUSISPIRA INFLATA *Meek* and *Worthen.*

PLATE LXXX, FIGS. 17 and 18.

Subulites inflatus MEEK and WORTHEN, 1870, Proc. Acad. Nat. Sci. Phila., p. 47; also 1875, Geol. Sur. Ill., vol. vi, p. 495.
Fusispira ventricosa HALL, 1871, Twenty-fourth Rep. N. Y. St. Mus. Nat. Hist., p. 229, pl. VIII, fig. 6; WHITFIELD, 1882, Geol. Wis , vol. iv, p. 245, pl. IX, fig. 2.

Casts of the interior comparatively short-fusiform, ventricose, consisting of six or seven convex whorls, the apical angle expanding with each whorl after the third or fourth; average apical angle about 60°. Volutions strongly convex, the last very ventricose and constituting over two-thirds of the entire hight of cast; under side of whorls, as seen along the whole inner side of the aperture, strongly concave, the upper half of the outline meeting the vertical lower or columellar half at an angle of about 135° in the typical form and about 125° in the variety *ventricosa;* suture distinct without being channelled or impressed. Aperture oblique, narrow, the length more than twice the width and a little more than half of the entire length of the cast; base abruptly rounded, forming a shallow canal; outer lip sharp, directed slightly forward in the middle; columella vertical, nearly straight, less than half the length of the aperture, very slightly twisted. Surface of casts smooth, of the shell unknown.

This species is very constant in most respects, and yet a recognizable and apparently persistent difference obtains between the specimens of the Fusispira bed and those of the overlying Maclurea bed. In the latter, namely, and these agree most closely with the Wisconsin types of *F. ventricosa*, the under side of the body volution is slightly more ventricose and rounds in more abruptly where it joins the columella, forming a deeper angle than in the typical form of the species. In Hall's figure, however, the angle is deeper than we have seen it, and, considering the constancy of the part in other specimens, we are inclined to believe that it was drawn deeper than it should be.

Formation and locality.—Rather common in the Fusispira bed at Hader, Aspelund, Wykoff and other localities in Goodhue and Fillmore counties; also in the Maclurea bed (var. *ventricosa*) at Sumner, Stewartville, Wykoff and other localities. Hall's type came from De Pere, Wisconsin; Whitfield had it from Waupun and West Jefferson, in the same state; while Meek and Worthen's types are from Carroll county, Illinois.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, Nos. 286, 7390, 7407, 7428, 7472, 7481, 7495, 8390.

FUSISPIRA INTERMEDIA, *n. sp.*

PLATE LXXX, FIGS. 19—21.

This species is closely related to *F. inflata*, but as shown in our figures, has a much smaller body volution, and relatively higher spire, giving on the whole a much narrower shell. The inner outline of the aperture also is different, while the whorls are much less convex, and the shell smaller. The apical angle increases with growth from about 37° to 45°.

Formation and locality.—Maclurea and Fusispira beds of the Trenton group, Stewartville and nine miles south of Cannon Falls, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O Ulrich.

Museum Register, No. 7451.

FUSISPIRA SUBBREVIS, *n. sp.*

PLATE LXXX, FIGS. 11—16.

This form also is related to *F. inflata* but may be distinguished at once by the fact that its whorls are coiled so that the apical angle, instead of becoming wider with the growth of the shell, remains about the same for the whole spire. The spire also is not so acute in its upper part, the apical angle being about 50°, while it is only about 45° for the first four or five whorls of *F. inflata.* The differences mentioned result in forming a shell that is also much narrower across the middle. *F intermedia* has a more elevated and slender spire.

Formation and locality.—Fusispira and Maclurea beds of the Trenton group, thirteen miles south of Cannon Falls, and Stewartville, Minnesota; Decorah, Iowa.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, Nos. 7362, 8728.

FUSISPIRA SCHUCHERTI, *n. sp.*

PLATE LXXX, FIG. 1.

Shell subfusiform, consisting of about six or seven gradually increasing, depressed-convex volutions; aperture very narrow, oblique, lenticular in outline, its hight forming rather less than two-fifths of the length of the shell; body whorl contracting very gradually; columella thick, involute; test very thick, causing the suture, which is not very distinct on the exterior, to be very deep and open in casts of the interior. Both cast and shell exhibit, the latter the more distinctly, a limited number of distant revolving lines.

This species is widely removed from the preceding forms by its heavy shell. It is a very interesting form, and we regret that we cannot devote more space to its discussion. The specific name is to remind us of Mr. Charles Schuchert, one of our colaborers on the paleontology of Minnesota, who discovered the only specimen known.

Formation and locality.—Black River group, Beloit, Wisconsin.

Collection.—Geological and Natural History Survey of Minnesota.

Museum Register, No. 7322.

Fusispira sulcata, *n. sp.* (*Ulrich.*)

PLATE LXXX, FIGS. 5–7.

Shell subfusiform, consisting of about six, gradually increasing and very depressed-convex whorls, the last one of which forms about two-fifths of the entire length of the shell; apical angle about 32°; suture deep in casts, scarcely distinguishable externally, the shell being thick; aperture elongate, obliquely subelliptical, strongly modified above by the preceding whorl, somewhat acuminate at both ends; surface of cast with several more or less obscure revolving furrows; exterior of shell appearing perfectly smooth and glossy to the naked eye, but under a good glass showing revolving rows of very minute punctæ, as shown in fig. 7.

The whorls are less convex in the spire, the last is more abruptly contracted below, and the test only about half as thick as in *F. schucherti.* The revolving furrows shown on the interior cast distinguish it from all previously described species of the genus.

Formation and locality.—From the base of the Utica group or top of the Trenton, at Roger's gap, Kentucky.

Collection.—E. O. Ulrich.

Fusispira subfusiformis *Hall.*

PLATE LXXXI, FIGS. 38 and 39.

Murchisonia subfusiformis HALL, 1847, Pal. N. Y., vol. i, p. 180; also 1850, Third Rep. N. Y. St. Cab. Nat. Hist., p. 171, pl. IV, fig. 2.
Fusispira subfusiformis HALL, 1871, Twenty-fourth Rep. N. Y. St. Cab. Nat. Hist., p. 229.
? Fusispira subfusiformis S. A. MILLER, 1874, Cin. Quar. Jour. Sci., vol. i, p. 316.

Casts of the interior elongate-subfusiform, the spire elevated, ascending with moderate rapidity, the apical angle 25° or 26°; volutions six or more, casts, however, rarely retaining more than four, very moderately convex and generally about a third wider than high in the spire; last whorl contracting rapidly below; aperture somewhat semi-elliptical, the length equalling about two and one-half times the greatest width, and only a little more than one-third of the total length of the shell; outer lip curving forward slightly in the middle; suture of very moderate depth in casts, from which we assume that the test was thin.

Hall's original figures in his 1847 work give, as he states himself in the museum report cited, "but a very imperfect idea of the species." Furthermore, we are satisfied that his original figures include more than one species, the apical angle and form of the aperture being quite different in figs. 2*a* and 2*c*, pl. XXXIX. In identifying the species we have relied chiefly upon Hall's figure of a better specimen in the third museum report. The species is reported from the Utica group at Cincinnati, but we are inclined to doubt that the form found there is strictly identical with the Trenton originals of the species.

F. subfusiformis is one of several closely related species. Of these *F. terebriformis* Hall, from the Utica group at Cincinnati, has a shorter spire, relatively longer aperture, and more convex whorls.

Formation and locality.—Rare in the Fusispira bed of the Trenton group, in Goodhue and Fillmore counties, Minnesota. Also in the middle portion of the group near Burgin, Kentucky. The species is frequently quoted in lists of Trenton fossils in New York and Canada, but as far as our experience is concerned, it appears that several species are there confused under the one name *subfusiformis*, among them the next described *F. convexa.*

Collection.—E. O. Ulrich.

Fusispira convexa, *n. sp.*

PLATE LXXX, FIGS. 8–10.

This shell resembles *F. subfusiformis* Hall but differs in the following particulars: The apical angle is wider, being from 33° to 37°, the latter in the specimen regarded as the type of the species; the whorls are more depressed and more convex, the result being a deeper suture; the aperture is relatively wider and not so high, the length being but little more than twice the greatest width; and, if we may depend upon the appearance of the suture in casts, the test must have been thicker, though perhaps not greatly so. One of the specimens (pl. LXXX, fig. 8) exhibits four or five obscure revolving furrows on each of the two lower whorls. These probably indicate even closer relations with *F. schucherti*, *F. sulcata* and *F. nobilis*, but we doubt if any one will be likely to confuse the present species with any of those. *F. terebriformis* Hall is a more slender shell and has a longer aperture.

There may be some doubt concerning the specific identity of the two specimens referred to this species on plate LXXX. The larger, which is from Cannon Falls, Minnesota, retains only the mouth and a part of the last two whorls. As near as we can judge from these the apical angle was several degrees narrower than in the specimen from Trenton Falls, New York. In other respects, however, the two agree very well.

Formation and locality.—Trenton group, Trenton Falls, New York; Clitambonites bed, near Cannon Falls, Minnesota.

Collection.—E. O. Ulrich.

Fusispira nobilis, *n. sp.*

PLATE LXXX, FIGS. 2–4.

Shell attaining a hight of 100 mm. and a width of 34 mm., the aperture in such a specimen having a hight of about 44 mm.; apical angle 27° to 30°; whorls six or seven, gently convex, the last sloping rather abruptly inward at the base; aperture acuminate above, narrowly rounded below, somewhat lozenge-shaped in outline, widest in the middle, the length slightly greater than twice the width; surface of cast sometimes showing about seven faint revolving lines on each whorl; test apparently very thin.

The apical angle is wider, the body whorl more abruptly contracted, and the whorls in the spire less convex than in *F. subfusiformis*. *F. convexa* has much more convex and more depressed whorls. In *F. schucherti* and *F. sulcata* the shell is much thicker, while in *F. planulata* the whorls are almost perfectly flat. None of the other species are very closely related.

We are indebted to Dr. C. H. Robbins, of Wykoff, Minnesota, for the best specimen seen by us.

Formation and locality.—Fusispira bed of the Trenton group, Wykoff, Pleasant Grove and Fountain, Minnesota.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich.

Museum Register, No. 7331.

Fusispira planulata, *n. sp.*

PLATE LXXXI, FIGS. 26 and 27.

This species resembles, and doubtless is closely related to, *F. nobilis*, but a critical comparison brings out several good differences. It probably did not attain the size of that noble shell, while the spire is more slender—the apical angle is only 21° as against 27° or more in *F. nobilis*—and forms almost an even cone, the whorls being quite flat and the suture, even in the cast, very slightly impressed. The base of the body whorl also turns inward even more abruptly, the junction between the base and outer side being obtusely angular rather than sharply rounded.

Formation and locality.—Fusispira bed of the Trenton group, Wykoff, Minnesota, where we obtained a single example. It is of smaller size than the illustrated specimen, which we collected some years ago in apparently equivalent strata at Eagle Point, Iowa.

Collection.—E. O. Ulrich.

FUSISPIRA ANGUSTA, *n. sp.*, and var. SUBPLANA, n. var.

PLATE LXXXI, FIGS. 28–32.

This species is represented in the collections before us by fourteen or more casts of the interior. These are slender, with an apical angle of 18° to 20°, and consist of four or five volutions, the perfect shell probably having had several more at the apex. The whorls are unusually high, very slightly convex—almost flat—and separated by very oblique, deep and open sutures, indicating a rather thick shell. The aperture is narrow, somewhat lenticular in outline, and about three times as long as wide. The largest specimens indicate a total hight of about 100 mm.

Figure 32 represents one of two specimens that may be distinguished at least as a good variety, for which we propose the name *subplana*. It differs from the typical form of the species in having an apical angle of 25°, instead of 20° or less, and less distinct sutures, indicating a thinner shell.

Formation and locality.—Fragments of this species are not uncommon in the Clitambonites bed of the Trenton group, at various localities in Goodhue county, and more rarely in the lower part of the Fusispira bed near Cannon Falls and Fountain, Minnesota. It occurs also in the lower half of the same group of rocks near Burgin, Kentucky.

Collections.—Geological and Natural History Survey of Minnesota; E. O. Ulrich; W. H. Scofield.

Museum Register, Nos. 218, 7378, 7423, 8394.

Family LOXONEMATIDÆ.

Genus MEEKOSPIRA, n. gen. (Ulrich.)

Shell elongate conical or somewhat fusiform, consisting of smooth, nearly flat or more distinctly convex, and but slightly overlapping, whorls; aperture subovate, occasionally somewhat effuse below; inner lip slightly reflected, simple, without folds winding about the columella so as to pass out of sight opposite the middle of the aperture, lines of growth nearly or quite straight and vertical. Type, *Eulima?* (later *Polyphemopsis*) *peracuta* Meek and Worthen, Coal Measures, Illinois. Probably congeneric species have been referred to *Melania, Eulima, Polyphemopsis, Macrochilina* and *Subulites.*

We regard this genus as occupying an intermediate position between *Loxonema,* Phillips, and *Soleniscus*, Meek and Worthen (*Macrochilus* Phillips), two genera which in some of their extreme forms border closely upon the ground of the proposed genus. In another direction *Meekospira* approaches *Bulimorpha,* Whitfield, while the new genus on the whole reminds one considerably of the *Eulimidæ* of which some of its species may be the ancestors.

Meekospira will probably include beside the type species also *Polyphemopsis nitidula* and *P. inornata* of Meek and Worthen, of the Coal Measures, *P. louisvillæ* Hall and Whitfield, and *Melania antiqua* Goldfuss, Devonian, *Macrochilina bulima, M. cancellata* and *M. fenestrata* of Lindström and *Subulites* (*Polyphemopsis*) *planilateralis* Fœrste, Upper Silurian, and the Lower Silurian species about to be described, *M. subconica.*

If all these species are indeed genetically related, then *Meekospira* certainly deserves recognition as an independent and long-lived generic type. Of them all, the oldest two (*M. subconica* and *M. planilateralis* Fœrste sp.) are the most like the Carboniferous type of the genus. The others have more convex whorls.

MEEKOSPIRA SUBCONICA, *n. sp.*

PLATE LXXXI, FIGS. 40 and 41.

Shell elongate subconical, apical angle about 33°; hight about 27 mm.; greatest width of body whorl 12 mm.; whorls six or seven, very slightly convex, separated by shallow sutures; base of body whorl somewhat flattened; aperture subquadrate, its width less than the hight; outer lip straight and nearly vertical, viewing it from the side; inner lip thin, passing out of sight a little above the middle of the aperture Surface smooth in the only specimen seen.

This is closely related to *M. planilateralis* Fœrste sp., from the Clinton group in Ohio, but is larger, has a wider apical angle and a more nearly quadrate aperture.

Formation and locality.—Richmond group, Spring Valley, Minnesota.

Collection.—E. O. Ulrich.

APPENDIX TO THE GASTROPODA.

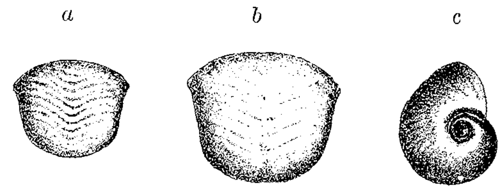

FIG. 10.—*Owenella antiquata* Whitfield sp., Upper Cambrian, Osceola Mills, Wisconsin. *a*, Dorsal view of a small specimen retaining surface markings and showing that there is no slit-band. *b* and *c*, Dorsal and lateral views of a larger specimen showing general form of shell and the umbilicus. The figures are magnified two diameters, and the specimens belong to the U. S. National Museum. (This cut should have appeared at the top of page 848.)

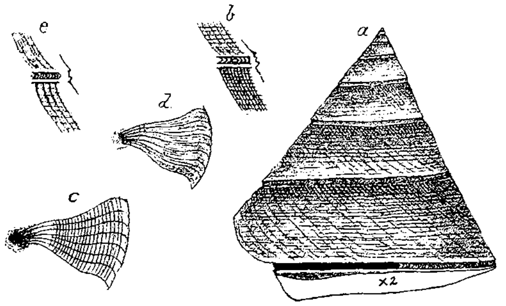

FIG. 11.—*a, b, c, Euconospira planibasalis,* n. sp. (Ulrich), Upper Carboniferous, Kansas City, Missouri. *d, e, Euconospira turbiniformis* Meek and Worthen sp., Coal Measures, La Salle, Illinois. *a*, Side view of an entire specimen of *E. planibasalis*, ×2, showing general form of shell, the flat base, surface

markings, apertural slit and band. The line beneath the figure shows the form of the basal side of *E. turbiniformis*. *b*, The band of the second to the last whorl of same specimen, with a small portion of the surface above and beneath it, ×3. *c*, Portion of the flat under surface of another specimen of *E. planibasalis*, ×2, showing the direction of the lines of growth and the revolving lines which cover nearly the whole of this surface. *d*, Similar portion of the under surface of *E. turbiniformis*, ×2, showing very delicate lines of growth but no revolving lines. *e*, Small portion of slope of spire of same for comparison with fig *b*. The surface markings are appreciably different and the sculpture and section of the slit-band widely at variance in the two species. (This cut should have appeared on page 956.)

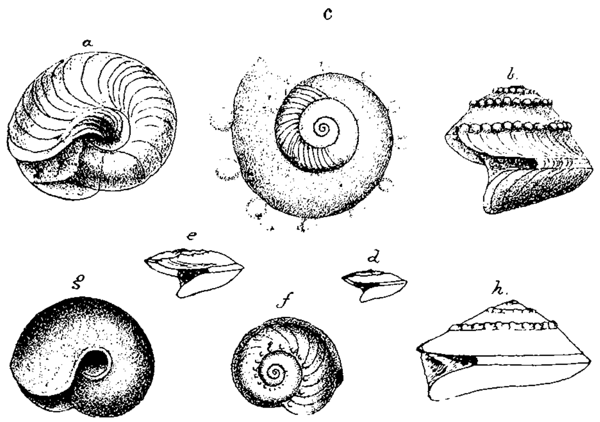

FIG. 12.—Several Carboniferous species of *Trepospira*. *a* and *b*, Two views of a perfect specimen of *T. sphærulata* Conrad sp., showing the depressed apex, short slit, projecting upper lip and other features characterizing in part this genus and species. *c*, Inner whorls of another specimen of this species, ×10, showing several changes which take place in the early development of the shell. Both specimens are from Springfield, Illinois. *d* and *e*, A small specimen of *T. convexa* Ulrich, natural size and magnified, viewed so as to show the depth of the apertural sinus and slit and the depressed convex spire. *f*, The same specimen viewed from above. *g*, Another specimen, also ×2, showing the under side. *T. convexa* is a new species, differing from the others in the gentle convexity of the upper side of the whorls. It is from the Lower Coal Measures at Seville, Illinois. *h*, Lateral view, ×2, of a specimen of *T. illinoisensis* Worthen sp., from Peoria, Illinois. (This cut should have appeared on page 957.)

Errata for the chapter on Gastropoda.

PAGE.

819, 15th to 17th lines from top. As this chapter has taken more space than was expected, it is necessary to omit the classification and summary spoken of in these lines.

846, 5th line from bottom, *C. subplanus*. This species is well figured on plate LXI (figs. 40 to 44), but unfortunately its description was overlooked.

847, add to last paragraph: For figures of Whitfield's species see appendix, page 1080.

871, 10th line from top, between third and fourth words insert inner.

956, add to first paragraph: For figures of species of this genus see appendix, page 1080.

957, add to second paragraph: For figures of this and other species of this genus see appendix, page 1081.

960, 4th line from bottom, for "page ——" read page 951.

978, 12th line from bottom, for "LOPHOSPIRA MULTIGRUMA *Miller*" read LOPHOSPIRA TROPIDOPHORA *Meek sp.*; and to synonomy of the species add: *Pleurotomaria (Scalites?) tropidophora* MEEK, 1873, Pal. Ohio, vol. i, p. 154, pl. XIII, figs. 6*a*, *b*.

979, 6th line from bottom, add: (Not HALL.)

982, 10th line from bottom, under LOPHOSPIRA SAFFORDI insert PLATE LXXIII, FIGS. 49—51.

995, 15th line from top, for "FIGS. 36—38" read FIGS. 35—38.

995, 27th line from top, the shell referred to in the paragraph beginning with this line is illustrated on plate LXXXII by figures 42—44, and is there named *Liospira modesta*.

PLATE LXI.

PAGE.

Figs. 1 and 2 ARCHINACELLA CINGULATA Ulrich 829
Dorsal and profile views of a silicified shell of this species. Black River group, Mercer county, Kentucky.

Figs. 3 to 5 ARCHINACELLA POWERSI U. and S. 829
3 and 5 Profile and dorsal views of a cast of the interior showing muscular impressions in a very satisfactory manner. A, rostral scars; B, antero-laterals; C, the loop: D, a narrow pair flying just within the loop. Stones River group, Beloit, Wisconsin. Collection, University of Wisconsin.
4 Dorsum of same shell as shown by a gutta percha impression of its matrix.

Figs. 6 and 7 ARCHINACELLA RICHMONDENSIS Ulrich 834
Dorsal and profile views of a gutta percha impression of the exterior of the shell which was overgrown by a bryozoan and subsequently dissolved away. Richmond group, Richmond, Indiana.

Figs. 8 and 9 ARCHINACELLA DEPRESSA U. and S. 830
Dorsal and profile views of the type of this species. Stones River group, Minneapolis, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 5523.

Figs. 10 and 11 ARCHINACELLA SIMULATRIX U. and S. 833
Profile and dorsal views of a cast of the exterior from the Phylloporina bed of the Black River group at St. Paul, Minnesota.

Figs. 12 and 13 ARCHINACELLA SEMICARINATA U. and S. 833
Two views of a cast of the interior, showing the carinate umbo and usual form of the species. The linear muscular loop is faintly indicated. Clitambonites bed of the Trenton group, Cannon Falls, Minnesota.

Figs. 14 and 15 ARCHINACELLA VALIDA Sardeson sp. 832
Two views of a rather small specimen of this species. Trenton group (Clitambonites beds), Cannon Falls, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 7417.

Figs. 16 to 20 ARCHINACELLA DELETA Sardeson sp. 831
16 and 20 Two views of an unusually narrow specimen, from Minneapolis. This, like the original of figures 18 and 19, grew upon the inner surface of a spiral shell. A part of the internal cast of the latter now forms the under side of the specimen and gives it the appearance of a bivalved shell.
17 A specimen of the usual size and proportions. Goodhue county, Minnesota.
18 and 19 Two views of a wide cast of the interior. Near Fountain, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 4067.
All from the Ctenodonta bed of the Black River group.

Figs. 21 to 23 ARCHINACELLA INSTABILIS var. INCURVA U. and S. 835
Three views of an imperfect specimen of this variety, the first of the natural size, the others magnified. Ctenodonta bed of the Black River group, Goodhue county, Minnesota.

Figs. 24 and 25 ARCHINACELLA ROTUNDA U. and S. 835
Two views of the cast of the interior upon which this species is founded. The inner border of the continuous muscular loop is sharply preserved, but the extreme point of the rostrum and part of the margin on the left side is wanting in the specimen. Utica group, Graf, Iowa.

Figs. 26 and 27 ARCHINACELLA SUBROTUNDA U. and S. 834
Profile and dorsal views of an entire shell of this species. Ctenodonta bed of the Black River group, near Cannon Falls, Minnesota.

Fig. 28 HELCIONOPSIS SUBCARINATA U. and S. 827
Dorsal view of a partial cast of the interior of this species. The upper line represents the appearance of this part of the outline in another specimen. The radiating lines in the right upper fourth of the figure probably represent muscular imprints. Between these and the margin the specimen shows numerous very fine radiating lines, which we believe correspond with lines upon the external surface of the shell. The profile is very nearly as in figure 20 of this plate. Clitambonites bed of the Trenton group, Goodhue county, Minnesota.

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Figs. 29 and 30 HELCIONOPSIS STRIATA Ulrich 827
Profile and dorsal views of a gutta percha cast of a natural mold of the exterior in the base of a bryozoan. Richmond group, Marion county, Kentucky.

Figs. 31 and 32 SCENELLA RADIALIS U. and S.. 841
Two views of the type of this species. The specimen is a cast of the interior. Trenton group, St. Paul, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 5535.

Figs. 33 and 34 SCENELLA BELOITENSIS U. and S.. 839
Two views of an internal cast preserving muscular imprints. Stones River group, Beloit, Wisconsin. Collection of the University of Wisconsin.

Fig. 35 SCENELLA SUPERBA Billings sp.. 838
Profile view of a specimen of the average size and proportions. Stones River group, Cannon Falls, Minnesota.

Figs. 36 and 37 SCENELLA AFFINIS U. and S.. 840
Two views of a nearly perfect example of the typical form of this species. Besides the transverse wrinkles shown in the figures, the specimen preserves obscure remains of very fine radiating and concentric lines. Black River group, Goodhue county, Minnesota.

Figs. 38 to 41 SCENELLA COMPRESSA U. and S 840

38 to 40 Three views of a cast of the interior, the compressed form slightly exaggerated by pressure. The second outline shown on two of the figures is intended to show the probable original dimensions of the specimen.

41 Portion of external surface, obtained from a gutta percha impression of a natural mold, ×3.

Figs. 42 to 44 STENOTHECA UNGUIFORMIS Ulrich.. 843
Profile and dorsal views of an average example, and part of its surface, ×3. Trenton group, Mercer county, Kentucky.

Figs. 45 to 48 PALÆACMÆA HUMILIS U. and S.. 837

45 and 46 Two views of a small but well preserved example. Ctenodonta bed of the Black River group, Goodhue county, Minnesota.

47 and 48 Similar views of a cast of the interior from the Vanuxemia bed of the Stones River group at Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 5104.

Figs. 49 to 54 PLATYCERAS (?) WISCONSINENSE U. and S.. 1068
Two views each of three casts of the interior showing the variable nature of this shell. Stones River group, Beloit, Wisconsin. Collections of the University of Wisconsin, and of E. O. Ulrich.

Figs. 55 and 56 PLATYCERAS (?) DEPRESSUM U. and S.. 1069
Two views of the type of this species. It preserves the shell and was collected from the Ctenodonta bed of the Black River group, near Cannon Falls, Minnesota.

(Gastropoda.)

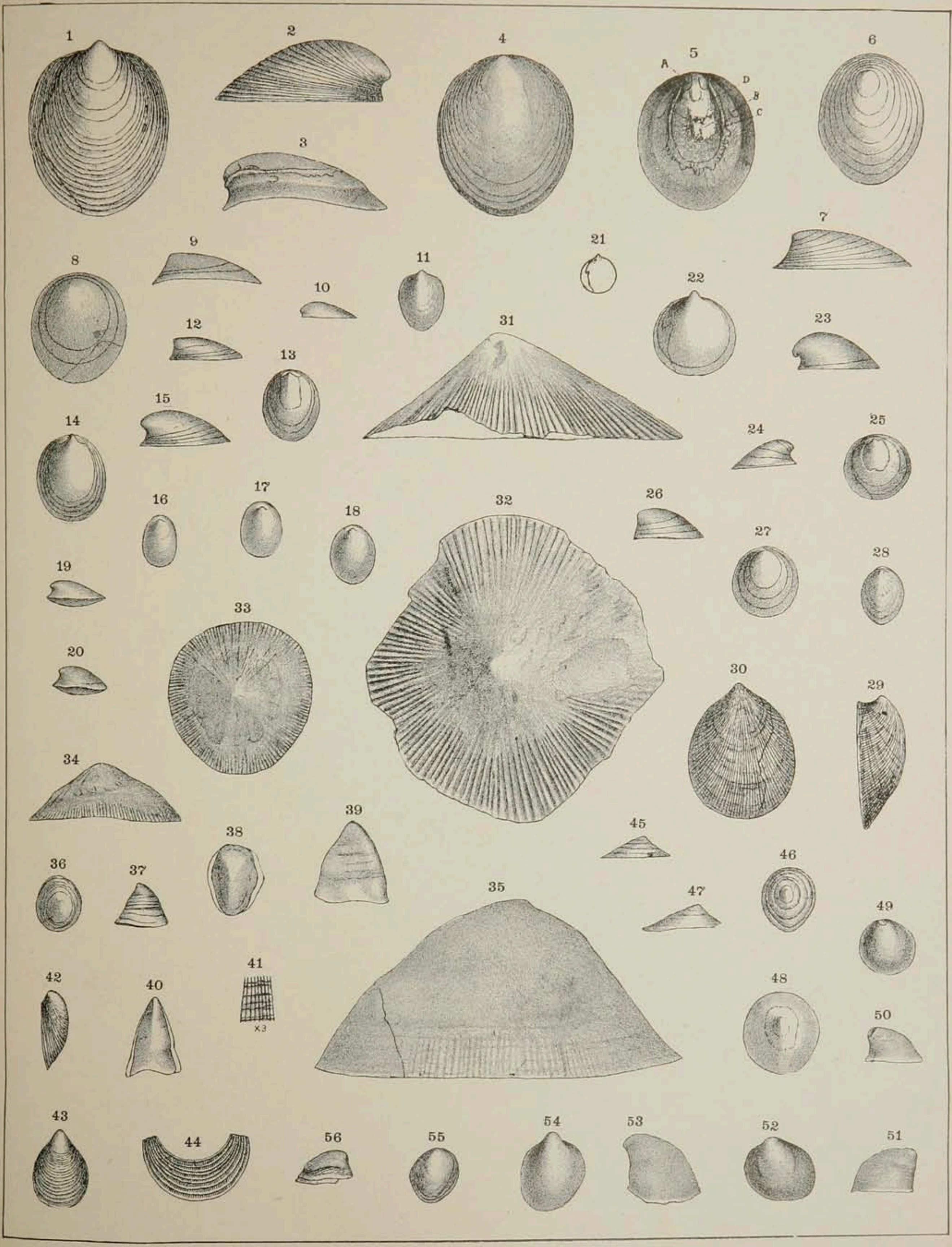
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PLATE LXII.

PAGE.

Figs. 1 to 4 CARINAROPSIS CYMBULA Hall 927
1 Dorsal view of a specimen imperfect at the sides.
2 Diagramatic longitudinal section. The dotted line represents the outline of the lateral margins in a profile view.
3 and 4 Two views of a broken specimen showing the internal septum.
Upper part of Trenton group, near Danville, Kentucky.

Fig. 5 CARINAROPSIS EXPLANATA Ulrich 929
Dorsal view of the imperfect type of this species. It is a cast of the interior. Upper part of Trenton group, Covington, Kentucky.

Figs. 6 to 9 CARINAROPSIS ACUTA U. and S. 928
6 and 7 Dorsal and profile views of a cast of the interior of a young shell. Black River group, near Fountain, Minnesota.
8 and 9 View of the interior of a very large example, and a diagrammatic longitudinal section of the same. Black River group, near Cannon Falls, Minnesota.

Figs. 10 to 13 CARINAROPSIS CUNULÆ Hall 927
10 Dorsal view of an average shell. The margin restored from other specimens.
11 Diagrammatic longitudinal section of same showing outer surface only of the operculum (at "O").
12 Another specimen showing a sharply defined dorsal band.
13 Inner surface of original of figure 10, showing the septum and, above it, a triangular plate which we regard as the operculum.
Trenton group, Nashville, Tennessee.

Figs. 14 to 18 CARINAROPSIS PHALERA Sardeson 928
14 A cast of the interior of this species from the Ctenodonta bed at St. Paul
15 Diagrammatic longitudinal section.
16 and 17 Interior and profile views of an imperfect shell.
18 A specimen broken so as to show the inner surface of the septum. This, like the preceding, is from the Ctenodonta bed at Chatfield, Minnesota.

Fig. 19 CARINAROPSIS MINIMA U. and S. 929
Dorsal view of the type and only known specimen of this species. Black River group, Cannon Falls, Minnesota.

Figs. 20 to 26 CYRTOLITES (?) DILATATUS U. and S. 865
20 to 23 Four views of a large cast of the interior, Beloit, Wisconsin. Collection of the University of Wisconsin.
24 to 26 Three views of a smaller testiferous example, from the Ctenodonta bed of the Black River group, near Cannon Falls, Minnesota.

Figs. 27 to 29 CYRTOLITES ORNATUS Conrad 860
27 Lateral view of a large specimen preserving some of the shell. The surface ornamentation is too delicate to be drawn of the natural size, and only a few of the transverse lines are represented in the figure to give an idea of their direction. Lorraine group, Cincinnati, Ohio.
28 Small portion of the surface markings on the dorsal slopes of another specimen from the same locality, ×10.
29 Dorsum of a third example, from the same locality, ×4.

Figs. 30 and 31 CYRTOLITES ORNATUS var. MINOR U. and S. 861
Lateral and dorsal views of a specimen of this variety, ×2. Clitambonites bed of the Trenton group, Cannon Falls, Minnesota.

Figs. 32 to 37 CYRTOLITES RETRORSUS Ulrich 861
32 and 33 Two views of a large silicified example showing the usual characters of the species. The backward sweep of the transverse markings on the dorsum and the small sutural fold are the principal distinctive features when compared with *C. ornatus*. Trenton group, Tennessee.
34 Surface of a specimen from Kentucky, ×10.
35 to 37 Three views, ×2, of a smaller silicified shell. Trenton group, Mercer county, Kentucky.

Figs. 38 and 39 CYRTOLITES RETRORSUS var. FILLMORENSIS U. and S. .... *
38 One of the largest and best specimens of this variety seen. It is chiefly a cast of the interior. Black River group, near Fountain, Minnesota.
39 The inner whorls of another specimen from the same locality magnified (×10) to show their rounded sides and the ornamentation.

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* Unfortunately the description of this new species was overlooked. Still, it is so well illustrated that it seems highly improbable that any one can fail to recognize it. Of its peculiarities we mention the surface markings and the form of the dorsum which at the center is merely angular instead of sharply keeled. The species is founded on several specimens found by Prof. J. M. Safford and kindly submitted by him to one of the authors for description.

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Figs. 40 to 44 CYRTOLITES SUBPLANUS Ulrich 862

40 and 41 Two views of an incomplete shell, preserving the surface ornamentation. Trenton group, Nashville, Tennessee.

42 and 43 Parts of the dorsal slopes of same, ×4 and ×2, showing the strong transverse lines and weak pittings characterizing the species.

44 Lateral view of a smaller but more complete example, with the surface markings indistinct; from the same locality.

Figs. 45 to 47 CYRTOLITES PARVUS Ulrich.. 864

Three views of the type of this species, two of the natural size, the third ×2. Utica group, Covington, Kentucky.

Figs. 48 and 49 CYRTOLITES DISJUNCTUS U. and S.... 864

Two views of a very perfect example of this species. The surface is ornamented almost exactly as in *C. ornatus*, so that figures 28 and 29 of this plate will serve equally well for both species.

Figs. 50 to 52 CYRTOLITES CARINATUS Miller 862

Three views of a small but characteristic specimen of this species, ×2. Utica group, Newport, Kentucky.

Figs. 53 to 55 CYRTOLITINA NITIDULA Ulrich 866

Three views, the first of the natural size, the others ×2, of one of the original types. The specimen is a cast of the interior but the shell was so thin that it preserves a distinct imprint of the surface markings. Upper part of Trenton group, Covington, Kentucky.

Figs. 56 to 61 BUCANOPSIS CARINIFERA Ulrich 925

56 and 57 Dorsal and lateral views of a large specimen.

58 Apertural view of the largest example seen.

59 to 61 Three views of a third shell, this being of the usual size and proportions. Trenton group, near Danville, Kentucky.

Figs. 62 to 65 OXYDISCUS SUBACUTUS Ulrich.. 913

(See also plate LXXXII)

62 and 63 Apertural and lateral views of a nearly perfect example of this species. The slit portion of the dorsum is broken in the specimen but has been restored in the figures.

64 Transverse section of a whorl, showing thickness of shell.

65 Lateral view of the remains of the largest of twenty-three specimens. All the specimens are from the upper part of the Trenton group near Danville, Kentucky. The figures are slightly magnified (about one and one-sixth).

Fig. 66 CONRADELLA FIMBRIATA U. and S.. 907

(See also plate LXVII.)

Vertical section showing transverse sections of all the whorls and portions of former apertural expansions about two of the inner turns.

Fig. 67 CONRADELLA GRANDIS Ulrich 908

Transverse section of the last whorl of specimen figured on plate LXVII.

Fig. 68 HELICOTOMA UMBILICATA U. and S..... 1034

(See also plate LXXIV.)

Transverse section of the whorls of a specimen from the Stones River group at Dixon, Illinois.

Fig. 69 HELICOTOMA VERTICALIS Ulrich.. 1035

Transverse section of the last whorl of the specimen figured on plate LXXIV.

Fig. 70 ECCYLIOPTERUS BELOITENSIS U. and S.. 1032

(See also plate LXXIV.)

Transverse section of whorl.

Figs. 71 and 72 ECCYLIOPTERUS VOLUTATUS Whitfield sp.... 1031

(See also plate LXXIV.)

Transverse section of the last whorl of two specimens, one with the shell, the other an internal cast only.

Fig. 73 ECCYLIOPTERUS TRIANGULUS Whitfield sp.... 1031

(See also plate LXXIV.)

Transverse section of the outer whorl of a cast.

(Gastropoda.)

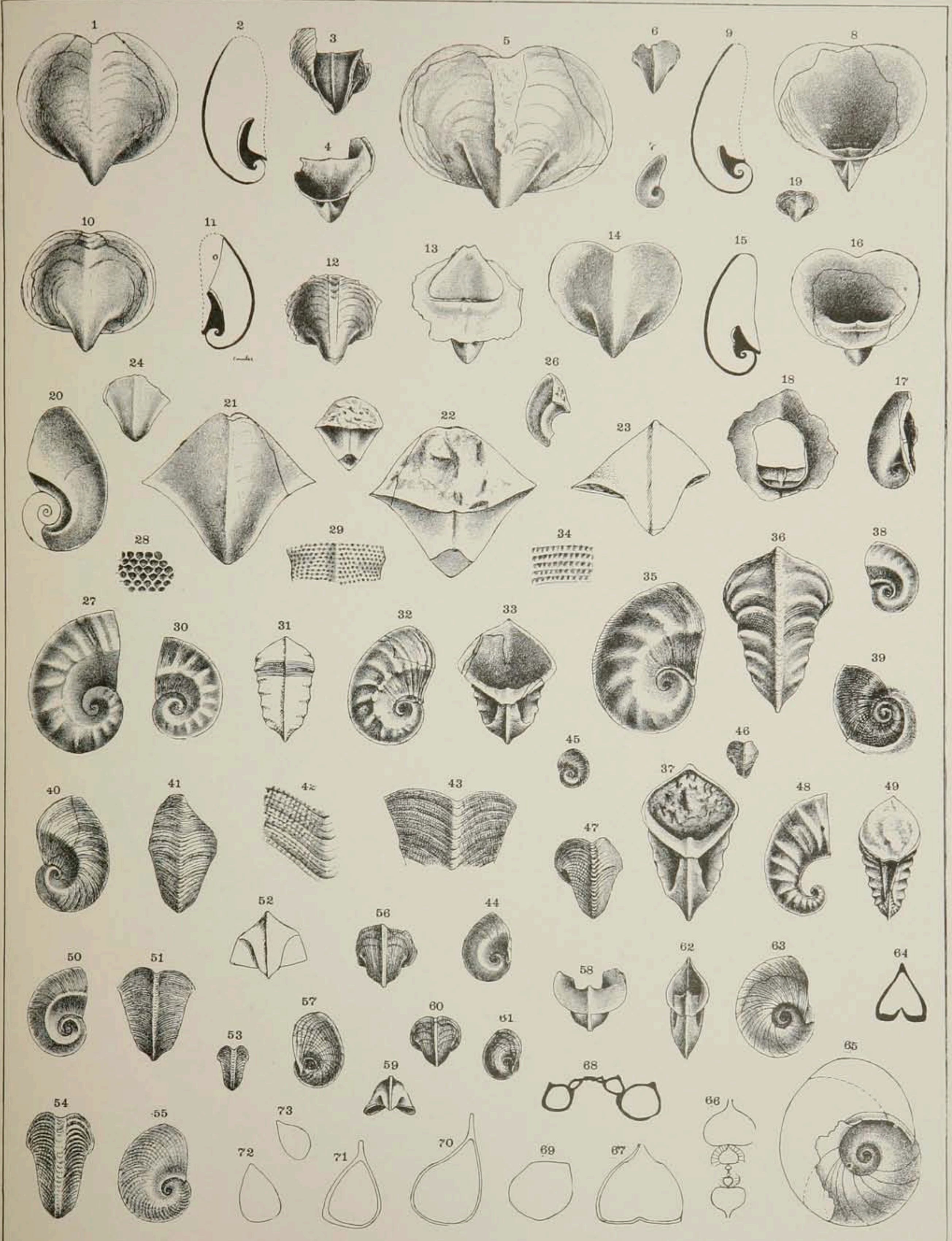
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PLATE LXIII.

		Page.
Figs. 1 to 14	PROTOWARTHIA CANCELLATA Hall sp.	872
1 and 2	Two views of a large cast of the interior, retaining a little of the shell in the umbilicus and having several strong wrinkles of growth near the aperture. Ctenodonta bed of the Black River group, West St. Paul, Minnesota.	
3	Apertural view of a shell having the mouth less expanded than usual. Ctenodonta bed, Goodhue county, Minnesota.	
4 to 6	Three views of an entire shell, representing an average for the species in size and proportions. Ctenodonta bed, Chatfield, Minnesota.	
7 and 8	Two views of a rather small cast of the interior from the Clitambonites bed of the Trenton group in Goodhue county. This is a fair sample of the species as it occurs in this bed.	
9	Surface of a specimen from the Utica group at Covington, Kentucky, ×4.5 and ×9. In certain lights the longitudinal lines look more like a series of minute granules. The right side of the figure corresponds very nearly with the center of the sinus. These fine markings are but rarely preserved on Minnesota specimens.	
10	Outline, in a dorso-lateral view, of left lobe of outer lip of an average example of the species from Covington, Kentucky.	
11	Outline of sinus, lobes and dorsum of same, viewed from above.	
12	Outline of same specimen in a view from below.	
13 and 14	Surface of left lobe of outer lip, ×4.5, and a dorsal view of a more globose and more delicately marked variety, occurring in the Utica group at Covington, Kentucky.	
Figs. 15 to 20	PROTOWARTHIA RECTANGULARIS U. and S.	868
15	Lateral view of a very large specimen—a partial cast of the interior—from the Stones River group, at Mineral Point, Wisconsin.	
16 and 18	Lateral and basal views of a cast having the central part of the back unusually prominent and marked with wrinkles of growth. Beloit, Wisconsin.	
17	Dorsal view of an average cast of the interior. Beloit, Wisconsin.	
19	Outline of right lobe of outer lip of same.	
20	Outline of sinus, lobes and dorsum of same viewed from above.	
Figs. 21 to 27	PROTOWARTHIA PERVOLUTA U. and S.	871
21	Basal view of an incomplete shell showing the granulose expansion which spreads from the aperture over the sides and back of the lower part of the shell. Black River group (Ctenodonta bed), St. Paul, Minnesota.	
22, 24 and 25	Apertural and lateral views of a small but well preserved shell of the natural size, and the lateral view ×2, showing the granulose layer spreading over the basal or inner half of the last whorl and the grano-lineate extensions curving around the umbilical callosity. Black River group, Chatfield, Minnesota.	
23	Transverse section of the outer whorl of a cast.	
26 and 27	Two views of an unusually large cast of the interior from the Black River group of Mercer county, Kentucky.	
Figs. 28 to 30	PROTOWARTHIA GRANISTRIATA Ulrich	870
28	Dorsal view of an average example of this species. Utica group, Covington, Kentucky.	
29 and 30	Apertural and lateral views of another specimen, from the same locality, showing the form of the mouth and the extent of the grano-striate expansion.	
Figs. 31 to 35	PROTOWARTHIA PLANODORSATA Ulrich	871
31 and 32	Dorsal and lateral views of a specimen that has evidently suffered slightly from lateral compression.	
33	Outline of same in a basal view. Utica group, Covington, Kentucky.	
34	Dorsal view of another example, from the same locality, showing normal proportions.	
35	Outline, as seen in a basal view, of another specimen from Covington, agreeing in all respects with other specimens of this species except that it is too wide.	
Figs. 36 to 39	PROTOWARTHIA CONCINNA U. and S.	874
	Four views of the type of this species. Richmond group, Spring Valley, Minnesota.	
Figs. 40 to 44	PROTOWARTHIA SUBCOMPRESSA Ulrich	873
40 to 43	Four views of the best specimen seen. It preserves the two inner layers of shell only and these even are absent in the upper part of the dorsum where the internal cast is exposed. Richmond group, Versailles, Indiana.	
44	Part of the surface of a smaller specimen showing the great width of the sinus and the relative narrowness of the lateral lobes. Butler county, Ohio.	
Figs. 45 to 47	PROTOWARTHIA OBESA Ulrich	874
45 and 46	Dorsal and lateral views of a good but rather small cast of the interior, showing a strong terminal constriction and several of minor depth farther down. Lower part of Trenton group, Danville, Kentucky.	
47	View from above of another specimen showing one of the constrictions and lines of growth beyond it. Mercer county, Kentucky.	
Figs. 48 and 49	BUCANIA SIMULATRIX Ulrich (See also plate LXVII.)	892
	Dorsal and upper views of a good cast of the interior, showing, among other features of the species, the deep sinus and long slit. Richmond group, Richmond, Indiana.	
Figs. 50 and 51	BELLEROPHON CAPAX Ulrich (See also plate LXIV.)	921
50	A specimen preserved in soft shale, from the upper part of the Utica group at Cincinnati, Ohio. The hight of this specimen has been considerably reduced by pressure, but it serves very well in showing the expansion of the aperture, the sinus and the surface markings.	
51	Apertural view of a specimen from the Lorraine group at Covington, Kentucky, that is largely covered by an incrusting bryozoan. The outline and thickness of the latter is indicated by the irregular line about the lower part of the figure.	

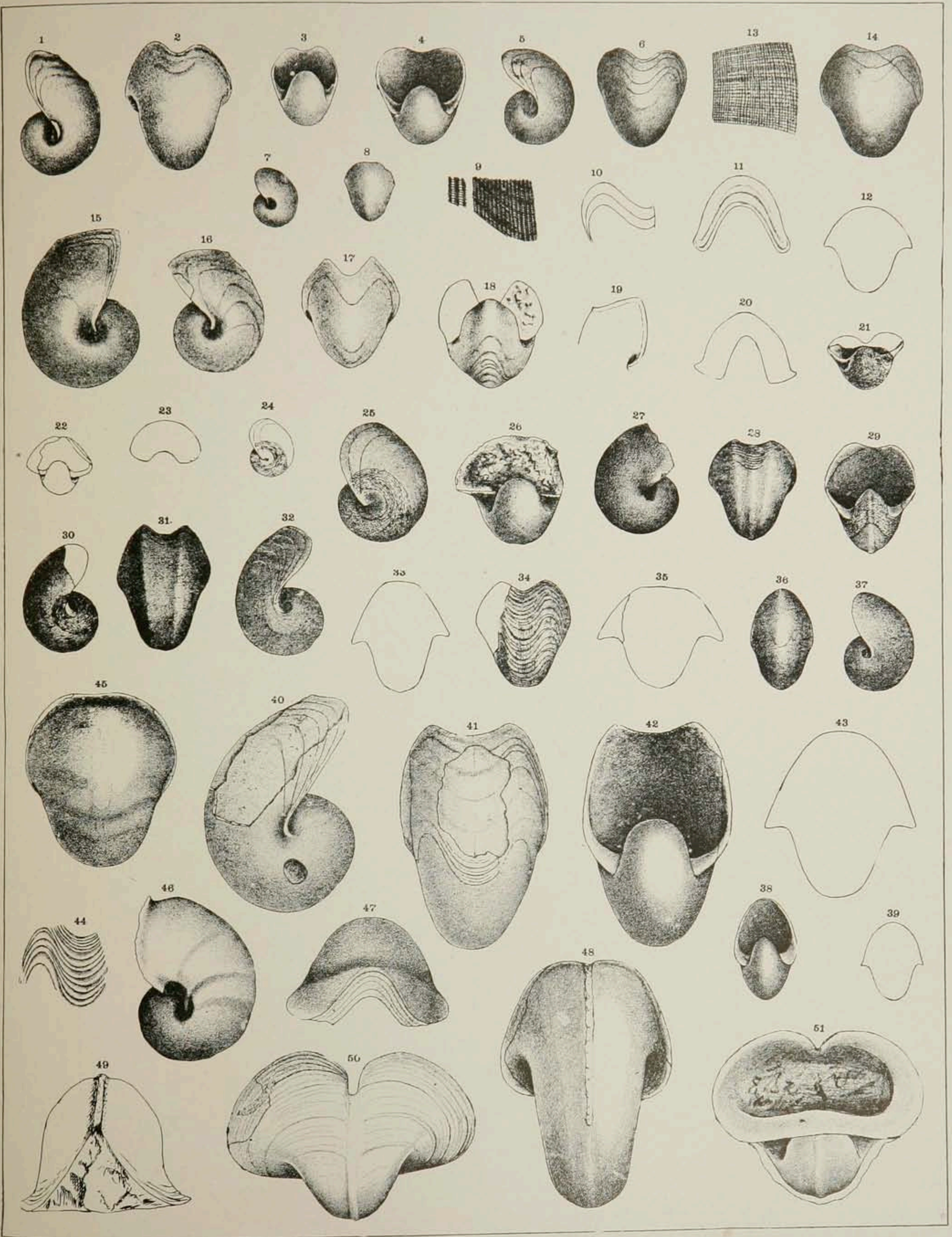
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PLATE LXIV.

			PAGE.
Figs.	1 to 5	BELLEROPHON TROOSTI (D'Orbigny) Safford	915
	1 to 3	Three views of a nearly entire example from the Trenton group near Nashville, Tennessee.	
	4 and 5	Two views of a specimen from Danville, Kentucky.	
Fig.	6	BELLEROPHON TROOSTI var. BURGINENSIS Ulrich	916
		Lateral view showing larger umbilicus and lesser reflection of the lower part of the lip than occurs in typical *B. troosti*. Trenton group, Burgin, Kentucky.	
Figs.	7 to 10	BELLEROPHON CLAUSUS Ulrich	916
	7 and 8	Apertural and lateral views of a silicified shell showing the closed umbilici, strongly reflected and deeply excavated lower lip, the lunulæ on the slit-band, sharp and subequal transverse markings, and other peculiarities of the species when compared with *B. troosti*. Trenton group, middle Tennessee.	
	9	Dorsal view of a smaller specimen from the Trenton at Frankfort, Kentucky.	
	10	Portion of the back of the Tennessee specimen, ×2.	
Figs.	11 to 13	BELLEROPHON RECURVUS Ulrich	920
	11	Dorsal view of a small specimen, probably of this species.	
	12 and 13	Lateral and dorsal views of the type, showing the marked backward sweep of the lines of growth on the back, with a rounded dorsal ridge as in *B. troosti*, and the lip reflected over and completely closing the umbilicus as in *B. clausus*. Lorraine group, Cincinnati, Ohio.	
Figs.	14 to 16	BELLEROPHON SUBANGULARIS Ulrich	920
		Three views of a specimen preserving much of the shell and surface markings. In figure 14 the mouth is turned forward a little more than usual to show the hight of the dorsal carina. Richmond, Indiana.	
Figs.	17 and 18	BELLEROPHON SUBGLOBULUS Ulrich	917
		Dorsal and lateral views of a silicified shell. Black River group, Mercer county, Kentucky.	
Figs.	19 to 21	BELLEROPHON BILINEATUS Ulrich	917
		Three views of a silicified shell showing, of features characterizing the species, the open umbilicus and the concave slit-band with its distinctly elevated bordering lines. Upper part of Trenton group, Danville, Kentucky.	
Figs.	22 to 30	BELLEROPHON PLATYSTOMA Meek and Worthen	918
	22 and 23	Dorsal and lateral views of a small cast of the interior with the lateral expansions of the aperture broken away. Fusispira bed of the Trenton group, Cannon Falls, Minnesota.	
	24 and 25	Two views of a similarly imperfect cast. This specimen was received from Prof. Worthen, who collected it from the Trenton (Galena) limestone at Dixon, Illinois.	
	26	An imperfect cast of the exterior preserving some of the surface markings. Clitambonites bed, Trenton group, Goodhue county, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 6765. The dorsal keel is quite prominent in this specimen and the slopes on each side distinctly concave.	
	27 to 29	Three views of another specimen, from the same horizon as the preceding, retaining part of one side of the outer lip.	
	30	Transverse section of whorl of original of figure 25, the inner line corresponds to the point marked "S" on that figure, the outer represents the section just within the apertural slit.	
Figs.	31 to 39	BELLEROPHON SIMILIS U. and S.	919
	31	Transverse section of whorl. Compare with figure 30.	
	32 and 33	Lateral and basal views of two small imperfect casts of the exterior, showing distinct impressions of the external lines of growth. Fusispira bed, Trenton group, Cannon Falls and Wykoff, Minnesota.	
	34 to 36	Three views of a nearly perfect and large cast of the interior; from the same locality.	
	37	Dorsal view of another large specimen from the locality last mentioned. On the outer parts of this specimen the regular lines of growth are quite distinct, while on the left side several broad longitudinal folds are somewhat obscurely visible.	
	38	Part of the dorsum of another specimen showing the prominent dorsal ridge and the lines of growth curving backward to it.	
	39	View of the aperture of a small example retaining a portion of the inner lip. Clitambonites bed, Trenton group, Cannon Falls, Minnesota.	
Figs.	40 to 43	BELLEROPHON CAPAX Ulrich (See also plate LXIII.)	921
	40 and 41	Two views of a large cast of the interior, imperfect at the aperture. Lorraine group, Covington, Kentucky.	
	42	Lateral view of a smaller cast from the same locality.	
	43	Transverse section of whorl of this and the following species. The sections are taken from casts of the interior, the inner line representing the ventral side of the whorl in *B. mohri*, the lower that of *B. capax*. As shown by the outlines, the surface descends into the umbilicus much more abruptly in the former than in the latter.	
Figs.	44 and 45	BELLEROPHON MOHRI Miller	920
	44	Lateral view of a large cast, imperfect at the aperture. Richmond, Indiana. (Compare with figures 41 and 42, and refer to explanation of figure 43.)	
	45	Apertural view of a testiferous example for comparison with figure 51 on plate LXIII.	
Figs.	46 to 49	KOKENIA COSTALIS U. and S.	882
	46 and 47	Lateral and dorsal views, the inner whorls restored, of the type of this genus and species. Clitambonites bed, Trenton group, Cannon Falls, Minnesota.	
	48	Transverse sections of the last whorl. The lower side of the figure is the dorsal.	
	49	Portion of the broad dorsal band and of the right slope, ×3.	

(Gastropoda.)

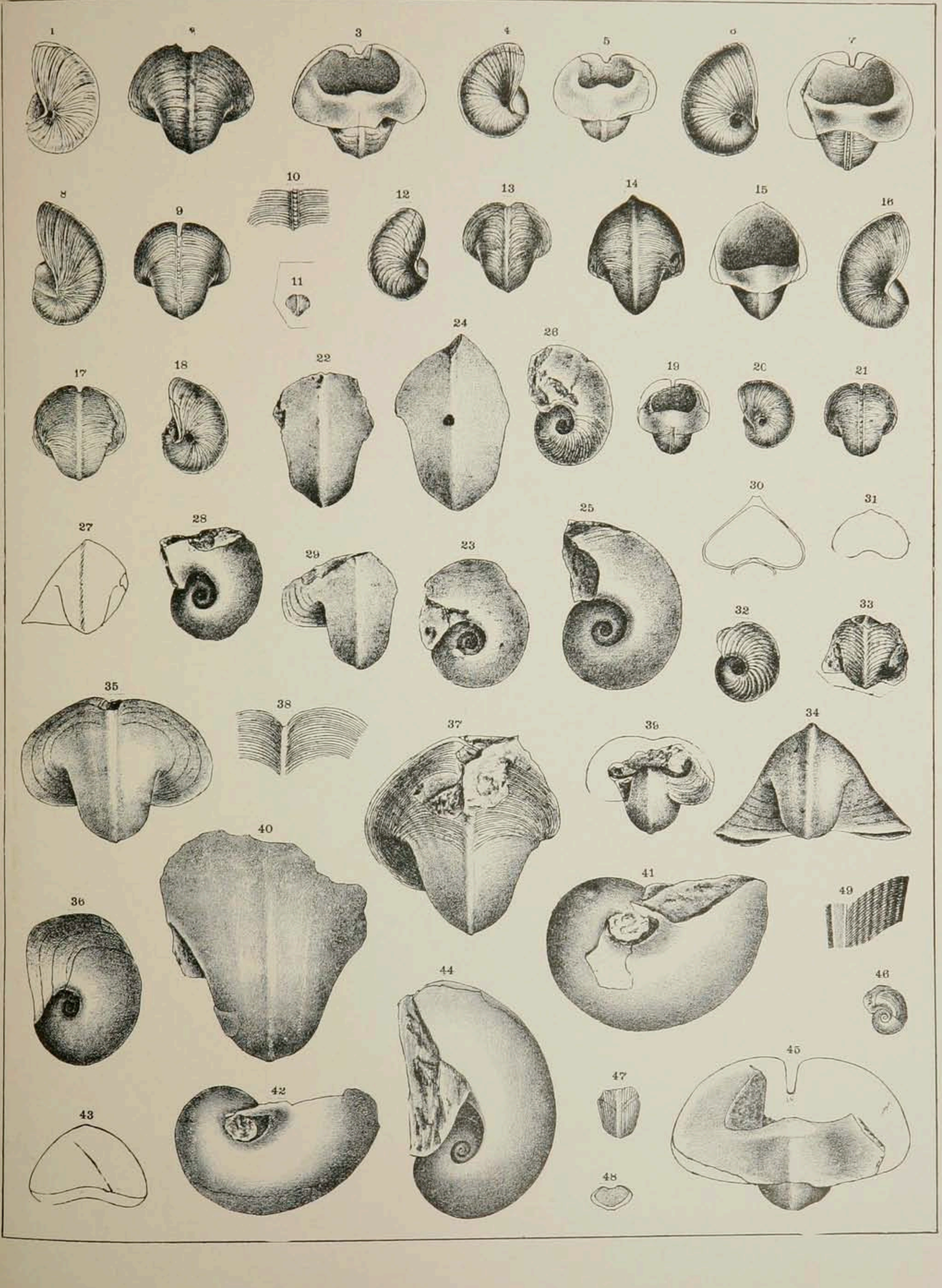

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PLATE LXV.

PAGE.

Figs. 1 and 2 TETRANOTA MACRA U. and S. 879
Dorsal and lateral views of the type of this species. Stones River group, Minneapolis, Minnesota. The specimen is a good cast of the interior and shows the expanded mouth, the peculiarly lean appearance and strongly ribbed character of the fossil.

Figs. 3 to 9 TETRANOTA SEXCARINATA U. and S. 878
3 and 4 Two views of an excellent specimen from the Fusispira bed at Wykoff, Minnesota. Though a cast of the interior, the surface markings are clearly indicated.
5 and 6 Dorsal and lateral views of a cast of an early variety of the species. Stones River group, Minneapolis, Minnesota.
7 Sectional view of preceding specimen.
8 Section of a whorl of a specimen from the Stones River group, at Dixon, Illinois.
9 Section of whorl of Wykoff specimen.

Figs. 10 to 18 TETRANOTA BIDORSATA Hall sp. 877
10 and 11 Two views of a large cast from the lower part of the Fusispira bed near Cannon Falls, Minnesota. This specimen evidently has been somewhat compressed laterally.
12 Another cast tilted forward slightly to show the hight of the central ridge. Clitambonites bed, Goodhue county, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register, No. 7382.
13 and 14 Two views of a specimen with the apertural parts broken away. Clitambonites bed.
15 Another specimen from the Clitambonites bed preserving the apertural margin with some of the surface markings on one side.
16 Surface markings of same. $\times 3$ and $\times 5$.
17 Ventral side of fragment of outer volution showing transverse section of same below and four grooves produced by the dorsal ridges of the preceding whorl. Clitambonites bed.
18 Dorsal view of a small specimen. The majority of the specimens seen from the Clitambonites bed range in size between this and figure 13.

Figs. 19 to 23 TETRANOTA OBSOLETA U. and S. 880
19 and 20 Dorsal and apertural views of a testiferous example on which the slit-band has remained concave throughout the growth of the shell. Ctenodonta bed, Chatfield, Minnesota.
21 to 23 Three views of the specimen which we regard as the type of the species. Though retaining the shell, we have failed to discover any remains of surface markings. Ctenodonta bed, Goodhue county, Minnesota.

Figs. 24 and 25 TETRANOTA, sp. undet. 880
24 Dorsal view of a good cast of the interior from the Utica group at Cincinnati, Ohio. This specimen may represent a later variety of *T. bidorsata* Hall, but in the obsolesence of the latero-dorsal ridges, as may be seen from the basal outline, it agrees more closely with *T. obsoleta.*
25 Dorsal view of a cast of the interior of an undescribed species of this genus. Stones River group, Minneapolis, Minnesota. The ridges in this species, of which our material is not sufficient to warrant us in giving it a name, are unusually obscure.

Figs. 26 to 29 TETRANOTA WISCONSINENSIS Whitfield sp. 881
26 Dorsal view of a large and nearly perfect cast of the interior. Stones River group, Beloit, Wisconsin. Collection, University of Wisconsin.
27 View of same with the smaller volutions removed, showing the ventral side of the outer whorl with the four furrows which are always found here in species of *Tetranota.*
28 Lateral view of same.
29 Dorsal view of a very small specimen supposed to be the young of this species. Minneapolis, Minnesota.

Fig. 30 SCHIZOLOPHA TEXTILIS Ulrich 992
A specimen showing the slit in the outer lip and preserving some of the delicate surface markings. The enlargement of the latter ($\times 2$) represents part of the upper third of the last whorl to the suture line and above this the slit-band of the preceding whorl. Upper part of Trenton group, Nashville, Tennessee.

Figs. 31 to 37 SCHIZOLOPHA MOOREI Ulrich 992
31 and 32 Two views of a nearly perfect cast of the interior of the typical form of this species showing the slit, the great prominence of the carina on the last whorl, the umbilicus, and other characteristic features. Richmond group, Richmond, Indiana.
33 Gutta percha impression from a natural mold of the exterior, showing the coarse surface markings. Richmond, Indiana.
34 Outer third of the last whorl of a specimen overgrown by a species of *Protarea,* which originally covered all of the exterior of the shell excepting the slit in the aperture. Locality, same as preceding.
35 Transverse section of the last whorl of a cast from the same horizon and locality. The small indentation on the umbilical side (left side of figure) is characteristic for the typical form of the species.
36 Transverse section of the last whorl of a small variety occurring in the Lorraine group at Cincinnati, Ohio. In casts of this form the peripheral angle is less prominent than in the typical form, and there is no indentation on the umbilical side. (Compare with figure 35.)
37 Vertical section of an unusually high, testiferous example of the Cincinnati variety.

Figs. 38 to 40 LOPHOSPIRA (?) KNOXVILLENSIS Ulrich 989
38 and 39 Umbilical and apertural views of a specimen showing the general form of the shell, which is much as in *Trochonema,* with the distinct peripheral band of a *Lophospira.* Knoxville, Tennessee. (? Chazy group.)
40 View of the umbilical side of another specimen from the same locality.

Figs. 41 to 44 LOPHOSPIRA? TROCHONEMOIDES Ulrich 990
Four views of the type of this species.

(Gastropoda.)

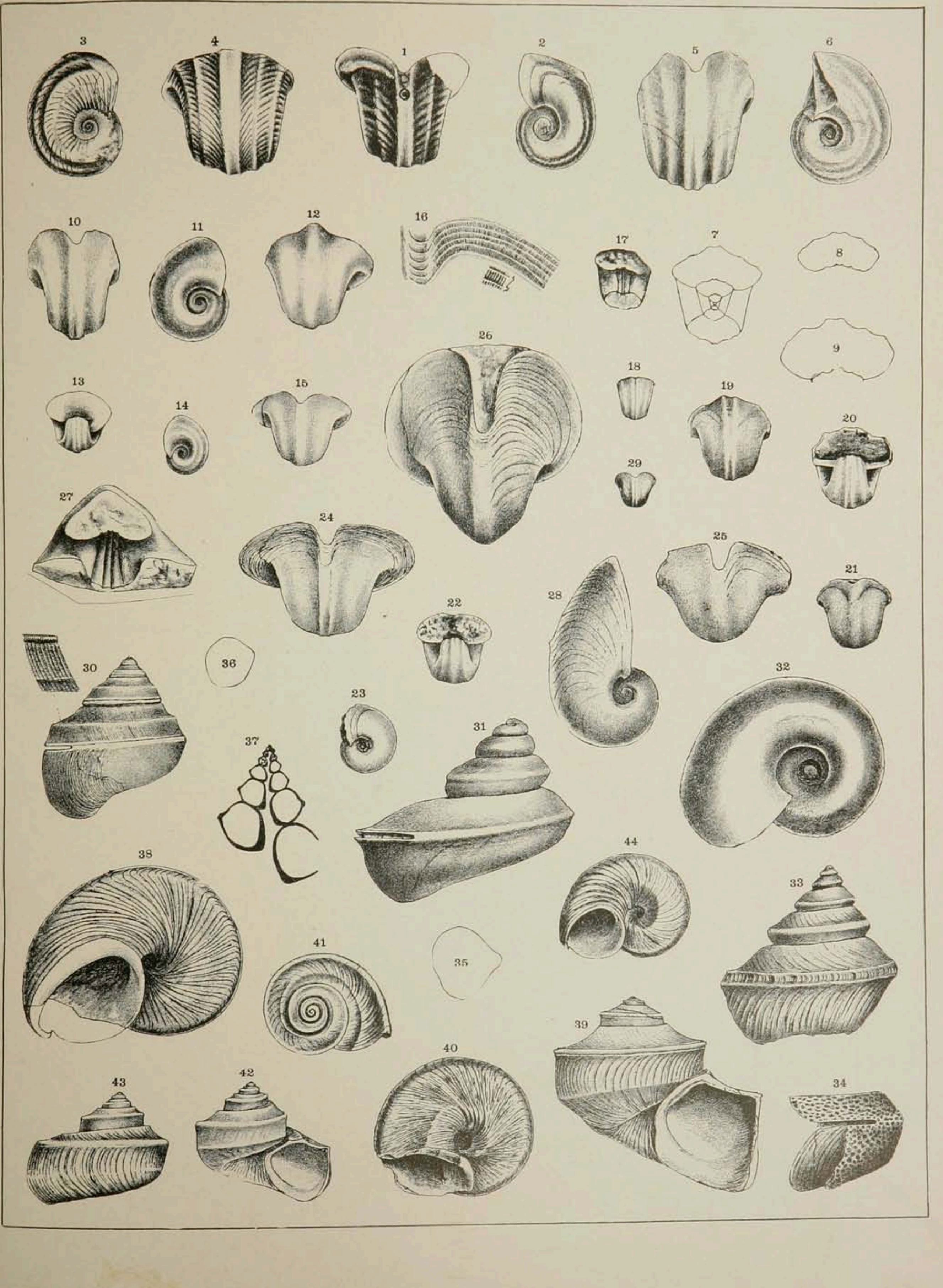
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PLATE LXVI.

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Figs. 1 to 3 BUCANIA EMMONSI U. and S. 887

1 and 3 Dorsal and lateral views of a specimen from the "Central limestone" of the Stones River group at Murfreesboro, Tennessee, showing surface markings, the narrow, impressed slit-band, and peculiar indentations along the suture line.

2 Apertural view of a specimen from the Black River group near Fountain, Minnesota, showing ribs on inner surface of ventral side of last whorl. In both of these specimens the slit portion of the last whorl (i. e., about half a turn) is broken away.

Figs. 4 to 8 BUCANIA HALLI U. and S. 886

4 and 5 Two views of a specimen retaining surface markings. About one-third of last whorl broken away. Stones River group, Cannon Falls, Minnesota.

6 View of the umbilicus of a coarsely silicified shell, showing its nearly even slope. Black River group, Mercer county, Kentucky.

7 Transverse section of inner volutions of specimen represented by figures 4 and 5.

8 Transverse section of a whorl of an internal cast from Mercer county, Kentucky. This specimen is somewhat doubtfully referred to this species, the back being unusually convex and the sides too blunt.

Figs. 9 and 10 BUCANIA MINNESOTENSIS U. and S. 887

Two views of the type of this species. Stones River group, Cannon Falls, Minnesota. The specimen is a cast of the interior and slightly distorted, but preserves some of the surface markings and shows the peculiar impression of the umbilical slope. It is to be noted also that the perfect shell was considerably larger, a third volution at least being absent.

Figs. 11 and 12 BUCANIA ELLIPTICA U. and S. 888

Two views of the cast regarded as the type of this species. Fusispira bed, Trenton group, near Cannon Falls, Minnesota. As usual with specimens of this genus, the slit portion of the last whorl is wanting.

Figs. 13 to 15 BUCANIA RUGATINA Ulrich 890

Three views of a silicified shell, imperfect at the aperture. Upper part of Trenton group, near Burgin, Kentucky

Figs. 16 to 19 BUCANIA SUBLATA U. and S. 888

16 to 18 Three views of a small silicified specimen. The surface markings have been destroyed excepting for a short distance beneath the edge of the lower lip (see figure 18). Trenton group, near Burgin, Kentucky.

19 Imperfect cast of the interior, probably of this species. Stones River group, Minneapolis, Minnesota.

Figs. 20 to 23 BUCANIA SUBANGULATA Ulrich 891

20 and 21 An imperfect and somewhat macerated silicified example, showing the angular dorsum and part of the expanded apertural margin. Trenton group, near Burgin, Kentucky.

22 and 23 A similar specimen from the same locality, showing the slit-band and surface markings.

Figs. 24 and 25 BUCANIA LINDSLEYI Safford sp. 889

Two views of the original type of this species. Trenton group, DeKalb county, Tennessee. The specimen is partly coated by a parasitic bryozoan, as shown in Safford's figures, but we thought it best to draw it without these disfiguring patches.

Figs. 26 to 29 BUCANIA MICRONEMA Ulrich 892

26 to 28 Three views o the silicified type, showing the unusually rapid expansion of the volutions Trenton group, Danville, Kentucky.

29 Part of dorsum of same $\times 2$, showing the delicate surface markings, the posterior end of the slit, and the slit-band.

(Gastropoda.)

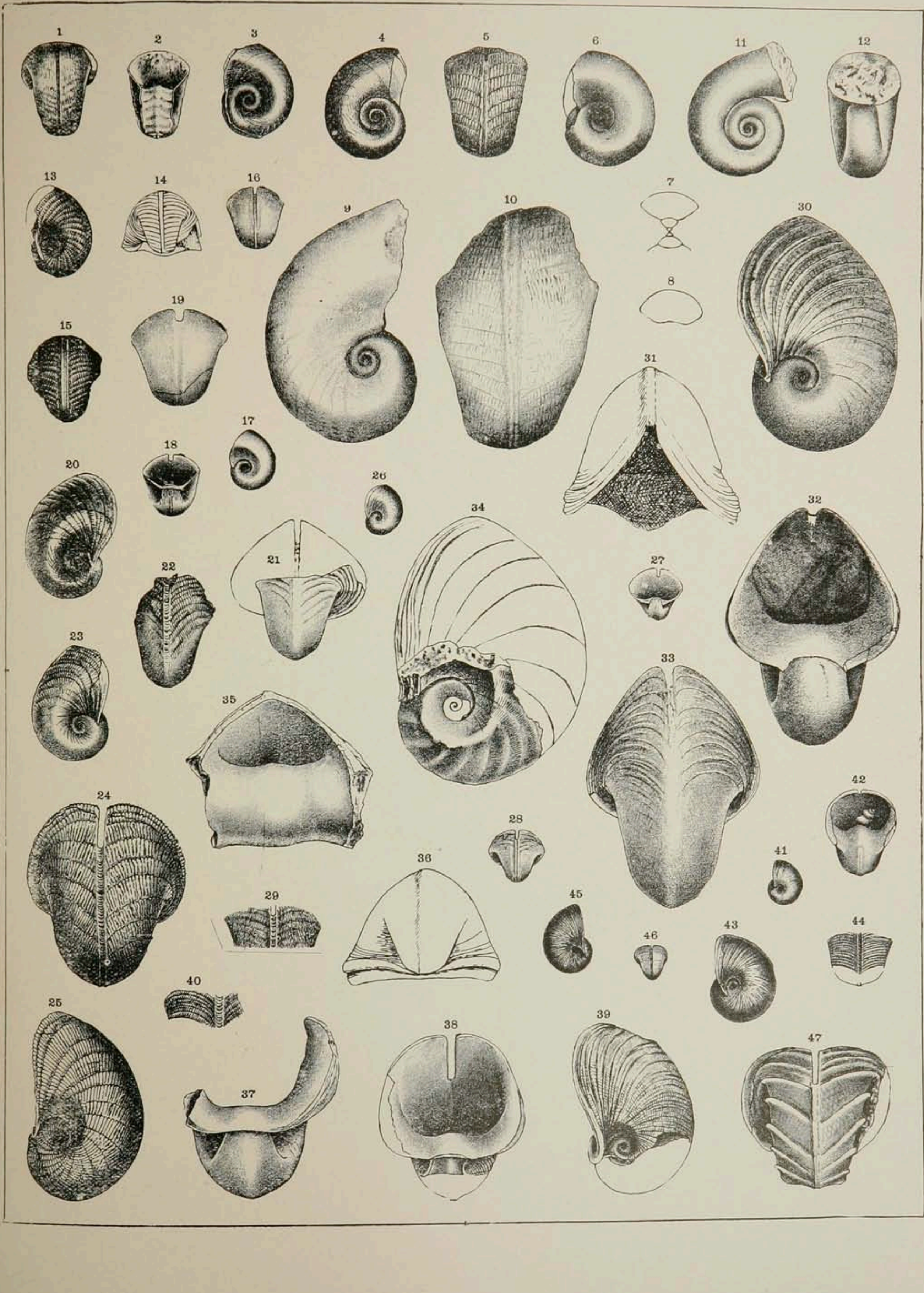
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PLATE LXVII.

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Figs. 1 to 6 CONRADELLA OBLIQUA U. and S. 906

1 Lateral view of an almost perfect and unusually large specimen, showing the decided obliquity of the transverse lamellæ which characterizes this species. Shales of the Black River group, Cannon Falls, Minnesota.

2 and 3 Two views of another specimen, slightly exceeding the average size. St. Paul, Minnesota.

4 Parts of two whorls of another specimen from St. Paul, ×2, the slight denticulations of the edge representing the prominent lunulæ of the slit-band. The decline at the upper right-hand corner of the figure is at the beginning of the open slit.

5 View of the back of part of the slit portion of a third specimen from St. Paul, ×2, having unusually prominent imbrications.

6 Dorsal surface, ×4, of same specimen that furnished figure 4, showing salient slit-band with its distant lunulæ, and surface markings.

Figs. 7 to 10 CONRADELLA FIMBRIATA U. and S. 907

(See also plate LXII.)

7 and 8 Two views of a large specimen. Stones River group, Minneapolis, Minnesota. The umbilicus is filled with stony matter and the left side of the apertural expansion broken away in the original of these figures, but as the missing and hidden parts are clearly shown by other specimens, no apology is necessary for restoring them in the drawings.

9 Portion of the terminal expansion and of the broken bases of two preceding expansions of same, ×2.5, showing fine surface markings. The right margin of the figure represents the edge of the slit.

10 Apertural view of a small specimen showing the expansion entire on one side. Geological and Natural History Survey of Minnesota, Museum Register No. 8724.

Fig. 11 CONRADELLA IMBRICATA Meek and Worthen sp. 911

Lateral view of a small but highly characteristic specimen of this species. Trenton group, Alexander county, Illinois.

Figs. 12 to 15 CONRADELLA ELEGANS Miller sp. 911

12 Lateral view of a specimen of the usual size, Lorraine group, Cincinnati, Ohio.

13 and 14 Lateral view of the natural size, and apertural view ×2, of the largest specimen seen; from the same locality.

15 Small portion of the left dorsal slope of same, ×4.

Figs. 16 to 18 CONRADELLA GRANDIS Ulrich 908

(See also plate LXII.)

16 and 17 Two views of a large specimen of this species. Stones River group, Lebanon, Tennessee. The specimen occurred in solid limestone, one side being now a cast of the interior, while the other retains some of the shell with the broken bases only of the transverse lamellæ.

18 Small part of the side of another specimen showing the imbricating lamellæ entire.

Figs. 19 to 22 CONRADELLA TRIANGULARIS U. and S. 908

19 to 21 Lateral views of three specimens showing very decided variability in the number of the transverse imbrications. All are from the Stones River group; the first, from Beloit, Wisconsin, has unusually numerous imbrications; in the second, from Dixon, Illinois, they are much fewer in number; in the third, from Minneapolis, Minnesota, their number is not far from an average for the species.

22 Section of a specimen from Dixon, Illinois, cutting the whorls transversely.

Figs. 23 to 26 CONRADELLA BELLULA Ulrich 910

23 and 24 Lateral and apertural views, the first of the natural size, the second ×2.4, of an apparently perfect example. Lorraine group, Covington, Kentucky.

25 Part of a dorsal view of same ×4, showing the slit-band and wavy surface imbrications.

26 Small part of surface in a lateral view, ×4.

(Gastropoda.)

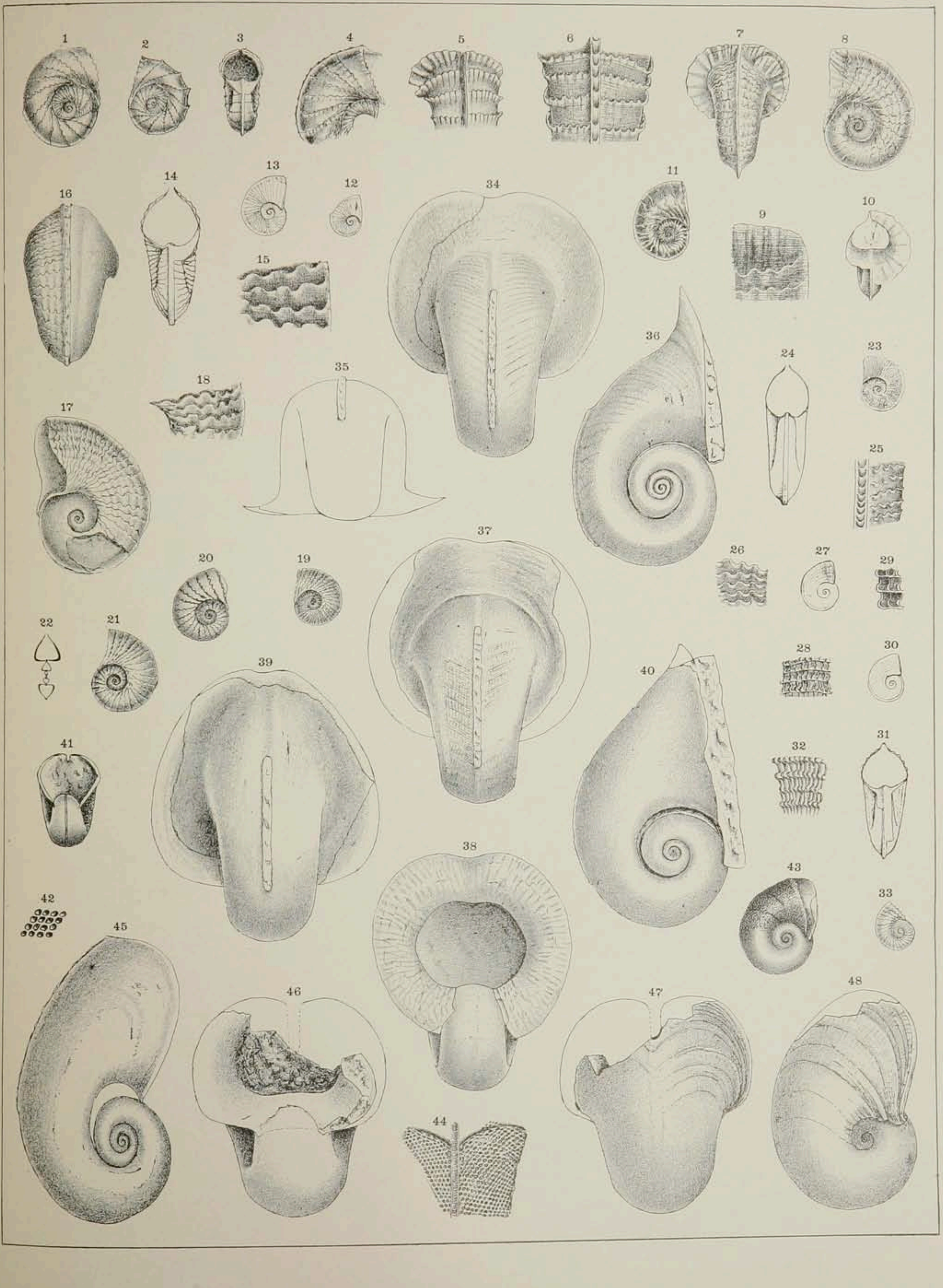
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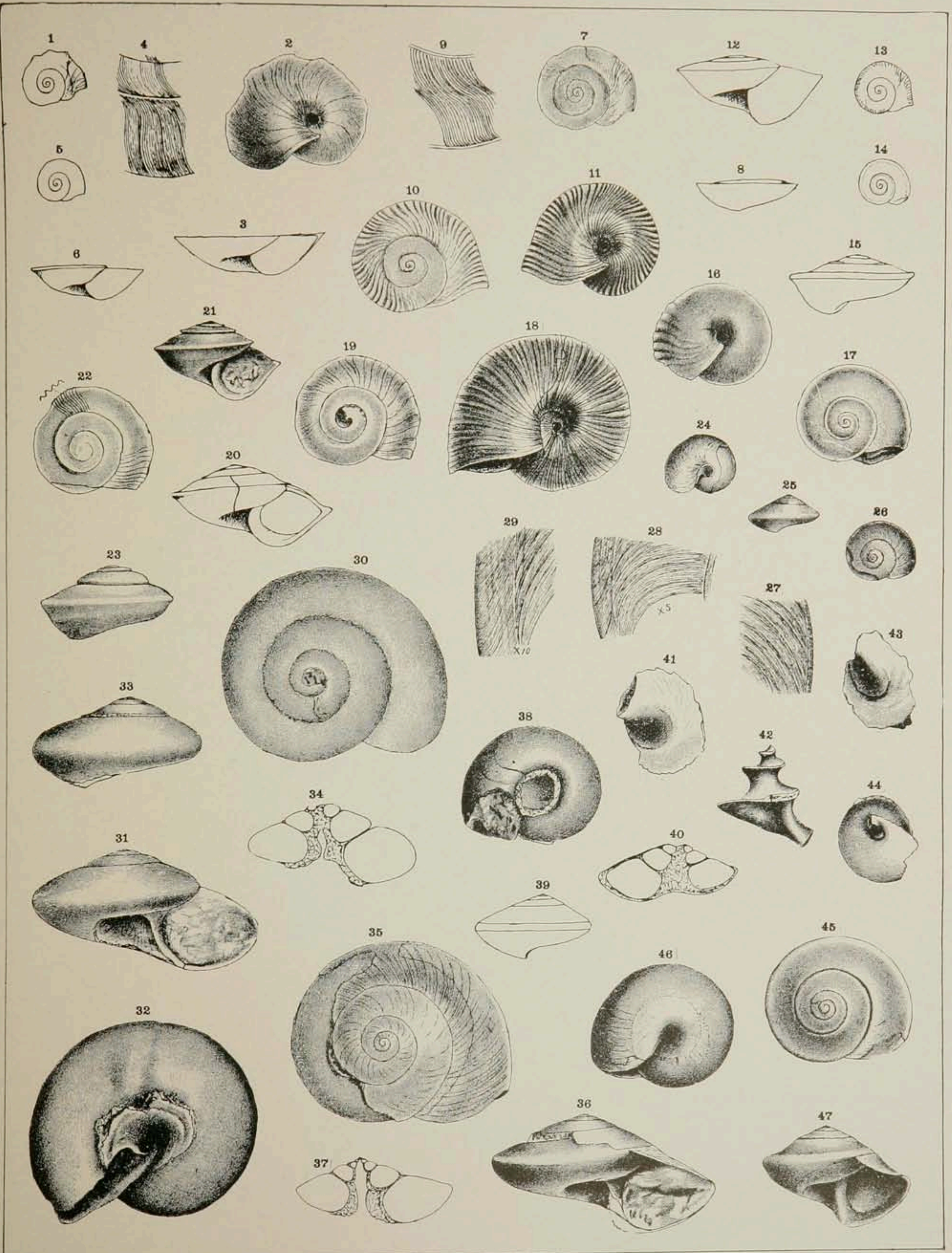
PLATE LXVIII.

		PAGE.
Figs. 1 to 6	RAPHISTOMA PERACUTUM U. and S.	940
1	Outline view of the flat side of a specimen preserving the shell with some of the surface markings. Ctenodonta bed, Black River group, near Cannon Falls, Minnesota.	
2	Umbilical side of the same, ×2.	
3	Apertural view of same, ×2, showing extremely acute periphery and slightly sunken spire.	
4	Small portion of outer whorl of figure 1, ×5, showing fine regular lines of growth of the delicate raised line interrupting their continuity about a third of the width of the whorl from the suture.	
5	Apical side of another example, from the same locality.	
6	Apertural view of same, ×2. The spire is not sunken in this specimen.	
Figs. 7 to 9	RAPHISTOMA RICHMONDENSE Ulrich	941
7 and 8	Two views of a specimen retaining some of the shell. Richmond group, Richmond, Indiana.	
9	Small part of the upper side of the last whorl of same, ×4, showing curvature of the sub-equal striae and the wire-like peripheral edge. The latter forms the lower boundary of the figure.	
Figs. 10 to 13	RAPHISTOMINA RUGATA U. and S.	944
	Four views, the last of the natural size, the others ×2, of an entire cast, apparently of the exterior of the shell. The unusual strength of the transverse striae is the most striking of the specific peculiarities of this species. Trenton group, Clitambonites bed, Goodhue county, Minnesota.	
Figs. 14 to 17	RAPHISTOMINA MODESTA Ulrich	943
	Four views, the first of the natural size, the others ×2, of the silicified type of this species. The peripheral wrinkles shown in figure 16 may have extended all around originally. Stones River group, Murfreesboro, Tenn.	
Figs. 18 to 20	RAPHISTOMINA LAPICIDA Salter sp.	942
18	Umbilical side of a large specimen, the apertural portion restored in the figure. Black River group, near Lebanon, Tennessee.	
19	Upper side of another specimen, from the same locality.	
20	Apertural view, with the apical whorls restored, of a third specimen, from the same locality.	
Figs. 21 to 23	RAPHISTOMINA DENTICULATA Ulrich	943
21 and 22	Two views of a coarsely silicified shell of this species. The surface markings are very obscure except on a small portion of the upper part of figure 22 where the denticulations of the periphery also are shown. Black River group, Mercer county, Kentucky.	
23	Dorsal view of a partial cast of the interior from the same locality, showing the obscure ridge beneath the peripheral angle.	
Figs. 24 to 29	LIOSPIRA MICULA Hall sp.	994
24 to 26	Three views of a large and nearly perfect example of this species. Utica group, Covington, Kentucky.	
27	Portion of the under side of same, ×5, showing surface markings and lower part of peripheral band. The portion of the latter exposed in this view is very narrow.	
28	Portion of upper side of last whorl of same, ×5, showing delicate lines of growth, the broad and faintly defined peripheral band, and obscure revolving lines on the latter. Such revolving lines often extend over the whole upper side of the whorls.	
29	Peripheral portion of preceding more highly magnified (×10) giving an idea of the exceeding delicacy of the markings.	

(Gastropoda.)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Figs. 1 and 2 LIOSPIRA ANGUSTATA U. and S. 997
(See also plate LXVIII.)
1 Vertical section of a large specimen, chiefly a cast of the interior, showing thickness of shell in the umbilicus. The sutures in this specimen are unusually deep. Trenton group, Wykoff, Minnesota.
2 Under side of the specimen figured on plate LXVIII (figures 35 and 36), showing the narrow umbilical perforation and thick shell surrounding it. Though the rest of this side of the specimen is a cast of the interior, the outer part of the last volution still gives a good idea of the surface markings.

Figs. 3 to 8 LIOSPIRA VITRUVIA Billings sp 995
3 to 5 Three views of a cast of the interior, from the Stones River group at Beloit, Wisconsin. The concavity of the upper side of the outer volution is usually somewhat less, while the hight of the casts is commonly a trifle greater among Minnesota specimens of this species.
6 Vertical section of the outer whorl of another specimen from Wisconsin, agreeing with the preceding and showing the outline generally pertaining to Wisconsin representatives of the species. Geological and Natural History Survey of Minnesota, Museum Register No. 7287.
7 and 8 Vertical sections of two specimens from the Vanuxemia bed of the Stones River group of Minnesota, the first from Minneapolis, the second from Cannon Falls. Both retain the shell in the umbilicus and show, one more distinctly than the other, the angular border of the large umbilical perforation which is characteristic of the species.

Figs. 9 to 14 EOTOMARIA CANALIFERA Ulrich 1002
9 to 12 Four views of an average example of this species. Lowest division of the Stones River group, Murfreesboro, Tennessee.
13 Surface markings of the upper side and contour of same portion, ×2, of a large specimen from the same locality. The upper slope of the contour line is a little too steep in the figure.
14 Outline view of a third specimen; the aperture is broken away but the spire is almost complete and shows the gradual increase of the apical angle.

Figs. 15 to 17 EOTOMARIA LABIOSA Ulrich 1003
Three views of a nearly entire silicified shell, showing the great strength of the inner lip which distinguishes the species from *E. canalifera*. Stones River group, Murfreesboro, Tennessee.

Figs. 18 to 20 EOTOMARIA VICINUS U. and S. 1003
18 Dorsal view of a cast of the interior from the Stones River group at Minneapolis, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 5106.
19 and 20 Apertural and basal views of a smaller and relatively higher cast from the same horizon at Mineral Point, Wisconsin. The species is closely related to *E. dryope* Billings sp., but has a more evenly conical spire.

Figs. 21 to 25 EOTOMARIA DRYOPE Billings sp 1003
21 Dorsal view of a large shell of this species from the Black River group of central Tennessee. Prof. J. M. Safford's collection.
22 Section of a whorl taken from a smaller specimen collected at the same locality as the preceding.
23 to 25 Three views of a good cast of the interior, the spire slightly lower than usual for the species. Stones River group, Cannon Falls, Minnesota.

Figs. 26 to 29 EOTOMARIA SUPRACINGULATA Billings sp 1004
26 Gutta percha impression from an incomplete natural mold of the exterior. Stones River group, Beloit, Wisconsin.
27 to 29 Three views of a large specimen from Dixon, Illinois, retaining the shell, in a macerated condition, however. Figure 29 shows the remarkable forward sweep of the outer part of the under lip.

Figs. 30 to 32 LIOSPIRA SUBCONCAVA Ulrich 999
30 and 31 Two views of an average example. Stones River group, Murfreesboro, Tennessee.
32 The upper side of a large specimen, from the same locality, showing the fine surface markings. The latter are more delicate than they appear in the figure.

Figs. 33 to 36 LIOSPIRA (?) RUGATA Ulrich 999
Four views of an average example of this species. The shell has suffered from maceration yet preserves distinct remains of the transverse wrinkles. Richmond group, McKinneys, Kentucky.

Figs. 37 to 41 LIOSPIRA (?) MUNDULA Ulrich 999
37 and 39 Two views of a specimen, medium in size and proportions. As usual the surface markings are very obscure. Upper part of Trenton group, Danville, Kentucky.
38 Upper side of a similar specimen.
40 and 41 Two views of a large shell, imperfect at the mouth but preserving unusually distinct lines of growth. Formation and locality same as preceding.

Figs. 42 to 46 LIOSPIRA (?) ANGULATA Ulrich 1000
42 and 43 Lower and upper sides of a silicified shell, showing the angular border of the umbilicus. Black River group, Mercer county, Kentucky.
44 Umbilical side of a cast of the interior from the same locality.
45 A large cast of the interior, the inner whorls restored from another specimen. Locality same as preceding.
46 Apertural view of original of figures 42 and 43.

Figs. 47 to 50 CLATHROSPIRA SUBCONICA Hall sp 1006
(See also plate LXX.)
47 and 48 Two views of a cast of the interior from the Stones River group at Beloit, Wisconsin, showing an unusual feature in the large pits in the peripheral band.
49 Another cast from Beloit with unusually strong ribs on the upper slope of the last volution.
50 Cast of the interior of a large and typical shell from the Vanuxemia bed at Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 5037.

Fig. 51 CLATHROSPIRA CONVEXA U. and S. 1007
Dorsal view of a specimen from the Stones River group in Calhoun county, Illinois. The upper slope of the whorls is more convex than in *C. subconica*.

(Gastropoda.)

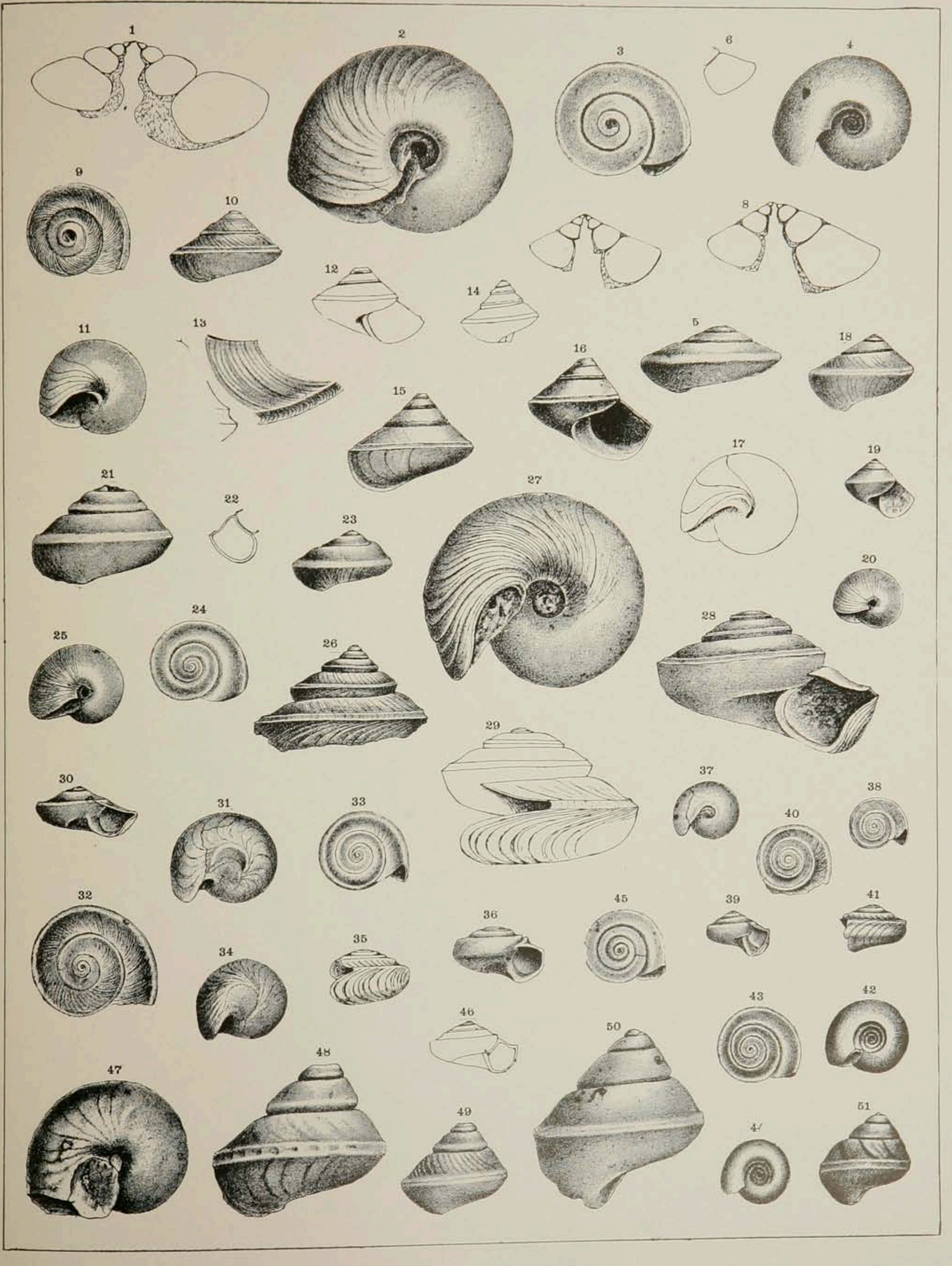
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PLATE LXX.

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Figs.	1 to 4	CLATHROSPIRA CONICA U. and S.	1008
	1 and 2	Basal and dorsal views of a rather small cast of the interior. Trenton group (Fusispira bed), near Cannon Falls, Minnesota.	
	3	A testiferous example from the Ctenodonta bed of the Black River group, at Chatfield, Minnesota. As usual the surface markings are very imperfectly preserved.	
	4	Small portion showing weathered surface markings, and profile outline of last whorl, ×2, as shown in a specimen from Goodhue county where it was found in the Ctenodonta bed.	
Figs.	5 and 6	CLATHROSPIRA SUBCONICA Hall. (See also plate LXIX.)	1006
	5	Surface markings and profile outline of last whorl of a small but well preserved example, ×2. Black River limestone, Tennessee.	
	6	Similar figures taken from a young example found in the upper member of the Stones River group near Lebanon, Tennessee. In this specimen the revolving lines on the upper slope appear not to cross the lines of growth.	
Fig.	7	PLETHOSPIRA STRIATA Ulrich.	1011
		Apertural view of an imperfect specimen, showing the comparatively low spire and coarse rib-like lines of growth which are characteristic of the species. Richmond group, Butler county, Ohio.	
Figs.	8 to 10	PLETHOSPIRA SEMELE Hall.	1010
	8	View of an incomplete example, preserving the surface markings. Utica group, near Graf, Iowa.	
	9	Portion of last whorl of same magnified.	
	10	A cast of the interior from the same locality, doubtfully referred to this species. Geological and Natural History Survey of Minnesota, Museum Register No. 7334. In another cast the peripheral band is not flat but almost as distinctly concave as on the exterior of the shell.	
Figs.	11 and 12	SEELYA MUNDULA Ulrich.	1012
		Two specimens of this species, the second somewhat shortened by pressure, from the lower half of the Lorraine group at Newport, Kentucky.	
Figs.	13 and 14	HORMOTOMA TRENTONENSIS U. and S.	1017
		Two views of a rather small but almost perfect cast of the interior, retaining, as shown in fig. 13, remains of the regular surface markings. Fusispira bed of the Trenton group, Wykoff, Minnesota.	
Figs.	15 to 17	HORMOTOMA BELLICINCTA Hall.	1017
	15	An average cast of the interior of this species, showing that it has a wider apical angle and more depressed and, therefore, relatively more numerous volutions than *H. trentonensis*. Clitambonites bed of the Trenton group, Goodhue county, Minnesota.	
	16 and 17	Another specimen, from the same locality, retaining some of the surface markings. The greater part of the last whorl is broken away so as to expose (see fig. 17) the filling of the small umbilical perforation.	
Figs.	18 to 36	HORMOTOMA GRACILIS Hall, and varieties.	1014
	18 and 19	Two views, natural size and a portion magnified, of a specimen of what we regard as the typical form of this species. Utica group, Graf, Iowa. Geological and Natural History Survey of Minnesota, Museum Register No. 7337.	
	20 to 22	Three specimens selected from a number which were found in association with var. *multivolvis* in the Richmond group near Spring Valley, Minnesota. The first is very much like the var. *angustata* (Hall), the second is a typical *gracilis*, the third has unusually angular whorls and may be compared with var. *subangulata*. See figs. 42 and 43.	
	23 to 25	Three figures of the var. *sublaxa*. The first is made up of the apical portion of one specimen and the lower whorls of another, and shows the relatively loose coiling of the whorls and the resulting obliquity of the sutures which distinguishes this variety from the others. The second figure represents the two lower whorls of same, ×2, while the third figure represents a portion of another specimen also ×2. Both of these figures show that the band is considerably wider than in other forms of the species. Trenton formation, Lincoln county, Missouri.	
	26 to 29	Four figures of the var. *multivolvis*. The first represents an almost entire shell, the second and third opposite views of a less perfect example, the fourth an unusually small specimen. This variety is distinguished by its more numerous whorls. Richmond group, near Spring Valley, Minnesota.	
	30 to 36	Seven figures of specimens which we have identified with the variety of this species which Hall described in 1847 as *Murchisonia angustata*. Fig. 30 represents a weathered example from the Stones River group, at High Bridge, Kentucky. The original of fig. 31 is a gutta percha impression of a natural mould in rock from an equivalent horizon at Beloit, Wisconsin; that of fig. 32 is from the Phylloporina bed of the Black River group near Cannon Falls, Minnesota. Fig. 33 shows two whorls, ×2, of a Black River limestone specimen from Tennessee. Figs. 34 and 35 represent opposite views of two specimens from the Utica group at Newport, Kentucky, and fig. 36 the lower part of a third specimen from this locality. The last shows the form of the apertural notch.	

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Figs. 37 to 41 HORMOTOMA SUBANGULATA U. and S. 1016

37 Cast of the interior, apparently of this species. Clitambonites bed of the Trenton group, Cannon Falls, Minnesota.

38 A small testiferous specimen from the Ctenodonta bed of the Black River group, Goodhue county, Minnesota.

39 and 40 Two views of a larger example. Ctenodonta bed at Chatfield, Minnesota.

41 Two whorls of the original of fig. 38, ×2, showing band and surface markings.

Figs. 42 and 43 HORMOTOMA GRACILIS var. GOODHUENSIS U. and S. 1015

Two specimens found in the Phylloporina bed of the Black River group near Cannon Falls, Minnesota.

Figs. 44 to 51 HORMOTOMA SALTERI Ulrich 1016

44 to 47 A series of four specimens selected from several hundred to show variation in the rim-like thickening of the upper edge of the whorls in the typical form of this species. Fig. 44 is the most like the var. *canadensis* (*Murchisonia* [*Hormotoma*] *gracilis* Salter, not Hall sp.) in which the rim is scarcely distinguishable. Upper part of Trenton group, Mercer county, Kentucky.

48 Two whorls of the original of fig. 47, ×2, to show the surface markings, band and outline of whorls more distinctly.

49 A small imperfect specimen, ×2, of var. *tennesseensis*, from the Black River limestone of Tennessee. Has finer and more equal lines of growth than the typical form of species.

50 Doubtful specimen from the same formation and state as the preceding. The shell is too thick and the whorls relatively too high.

51 A third fragment from this locality that is doubtful because the band is too wide. A fourth example from the same locality seems to be identical with the var. *canadensis*.

Figs. 52 to 55 SOLENOSPIRA PRISCA Billings sp. 1022

52 Silicified specimen of var. *extenuata*. Lower division of the Stones River group at Murfreesboro, Tennessee.

53 Diagrammatic figure made up from gutta percha impressions of several incomplete moulds of the exterior collected at Beloit and Janesville, Wisconsin.

54 Two whorls of the Tennessee form, ×2.

55 Three whorls of the northwestern form, ×2, showing that they are relatively wider than in the Tennessee variety.

Figs. 56 to 60 SOLENOSPIRA PAGODA Salter 1022

56 and 57 Two views of a fragment, showing the form of the mouth, the four revolving carinæ and several of the fine lines of growth. The latter show that the outer lip is notched and that the space between the central pair of ridges represents a true slit-band. Phylloporina bed of the Black River group, near Cannon Falls, Minnesota.

58 Same specimen in another view, ×2, to show the form of the volutions more clearly and to admit of easier comparison with *S. prisca*.

59 and 60 The apical portion, natural size, and two whorls ×2, of a specimen from an equivalent horizon at Porter's station in Wisconsin. Collection of Wisconsin State University.

Figs. 61 to 63 CŒLOCAULUS ŒHLERTI Ulrich 1020

Two casts of the interior and the base of one, showing the numerous depressed whorls and the narrow umbilical perforation. Trenton group, Jo Daviess county, Illinois.

Figs. 64 and 65 OMOSPIRA LATICINCTA Ulrich 945

64 A large testiferous example of this species, imperfect below and at the apex. Black River limestone, Tennessee.

65 A slightly oblique view from above of a portion of the last whorl of same, ×2, showing the course of the regular lines of growth.

Figs. 66 and 67 OMOSPIRA ALEXANDRA Billings sp. 946

66 An imperfect silicified shell of this species, from the top of the Black River limestone of Mercer county, Kentucky. The whorls are more rounded than in the preceding species.

67 A cast of the interior from the same formation at Dixon, Illinois, doubtfully referred to this species.

Figs. 68 and 69 EOTOMARIA ELEVATA Ulrich 1005

Two views of the nearly entire type of this species. Trenton group, Hartsville, Tennessee.

(Gastropoda.)

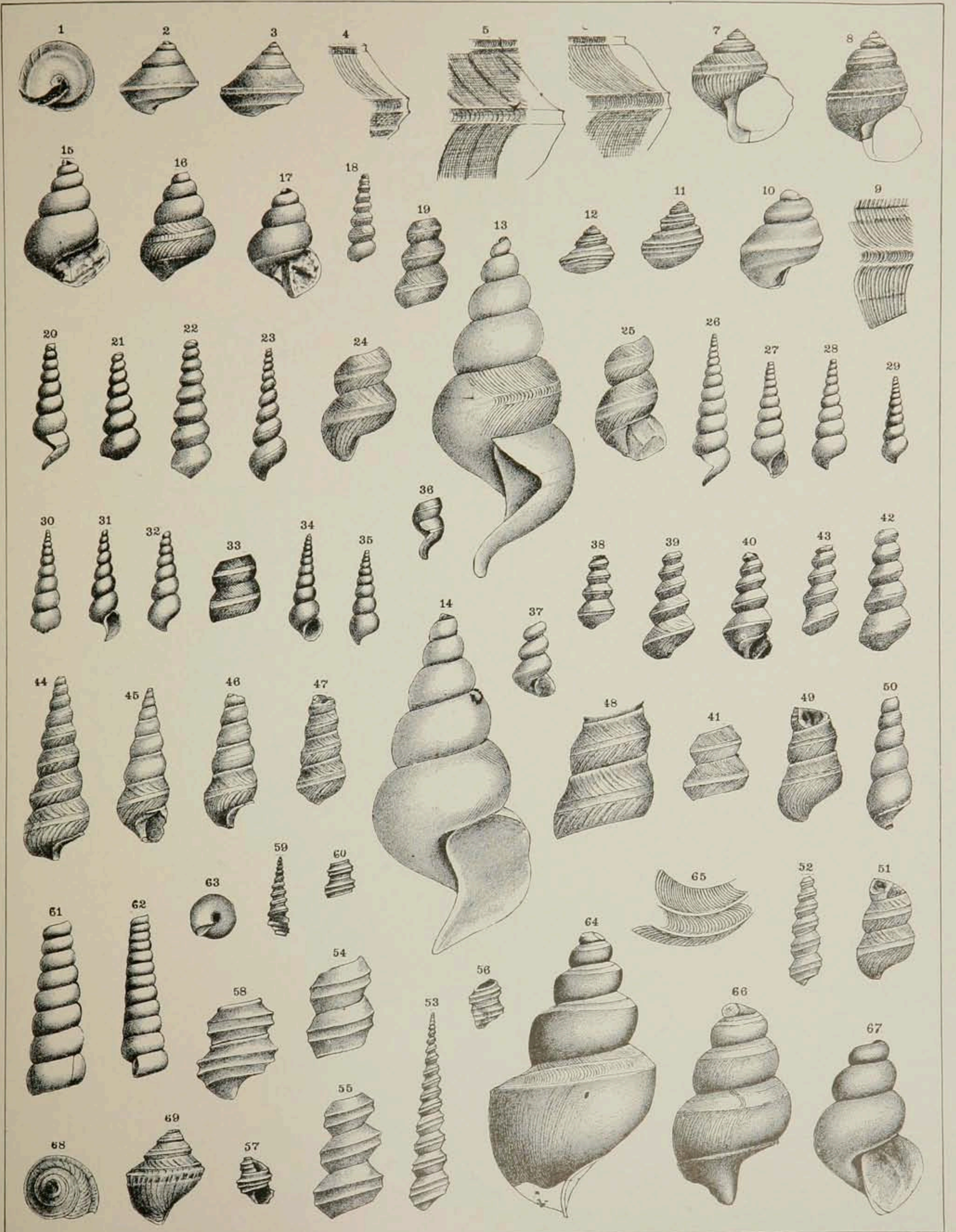
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PLATE LXXI.

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Figs. 1 and 2	LOPHOSPIRA AUGUSTINA Billings sp..	987
	Two figures of a rather large cast of the interior of the Minnesota form which we refer to this species. Fig. 2 shows the filling of the umbilical perforation. Maclurea bed of the Trenton group, Stewartsville, Minnesota.	
Figs. 3 and 4	LOPHOSPIRA AUGUSTINA var. MINNESOTENSIS U. and S..............................	988
3	A large specimen of this variety, from the same locality as the preceding. The outline restoration of the aperture may not be entirely correct.	
4	A smaller specimen, also a cast of the interior; from the same locality. The smallest two whorls are restored from another specimen.	
Figs. 5 to 7	HORMOTOMA (?) MAJOR Hall sp..	1018
5	The last four whorls of a cast of the interior that we believe to belong to this species. Trenton group, Pike county, Missouri. Geological and Natural History Survey of Minnesota, Museum Register No. 7842.	
6	Outline of outer lip of same, showing the broad sinus or notch.	
7	Last two whorls of a specimen retaining part of the shell, but so ill preserved that not a trace of surface markings remains. The specimen is important, however, because it shows the external character of the sutures. Maclurea bed of the Trenton group, Olmsted county, Minn. Geological and Natural History Survey of Minnesota, Museum Register No. 7485.	

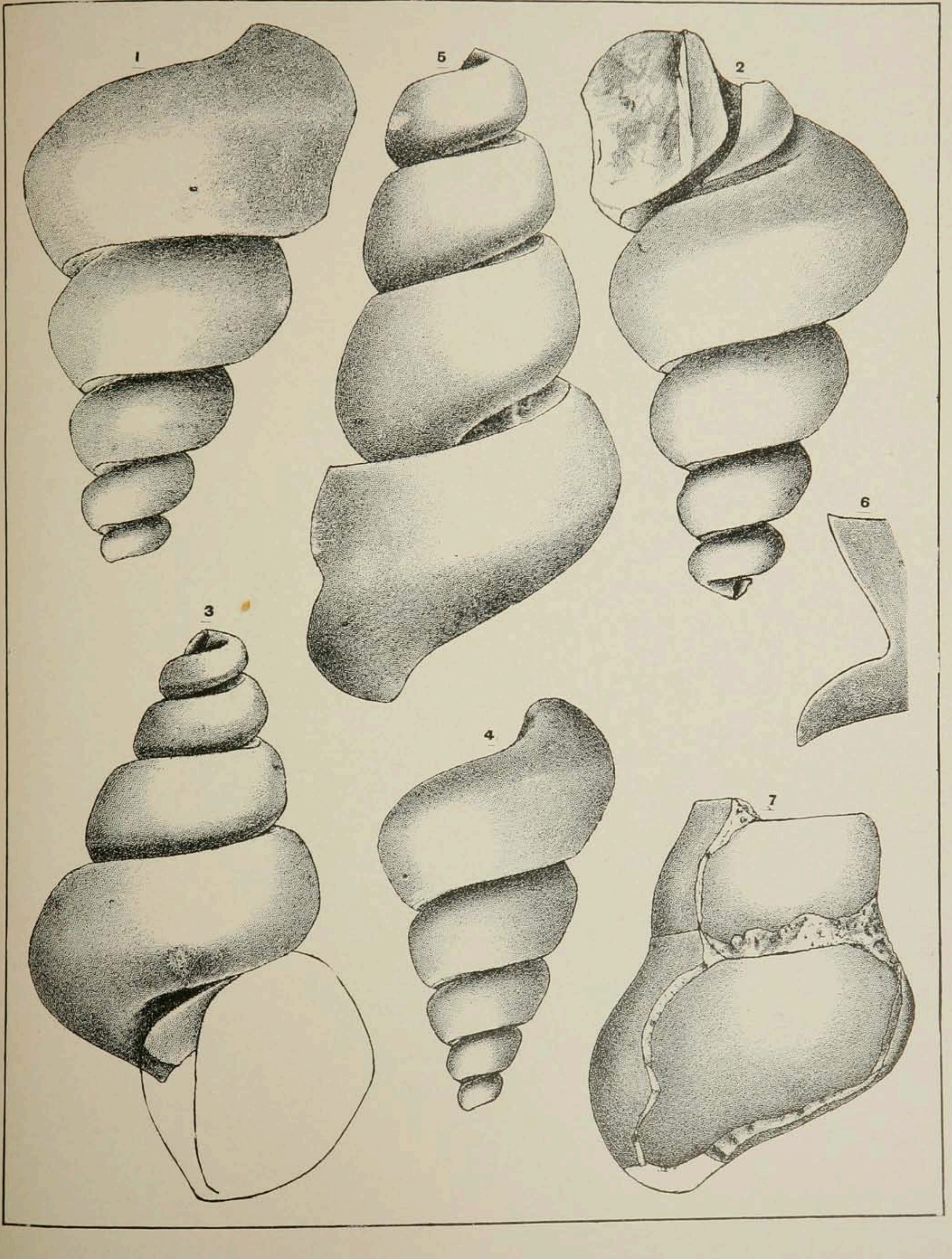
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PLATE LXXII.

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Figs. 1 to 5 LOPHOSPIRA BICINCTA Hall sp. 964

1 A perfect silicified shell of this species, from the lowest member (Safford's Central limestone) of the Stones River group, at Murfreesboro, Tennessee.

2 Portion of the last whorl of same, ×2, showing the direction and regularity of the lines of growth.

3 Right side of last whorl of fig. 1, ×2.

4 A large cast of the interior, on which some of the external lines of growth are obscurely preserved. Stones River group, Beloit, Wisconsin.

5 Vertical section of an elongated specimen. Stones River group, Dixon, Illinois.

Figs. 6 to 8 LOPHOSPIRA OBLIQUA U. and S. 967

Views of three specimens of this species. The general aspect is precisely as in *L. bicincta*, but the lines of growth are constantly more oblique beneath the peripheral angle and of a different character. Stones River and Trenton groups, Mercer county, Kentucky.

Fig. 9 LOPHOSPIRA PROCERA Ulrich 968

View of the type of this species, the basal portion restored in outline. Stones River group, Murfreesboro, Tennessee.

Figs. 10 and 11 LOPHOSPIRA QUADRISULCATA U. and S. 967

Opposite views of an excellent example of this species. Richmond group, Spring Valley, Minnesota.

Figs. 12 to 15 LOPHOSPIRA HUMILIS Ulrich 968

12 and 13 Opposite views of a rather small specimen. Trenton group, near Burgin, Kentucky.

14 Same specimen, ×2, to show the lines of growth.

15 Right side of last whorl of fig. 12, ×6.

Figs. 16 to 19 LOPHOSPIRA CONCINNULA U. and S. 966

16 A testiferous specimen from the Ctenodonta bed at St. Paul, Minnesota, showing the usual size and appearance.

17 and 18 Opposite views of a smaller specimen from the same bed near Cannon Falls, Minnesota.

19 Portion of last whorl of same ×6, showing the direction and regularity of the lines of growth, the extremely fine revolving lines and the form and character of the peripheral band

Figs. 20 to 24 LOPHOSPIRA FILLMORENSIS U. and S. 967

20 and 21 Opposite views of two casts of the interior. Fusispira bed, Trenton group, Wykoff, Minnesota.

22 and 23 A testiferous specimen from the same horizon near Fountain, Minnesota, natural size and a portion of the last whorl ×2. The latter shows the surface markings which consist of rather coarse and distant lines of growth and a much finer intermediate set.

24 The last whorl of a cast from the Wykoff locality, on which the stronger set of surface markings are rather distinctly reproduced.

Figs. 25 to 28 LOPHOSPIRA HELICTERES var. WISCONSINENSIS U. and S. 971

25 and 26 Two views of a cast of the interior of medium size. The apertural portion is perfect but the closely coiled upper whorls are broken away. Stones River group, Beloit, Wisconsin.

27 A smaller cast from the same horizon at Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 6858.

28 Small portion of the last whorl of another cast of the interior, showing strong, even lines of growth. From the same horizon at Dixon, Illinois.

Figs. 29 to 32 LOPHOSPIRA CONRADANA U. and S. 979

29 A nearly complete cast of the interior. Stones River group, Minneapolis.

30 Under side of another cast from the same locality, showing the strong convexity of the under side of the whorls and a faint indication of the ridge which surrounds the umbilical cavity on the exterior of the shell.

31 Another view of the original of fig. 29 to show anterior outline of the outer lip.

32 The body whorl of another cast from Minneapolis showing, besides obscure lines of growth, a faint ridge beneath the peripheral carina. The latter is rarely seen on casts.

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Figs. 33 to 35 LOPHOSPIRA (?) NOTABILIS Ulrich.. 990
Three views of an almost perfect silicified shell of this remarkable species. Black River limestone of central Tennessee.

Figs. 36 to 39 LOPHOSPIRA TROPIDOPHORA Meek sp., instead of MULTIGRUMA Miller sp.*....... 978
36 and 37 Opposite views of a large specimen showing the usual characters of the species. Lorraine group, Newport, Kentucky.
38 Portion of the last whorl of a smaller example on which the surface markings are better preserved, ×2. Richmond group, Butler county, Ohio.
39 A variety from the Richmond group at Madison, Indiana, in which the whorls descend more slowly, causing a wider apical angle.

Figs. 40 to 43 LOPHOSPIRA BOWDENI Safford sp.. 986
40 A large specimen, imperfect at both ends, presenting the usual characters of the species. Richmond group, Boyle county, Kentucky.
41 and 42 Two specimens, from the same locality, showing the extremes, respecting the relative hight of the spire, so far observed.
43 Last whorl, with aperture slightly restored, of the original of fig. 41.

Figs. 44 to 47 LOPHOSPIRA SPIRONEMA U. and S.. 983
44 and 45 Opposite views of a specimen from the Ctenodonta bed of the Black River group, at Chatfield, Minnesota.
46 Another specimen from the same bed near Cannon Falls, Minnesota.
47 Portion of surface and outline of right side of last whorl of fig. 46, ×10, showing the delicate cancellation of the surface and the angular form of the peripheral band.

Figs. 48 to 50 LOPHOSPIRA TENUISTRIATA Ulrich.. 983
48 Nearly perfect example from the Utica group at Newport, Kentucky.
49 The peripheral band of another specimen from the same locality, ×10. The fine revolving lines which occur both above and beneath the band are not shown in the drawing.
50 Small portion of the surface between the band and the lower angle, ×10, showing the strong lamellar lines of growth, fine intermediate lines, and an unusual degree of irregularity in the direction of the spiral lines. The remarkable preservation of the more delicate markings on these specimens is due to the fact that they were protected by a thin parasitic bryozoan (*Leptotrypa clavis* Ulrich) which, on being removed, left them as distinct as during the life of the mollusk.

Figs. 51 to 55 LOPHOSPIRA SERRULATA Salter sp.. 968
(See also plate LXXIII, fig. 57.)
51 An average cast of the interior. Stones River group, Beloit, Wisconsin.
52 The empty mould of the exterior of a specimen of about the same size and character as that of which fig. 51 represents an internal cast. Beloit, Wisconsin.
53 Gutta percha impression of a natural mould of the exterior of a shell having the whorls in contact through a longer period than usual. Shows the wavy peripheral plate very distinctly. Janesville, Wisconsin.
54 A small cast of the interior from Minneapolis. The four or five other specimens of this species seen from the limestone at Minneapolis are all like this in size and character.
55 The cast of the last whorl of an unusually large shell, figured so as to show the anterior outline of the outer lip. (Compare with fig. 26.) Janesville, Wisconsin.

Figs. 56 to 59 LOPHOSPIRA (? SEELYA) LIRATA Ulrich.. 988
56 A specimen with numerous spiral ridges on the basal part of the volutions. Utica group, Newport, Kentucky.
57 Portion of the lower part, including the band, of the last whorl of same, ×3.
58 Part of the last whorl of a specimen of the form (var. *obsoleta*) having but a single spiral line beneath the peripheral band, ×3. Also from Newport, Kentucky.
59 Upper surface of whorl viewed from above, ×3, showing interpolation of striæ.

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* Since page 978 was printed we have come to the conclusion that this species is not distinct from Meek's *Pleurotomaria tropidophora* (Pal. Ohio, vol. 1, p. 154, pl. XIII, figs. 6*a* and 6*b*). Our references to the shell should therefore be corrected by changing the name to *Lophospira tropidophora* Meek sp.

(Gastropoda.)

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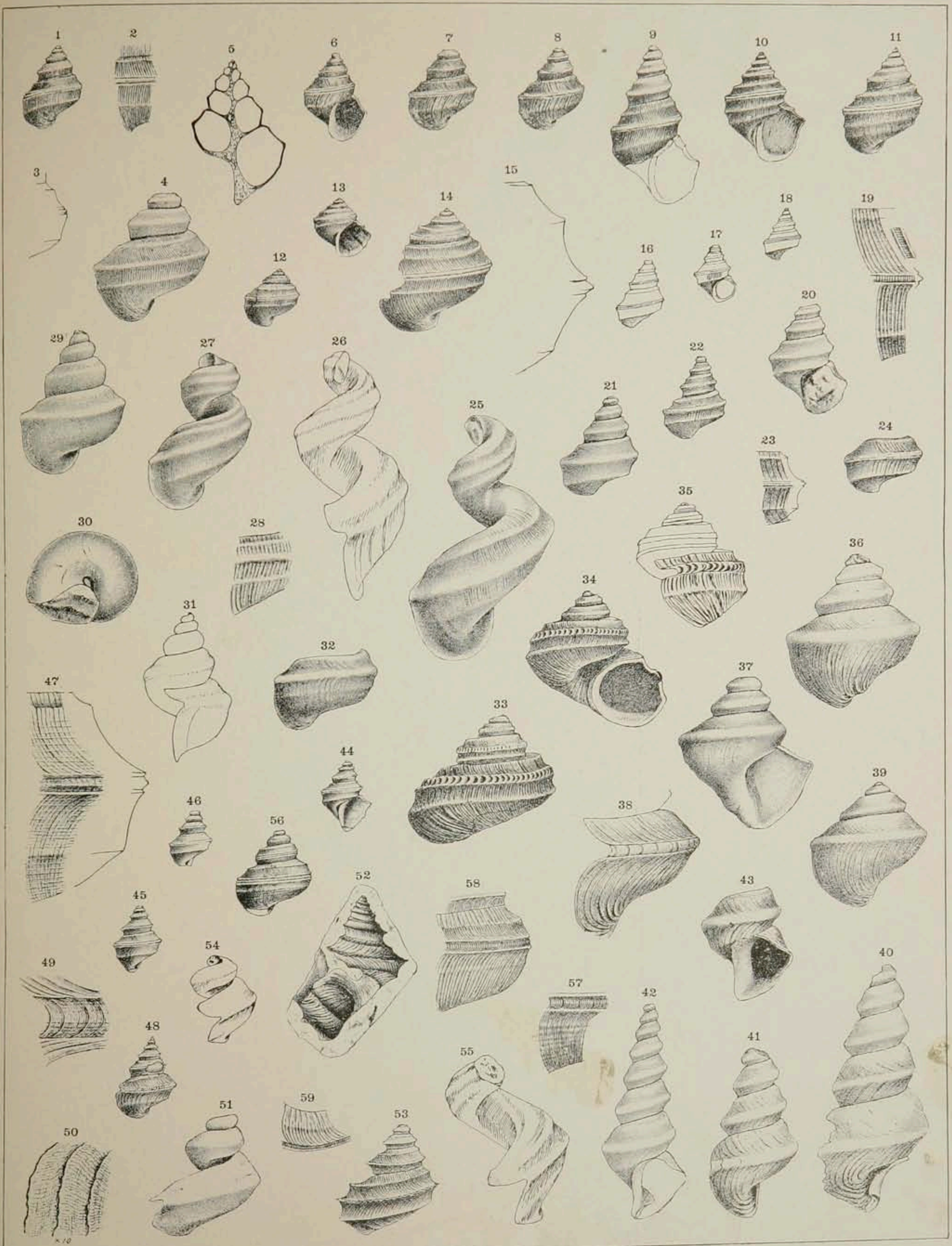

PLATE LXXIII.

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Figs.	1 to 7	LOPHOSPIRA PERANGULATA Hall sp.	972
	1	Apertural view of a rather large specimen.	
	2 and 3	Opposite views of two small shells.	
	4	An unusually large specimen, the last whorl of which is free.	
	5 and 6	Two specimens of the average size, the first with the apical angle a trifle wider than usual.	
	7	Under side of a specimen showing the umbilicus. Stones River group (Safford's "Central limestone"), Murfreesboro, Tennessee.	
Fig.	8	LOPHOSPIRA ACUMINATA U. and S. (or var. of PERANGULATA).	973
		An excellent specimen of this variety, from the Richmond group, near Richmond, Indiana.	
Fig.	9	LOPHOSPIRA CENTRALIS Ulrich	979
		Dorsal view of the largest and best of seven specimens of this species. Safford's "Central limestone" of the Stones River group, Murfreesboro, Tennessee.	
Fig.	10	LOPHOSPIRA DECURSA Ulrich	975
		Anterior view of the best of two specimens, the outer side of the aperture restored. Trenton group, Burgin, Kentucky. The comparative flatness of the upper slopes and the hight of the spire, considering the size of the mouth, are the principal peculiarities when compared with species like *L. perangulata*.	
Figs.	11 to 14	LOPHOSPIRA ELEVATA U. and S.	977
	11	An imperfect silicified shell from the upper part of the Trenton group near Burgin, Kentucky. This specimen may not belong to this species.	
	12	Cast of the interior of this species. Fusispira bed, Trenton group, Decorah, Iowa. Geological and Natural History Survey of Minnesota, Museum Register No. 7370.	
	13 and 14	Opposite views of another cast, this being from the same horizon as the preceding, at Kenyon, Minnesota.	
Figs.	15 to 17	LOPHOSPIRA PERACUTA U. and S.	976
	15	An unusually depressed specimen. Most of the specimens found with this are like the next, only not so large. Black River shales (Rhinidictya bed), St. Paul, Minnesota.	
	16 and 17	Opposite views of the specimen which we regard as the type of the species. It is from the upper division of the Stones River group, at Lebanon, Tennessee.	
Figs.	18 to 20	LOPHOSPIRA SUMNERENSIS Safford sp.	978
	18 and 19	Opposite views of the original type of this excellent species. Upper part of Trenton group, Sumner county, Tennessee.	
	20	Another good specimen from the same locality.	
Fig.	21	LOPHOSPIRA PRODUCTA Ulrich	975
		Apertural view of the type of this important species. Trenton group, Nashville, Tennessee.	
Fig.	22	LOPHOSPIRA CONOIDEA Ulrich	976
		Front view showing the general form, umbilicus and inner lip of the type of this species. Trenton group, Nashville, Tennessee.	
Figs.	23 to 29	LOPHOSPIRA MEDIALIS U. and S.	973
	23 to 26	Four representative specimens, showing slight variation in the apical angle and in other unimportant respects. Upper Trenton, near Burgin, Kentucky.	
	27	An example from middle Tennessee, agreeing in every respect with the Kentucky types of the species.	
	28	Under side of a cast of the interior.	
	29	Part of the last whorl of another Kentucky specimen retaining the lamellose surface markings in an unusually good state of preservation; ×2.	

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Figs. 30 and 31 LOPHOSPIRA MEDIALIS var. BURGINENSIS Ulrich 974

30 An average example of this variety, ×2, showing that it differs from the typical form, with which it is associated, in having a distinct lower carina.

31 Represents a specimen that agrees very well with this variety excepting that it is much larger than the average and has a wider apical angle. Burgin, Kentucky.

Figs. 32 to 35 LOPHOSPIRA PERFORATA U. and S. 984

32 Cast of the interior, almost entire. The hight of the lower whorl is somewhat less than normal, because of pressure. Trenton group (Galena limestone), Jo Daviess county, Illinois.

33 to 35 Three views of the last whorl of another cast from the same locality, with dimensions normal. A thin spiral line should have been drawn in the middle of the base of the body whorl in fig. 35.

Figs. 36 to 40 LOPHOSPIRA ABNORMIS Ulrich 974

36 to 38 Two casts of the interior in lateral and basal views, the former showing the decided increase of the apical angle with the growth of the last whorl. Top of Trenton at Covington, Kentucky.

39 Surface markings of last whorl of a testiferous example, magnified.

40 Contour of right side of a whorl of same, magnified.

Figs. 41 to 45 LOPHOSPIRA OWENI U. and S. 980

41 Outline view of a specimen from the Ctenodonta bed of the Black River group at Chatfield, Minnesota.

42 The lower whorl of a specimen from the same horizon near Cannon Falls, Minnesota, showing the ridge-like swelling about the minute umbilicus.

43 A second specimen from this locality having an unusually strong swelling or ridge along the upper edge of the whorls.

44 and 45 Opposite views of an average example. Near Cannon Falls, Minnesota.

Figs. 46 to 48 LOPHOSPIRA PULCHELLA U. and S. 982

46 and 47 Two specimens, ×2, showing the features which readily distinguish this pretty shell from *L. medialis* var. *burginensis*, with which it is commonly associated. Upper Trenton, Burgin, Kentucky.

48 One of a number of specimens from the Richmond group at Spring Valley, Minnesota, which we cannot distinguish from this species; ×2. The angles are rounded through maceration.

Figs. 49 to 51 LOPHOSPIRA SAFFORDI Ulrich 982

49 A specimen with half of the last whorl missing, yet showing all the essential characters of this fine species. Both the upper and lower angles are constantly developed, and therein lies the most obvious of the differences between *L. saffordi* and *L. oweni*. Trenton group, Davidson county, Tennessee.

50 A more perfect and somewhat wider specimen from the same locality.

51 A third example from the locality mentioned.

Figs. 52 to 54 LOPHOSPIRA AMPLA Ulrich 981

52 Apertural view of a large specimen that, excepting that its spire is unusually depressed, may be considered as fairly typical of the species. Richmond group, Boyle county, Kentucky.

53 and 54 Opposite views of a rather large example of the lower variety. Lorraine group, Newport, Kentucky.

Figs. 55 and 56 LOPHOSPIRA PERLAMELLOSA Ulrich 985

A specimen of this species, natural size and ×2, showing the strongly lamellose surface markings and the remarkably produced and twisted basal extremity. Richmond group, Butler county, Ohio.

Fig. 57 LOPHOSPIRA SERRULATA Salter sp. 968

(See also plate LXXII, figs. 51-55.)

Fragment of a natural mould of the exterior, showing the lines of growth on somewhat less than half of the under side of the last whorl and an impression of the broad peripheral frill with its oblique plications. Stones River group, Dixon, Illinois.

{Gastropoda.}

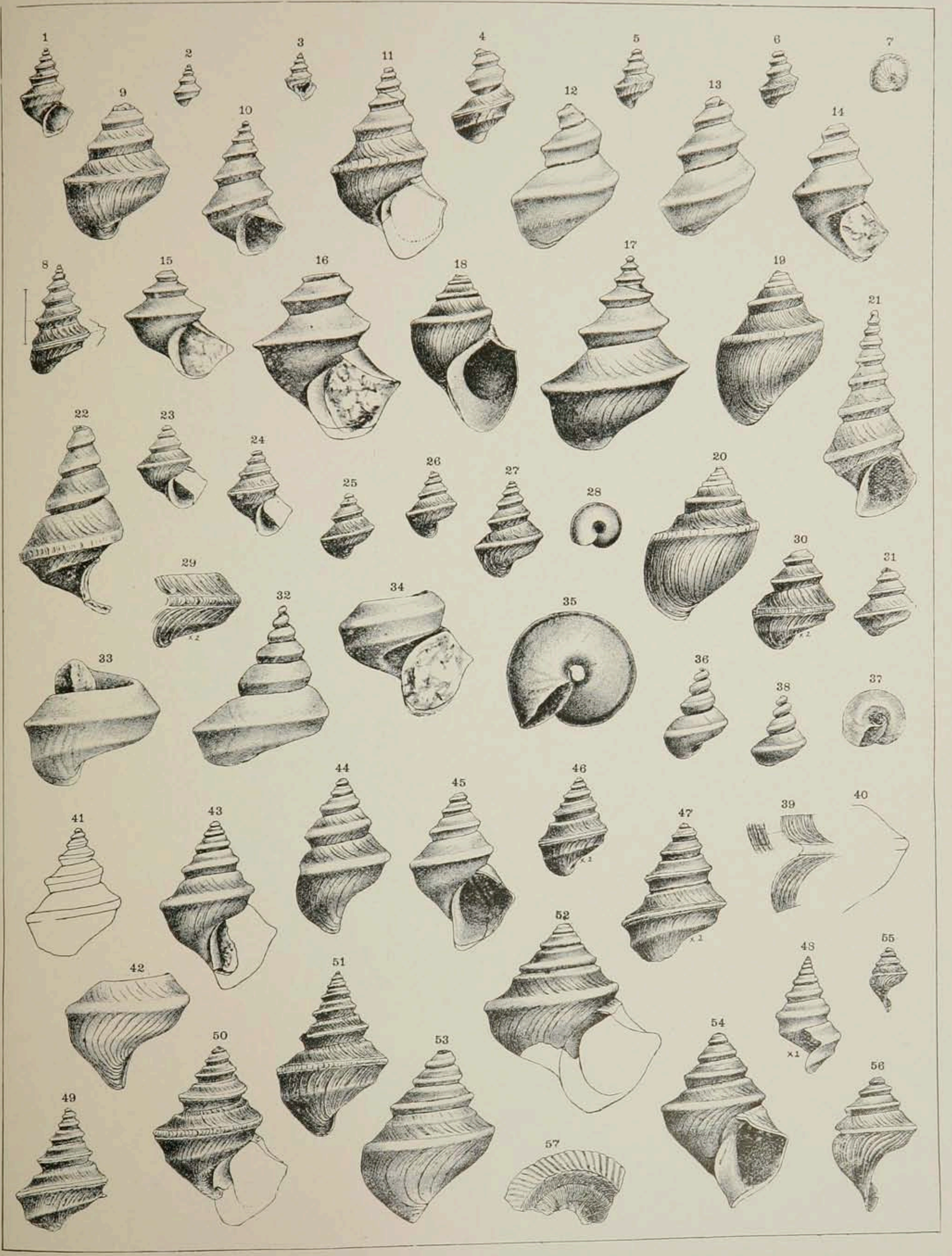

PLATE LXXIV.

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Figs. 1 to 4	ECCYLIOPTERUS BELOITENSIS U. and S. (See also plate LXII, fig. 70.) Four views of a cast of the interior. Lines of growth are indicated on the outer half of the last turn, somewhat obscurely, it is true, yet unmistakably. Stones River group, Beloit, Wisconsin.	1032
Figs. 5 and 6	ECCYLIOPTERUS TRIANGULUS Whitfield sp. (See also plate LXII, fig. 73.) Two views of a cast of the interior. There is some doubt respecting the character of the inner whorl. It may form a closely coiled nucleus, but we doubt it. Calciferous formation, Providence Island, Vermont.	1031
Figs. 7 to 9	ECCYLIOPTERUS VOLUTATUS Whitfield sp. (See also plate LXII, figs. 71-72.)	1031
7	Lateral view of a cast of the interior, preserving a portion of the "collar-like" upper carina. Calciferous formation, Fort Cassin, Vermont.	
8	Under side of another cast from the same locality.	
9	Small portion of the shell from the inner or rather upper slope, beginning at the inner basal angle and extending upward almost to the base of the "collar." Shows the strong anterior convexity of the lines of growth. Fort Cassin, Vermont.	
Figs. 10 to 14	ECCYLIOPTERUS OWENANUS Meek and Worthen sp.	1032
10	Lateral view of a cast of the interior including the enormous "collar." The stony matter which lies upon the concave spire is not represented in the drawing, causing the latter to appear like the shell itself. Fusispira bed of the Trenton group, Wykoff, Minnesota.	
11	Vertical section of another specimen from Wykoff.	
12 and 13	Lateral and basal views of a cast of the interior from the same locality. This specimen represents the usual mode of occurrence, very few of the examples seen giving any idea of the high "collar" into which the outer angle is continued in the shell itself.	
14	Upper side of a specimen from the shaly portion of the Fusispira bed in Goodhue county. Shows an impression of the "collar" on the inner turns.	
Fig. 15	HELICOTOMA PLANULATA var. ROBUSTA U. and S. Lateral view of the specimen described.	1033
Figs. 16 and 17	HELICOTOMA PLANULATA Salter. Lateral and basal views of a typical example of this species. Black River limestone, Pauquette's Rapids, Canada.	1033
Figs. 18 and 19	HELICOTOMA VERTICALIS Ulrich. (See also plate LXII, fig. 69.) Basal and lateral views of a cast of the interior. Stones River group, High Bridge, Kentucky.	1035
Figs. 20 to 24	HELICOTOMA TENNESSEENSIS Safford	1034
20	Upper side of a good silicified shell, showing the small channel along the inner edge of the whorls which appears to be always present and readily serves in distinguishing this species from *H. planulatoides.* Stones River group, Murfreesboro, Tennessee.	
21 to 23	Three views of another specimen, from the same locality.	
24	The upper angle and portions of the surface on each side of it, $\times 2$.	
Figs. 25 to 27	HELICOTOMA UMBILICATA U. and S. (See also plate LXII, fig. 68.) Three views of the largest specimen seen. Stones River group, near La Salle, Illinois.	1034
Figs. 28 to 30	HELICOTOMA PLANULATOIDES Ulrich. Three views of an entire silicified specimen. Black River group, Mercer county, Kentucky.	1034

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Figs. 31 to 33 HELICOTOMA SUBQUADRATA Ulrich 1033

31 and 32 Lateral and basal views of a specimen. The central ridge in fig. 31 is probably abnormal.

33 Lateral view of another specimen from Murfreesboro, Tennessee, with rather obscure revolving lines on the vertical side.

Figs. 34 to 38 HELICOTOMA DECLIVIS Safford 1036

34 Upper side of a small but well preserved example of this sharply defined species. Lower division of the Stones River group, Murfreesboro, Tennessee.

35 to 38 Four views of an average specimen, from the same locality. Among the peculiarities that should be especially noted, is the even slope of the umbilical cavity, in the bottom of which the inner whorls are not distinguishable.

Fig. 39 HELICOTOMA MARGINATA Ulrich 1036

Upper side of a specimen adhering to a piece of the limestone matrix. Beneath the figure, a line showing profile. Top of Richmond group, near Richmond, Indiana.

Figs. 40 to 42 and 47 OPHILETINA SUBLAXA U. and S. 1030

40 Upper side and a section of the free whorl of a testiferous example of the typical form; from the Stones River group at Dixon, Illinois.

41 Portion of the free whorl of same, ×2, showing the surface markings from above.

42 Upper side and section of free whorl of a silicified specimen of the var. *depressa*, from Murfreesboro, Tennessee. As may be seen at once by comparing the transverse sections, the free whorl in this specimen is narrower than in the Illinois specimen.

47 Portion of the upper side of the outer whorl of a specimen from Mineral Point, Wisconsin, ×3. Geological and Natural History Survey of Minnesota, Museum Register No. 7302.

Figs. 43 to 46 OPHILETINA ANGULARIS U. and S. 1031

43 to 46 Four views of the type of this species, ×2. Phylloporina bed of the Black River group, near Cannon Falls, Minnesota.

Figs. 48 to 52 ECCYLIOMPHALUS CONTIGUUS Ulrich 1037

48 Apertural view of a specimen having the inner whorls slightly raised above the plane of the outer one. Lower division of the Stones River group, Murfreesboro, Tennessee.

49 and 50 Somewhat restored views of the upper and lower sides of a larger specimen.

51 and 52 Two views of a small example having the inner whorls slightly depressed.

Figs. 53 to 56 ....

Four views of three specimens of a totally unplaced gastropodous shell. Richmond group, Boyle county, Kentucky.

(Gastropoda.)

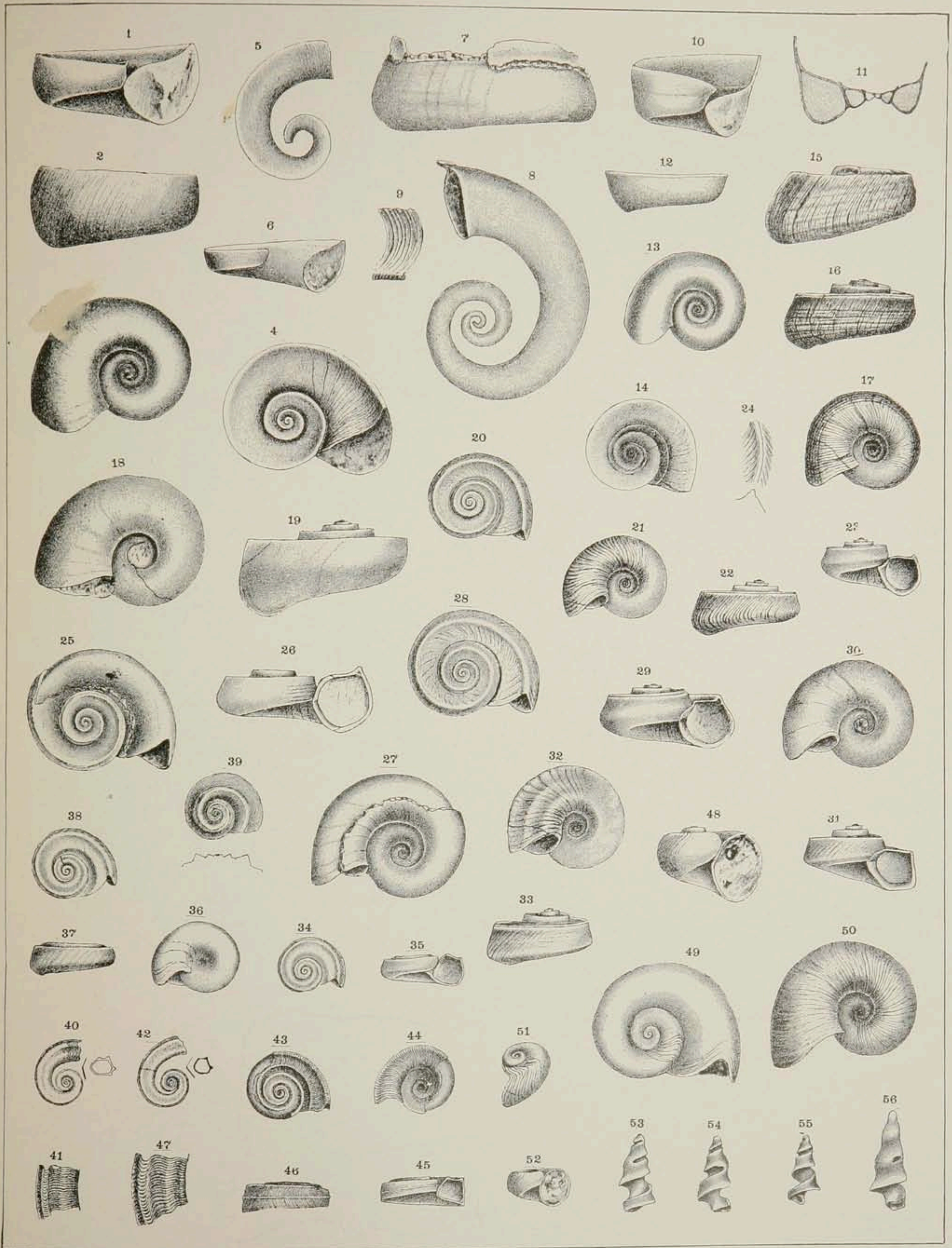
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PLATE LXXV.

PAGE.

Figs. 1 to 4 MACLUREA DEPRESSA U. and S. 1040

1 Lateral view of a cast of the interior. Stones River group (Vanuxemia bed), Minneapolis, Minnesota.

2 to 4 Three views of another cast from Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 6868.

Figs. 5 to 10 MACLUREA BIGSBYI Hall 1039

5 to 8 Four views of a specimen, from the Stones River group at Beloit, Wisconsin, somewhat better preserved than usual. A considerable portion of the upper side is a cast of the exterior and therefore retains some of the surface markings. Geological and Natural History Survey of Minnesota, Museum Register No. 7308.

9 The outer line represents a transverse section of the outer whorl of the same specimen, while the inner lip is a similar section of a specimen of *M. nitida* U. and S.

10 A small specimen from Dixon, Illinois, figured for comparison with *M. nitida.* It may be well to point out that the umbilicus is wider and the whorls lower than in that species.

Fig. 11 MACLUREA NITIDA U. and S. 1040

Upper side of one of the largest specimens, showing the rather small umbilicus and regular lines of growth. Stones River group, Mineral Point, Wisconsin. Geological and Natural History Survey of Minnesota, Museum Register No. 7356. The inner line of fig. 9 represents the outline of the aperture of this specimen.

Figs. 12 to 14 MACLUREA CRASSA U. and S. 1040

12 and 13 Upper and lower sides of an entire cast of the interior. The obtuse central angulation of the whorls is not quite as abrupt in fig. 12 as it should be (see top of fig. 14). Trenton group, Lime City, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 8442.

14 Transverse section of the outer whorl of same. The lower line at the bottom of the figure represents the outline of this part of the whorl in a specimen from Wykoff, Minnesota.

Figs. 15 and 16 MACLUREA CRASSA var. MACRA U. and S. 1040

The upper side and a lateral view of the type of this variety. Fusispira bed of the Trenton group, Hader, Minnesota.

Figs. 17 and 18 ECCYLIOMPHALUS SUBROTUNDUS U. and S 1037

17 Lateral view of a cast of the interior, showing the rounded section of the shell and the elevated line near the base of the inner side. Fusispira bed of the Trenton group, Wykoff, Minnesota.

18 Upper side of same, showing the deep sinus in the upper lip.

Figs. 19 to 23 ECCYLIOMPHALUS UNDULATUS Hall 1036

19 The lower side of a specimen which retains some of the shell in good condition. Stones River group, Lebanon, Tennessee.

20 Lateral view of same showing cicatrices where foreign particles had formerly been attached.

21 and 22 Opposite lateral views of an incomplete cast of the interior. Beloit, Wisconsin.

23 Transverse section near the mouth of same.

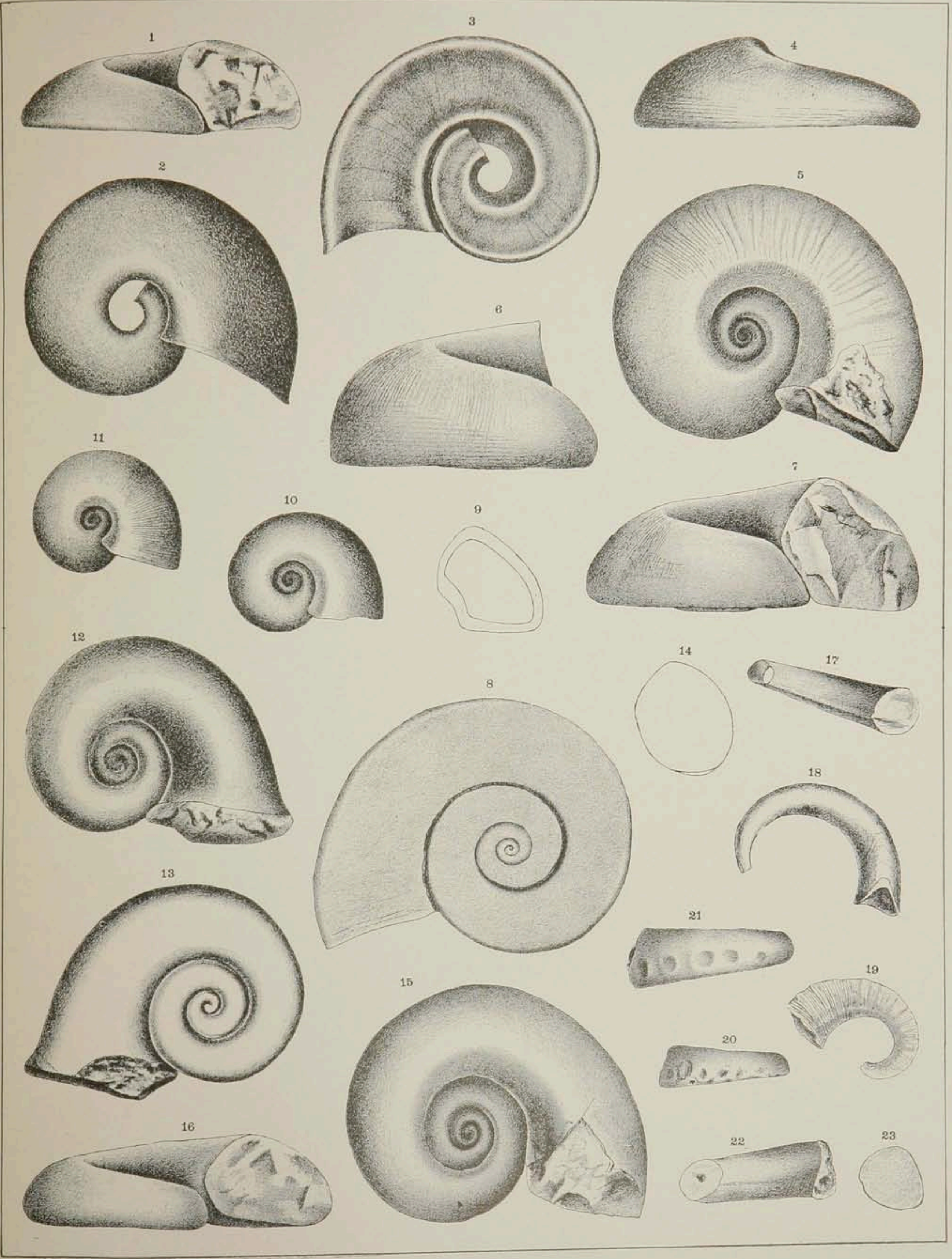
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PLATE LXXVI.

		Page.
Figs. 1 to 3	Maclurina cuneata Whitfield (See also plate LXXXII.)	1042
1	Upper side of an average cast of the interior of this common species, showing the small umbilicus. 7 mm. less than natural size. Geological and Natural History Survey of Minnesota, Museum Register No. 8440.	
2 and 3	The lower side and a lateral view of another specimen. 5 mm. less than natural size. Maclurea bed of the Trenton group, Stewartsville, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 8441.	
Figs. 4 and 5	Maclurina manitobensis Whiteaves (See also plate LXXXII.)	1041
	Two views of a cast of the interior. Trenton group, Lime City, Minnesota. Geological and Natural History Survey of Minnesota. Museum Register No. 4105.	
Figs. 6 to 8	Trochonema obsoletum Ulrich	1054
6	A finely preserved example of the natural size. Upper Trenton, near Burgin, Kentucky.	
7	Lateral view of same $\times 2.5$, showing surface markings and obsolescence of revolving ridges on the last whorl. The ridges are quite distinct on turns preceding the last.	
8	Basal view of same $\times 1.8$.	
Figs. 9 and 10	Trochonema arctatum Ulrich	1054
9	Outline view of the type of this species. Trenton group, near Burgin, Kentucky.	
10	Apertural view of same $\times 2$. A few of the fine lines of growth are faintly indicated. The peripheral band is unusually narrow for species of this genus, and might easily be mistaken for the band of a pleurotomarian shell.	
Figs. 11 to 15	Trochonema robbinsi U. and S.	1053
11 to 14	Four views of a large cast, in part both interior and exterior, imperfect at both extremities. The even slope of the surface from the suture to the peripheral band is one of the most striking features. Fusispira bed, Wykoff, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 7516.	
15	A small cast of the interior from the same locality.	
Figs. 16 to 18	Trochonema niota Hall sp.	1052
	Three views of the nearly entire cast of the interior upon which this species is founded. Stones River group, Beloit, Wisconsin.	

(Gastropoda.)

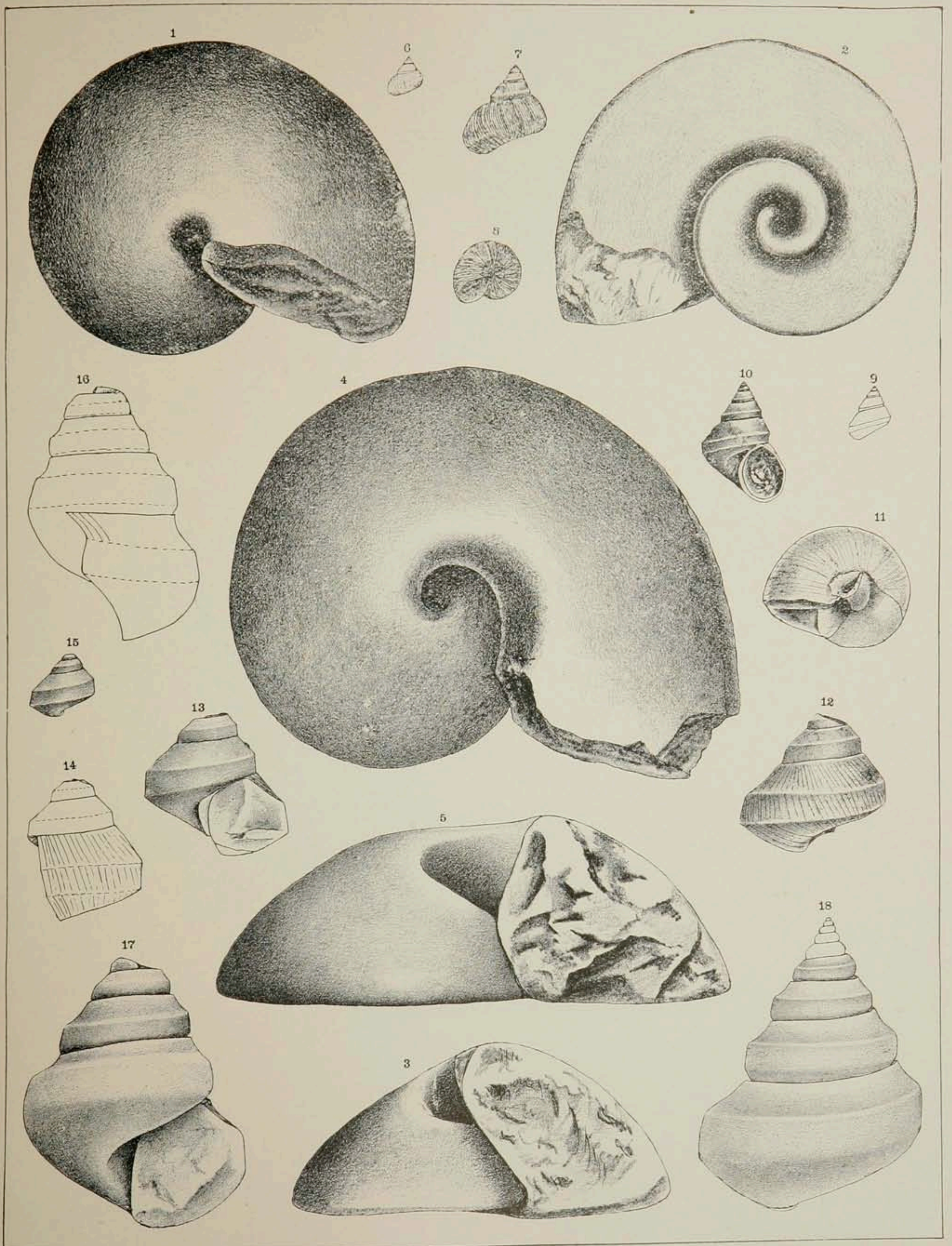


PLATE LXXVII.

PAGE.

Figs. 26 to 29 TROCHONEMA BELLULUM Ulrich.. 1050

Four views of the largest and relatively lowest of six specimens, all from the Stones River group, near Murfreesboro, Tennessee. It is to be observed that this is not only a smaller type than *T. eccentricum* but that the lines of growth lean backward on the peripheral band instead of forward. The left side of the last whorl projects too far in fig. 26.

Figs. 30 to 34 TROCHONEMA SUBCRASSUM U. and S.. 1051

30 Rather small silicified shell showing the under side.

31 and 32 Two views of a gutta percha impression, showing surface markings.

33 A silicified specimen from which part of the shell has been removed. This specimen shows that the shell is comparatively thick, the angles being very obtuse on the interior cast.

34 Lateral view of the specimen of which fig. 30 represents the under side. Upper part of Trenton group, Mercer county, Kentucky.

Figs. 35 to 38 TROCHONEMA RETRORSUM U. and S.................... 1051

35 to 37 Two lateral and a basal view of a testiferous example, showing the narrow and exceedingly abrupt umbilicus and the comparatively slight obliquity of the aperture. Black River group (Ctenodonta bed), Goodhue county, Minnesota.

38 A strip across the last whorl of same and the right side in outline, ×3. The lines of growth are very fine and regular. Their direction is peculiar; first because it is turned so strongly backward on the upper peripheral angle, and, second, because the backward sweep of the lines on the base is less than usual among Trochonemas of similar appearance.

Figs. 39 to 41 TROCHONEMA ALTUM U. and S.. 1052

Three views of a cast of the interior. Fusispira bed, Cannon Falls, Minnesota.

Figs. 42 and 43 TROCHONEMA (EUNEMA) SALTERI U. and S........................... 1053

Opposite views of a cast of the exterior chiefly, showing general form of shell and lines of growth. Base of Fusispira bed, Cannon Falls, Minnesota.

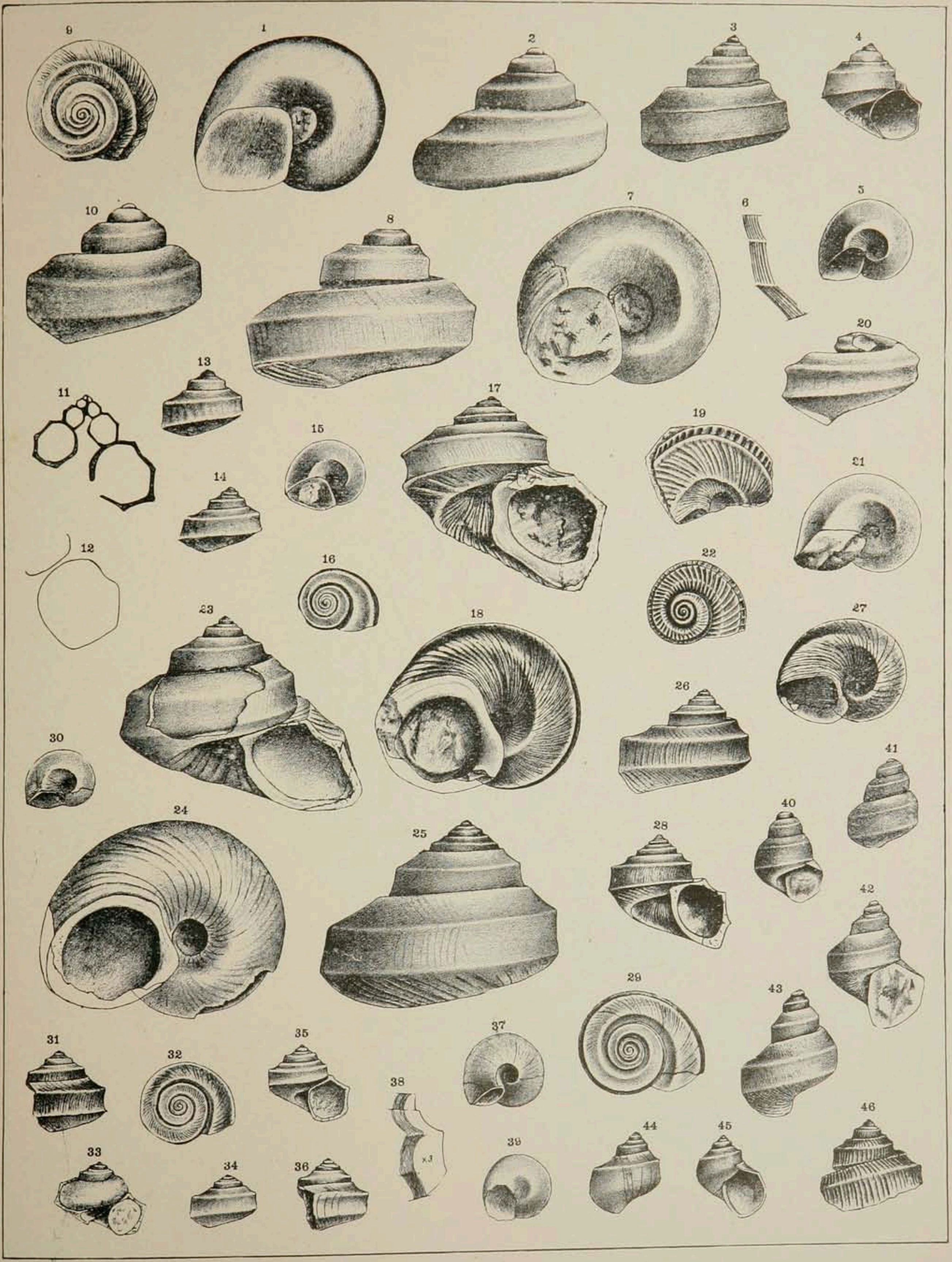
Figs. 44 and 45 TROCHONEMA (EUNEMA) NITIDUM Ulrich... 1053

Opposite views of an average specimen. Utica group, Covington, Kentucky. The dark lines crossing the last whorl of fig. 44 indicate merely the direction of the lines of growth. The latter are equal and exceedingly fine on the specimen.

Fig. 46 TROCHONEMA VAGRANS U. and S... 1049

(See also plate LXXVIII, figs. 10–13.)

Gutta percha impression of a natural mould of the spire, showing external form and surface markings of shell. Vanuxemia bed, Minneapolis, Minnesota.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1 Dorsal side of a cast of the interior, from Beloit, Wisconsin.

2 and 3 Umbilical and dorsal views of a well marked specimen of the form of the species prevailing at Dixon, Illinois. Excepting the umbilical region, which gives an idea of the thickness of the shell, the specimen is a cast of the interior.

4 to 6 Three views of a large example, retaining most of the shell, from Mineral Point, Wisconsin.

7 Gutta percha impression of a natural mould of the exterior, from Beloit, Wisconsin.

8 Dorsal side of an interior cast of the Minnesota form of the species, having the last whorl partly free; Minneapolis.

9 Under side of a similar specimen from the same locality.

Figs. 10 to 13 TROCHONEMA VAGRANS U. and S. 1049
(See also plate LXXVII, fig. 46.)

10 and 11 Basal and lateral views of a cast of the interior, from Minneapolis.

12 and 13 Similar views of a nearly perfect cast from the same locality. Survey collection, Museum Register No. 6865

Figs. 14 to 16 GYRONEMA LIRATUM U. and S. 1056
Three views of the specimen upon which this species is founded. While the greater part is preserved as a cast of the interior, a portion, as shown in fig. 14, is of the exterior. Beloit, Wisconsin.

Figs. 17 and 18 GYRONEMA SEMICARINATUM Salter sp. 1055
Dorsal views, natural size and ×2, of a specimen retaining the shell; near Cannon Falls, Minnesota.

Figs. 19 to 21 GYRONEMA PULCHELLUM U. and S. 1054

19 Dorsal view of a small but nearly perfect example; Chatfield, Minnesota.

20 Portion of same ×5 to show extremely fine lines of growth.

21 Apertural view of a larger and excellently preserved specimen; Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 6854.

Figs. 22 to 25 GYRONEMA DUPLICATUM U. and S. 1055

22 Side view of a specimen which retains some of the shell and has a higher spire than usual; Dixon, Illinois.

23 and 24 Apertural and dorsal views of a large and almost entire cast of the interior belonging to the collection of the University of Wisconsin; Beloit, Wisconsin.

25 The lower whorl of a cast of the exterior from the same collection and locality.

Fig. 26 CYCLONEMA (? GYRONEMA) PRÆCIPTUM, n. sp. (Ulrich.) ....
Dorsal view of an average example of this species; Stones River group, Murfreesboro, Tennessee. It was through a species like this that *Cyclonema* was evolved from *Gyronema*. The inner lip is relatively thicker, straighter, and more reflexed than in species of *Gyronema*, but not excavated as it should be in a true *Cyclonema*. A minute umbilicus is often present. This species is referred to but not named in the fifth paragraph on page 1046.

Figs. 27 and 28 CYCLONEMA VARICOSUM Hall 1060

27 Apertural view of a specimen from the upper part of the Trenton group at Nashville, Tennessee.

28 Dorsal view of a larger specimen, from Colby, Kentucky. The inner lip is nearly vertical and the carinæ very strong in this species.

Figs. 29 and 30 CYCLONEMA MEDIALE Ulrich 1059

29 Dorsal view of an average example of the typical form of this species; Covington, Kentucky. In another common variety the revolving carinæ are less equal, being more as in fig. 34 of this plate.

30 Under side of another specimen from Covington.

Figs. 31 and 32 CYCLONEMA INFLATUM Ulrich 1060
Dorsal views of two specimens from Cincinnati, Ohio, showing rather extreme conditions in the manner of growth. The apex in the first is entire.

Figs. 33 and 34 CYCLONEMA PYRAMIDATUM James 1061
Basal and dorsal views of a typical example of this species; from the vicinity of Morrow, Ohio.

Figs. 35 to 39 CYCLONEMA BILIX Conrad sp. 1058

35 Dorsal view of a rather large example of this species, from Versailles, Indiana.

36 A similar view of a smaller specimen, from Waynesville, Ohio.

37 A dorsal view of a third specimen, from Clarksville, Ohio. These three specimens are regarded as agreeing in every respect strictly with the original type of the species. It is to be observed that the revolving carinæ are not as strong as in *C. mediale*, and the suture more abruptly impressed.

38 and 39 Dorsal views of two specimens of the form which Miller proposed to distinguish as variety *conicum;* from Versailles, Indiana.

Figs. 40 to 42 CYCLONEMA BILIX var. FLUCTUATUM James 1059

40 Dorsal view of a perfect specimen of this variety, from Versailles, Indiana, showing the relatively fine revolving lines, oblique folds and concave slopes of the whorls which usually characterize this variety.

41 and 42 Two views, ×5, of the apex of same.

Figs. 43 to 46 CYCLONEMA HUMEROSUM Ulrich 1061

43 A large and strongly marked specimen of the Richmond group variety of this species; Waynesville, Ohio. Possibly this is an extreme variety of *C. bilix*, with which it was found associated, rather than of the Lorraine group types of this species.

44 Apertural view of a large example of an abundant variety in the Lorraine group at Cincinnati. The whorls are more rounded and the "shoulder" less distinct than in the typical form of the species.

45 and 46 Dorsal and basal views of a typical example from Cincinnati. The shoulder at the top of the whorls is often more pronounced.

Fig. 47 CYCLONEMA SIMULANS Ulrich 1061
Dorsal view of an average example of this species, showing the rather delicate revolving lines growing more and more obsolete on the last volution; Cincinnati, Ohio.

Figs. 48 and 49 CYCLONEMA SUBLÆVE Ulrich 1062

48 Dorsal view of a representative example; Covington, Kentucky.

49 Similar view of [illegible]

(Gastropoda.)

VOL. III

PLATE LXXVIII.

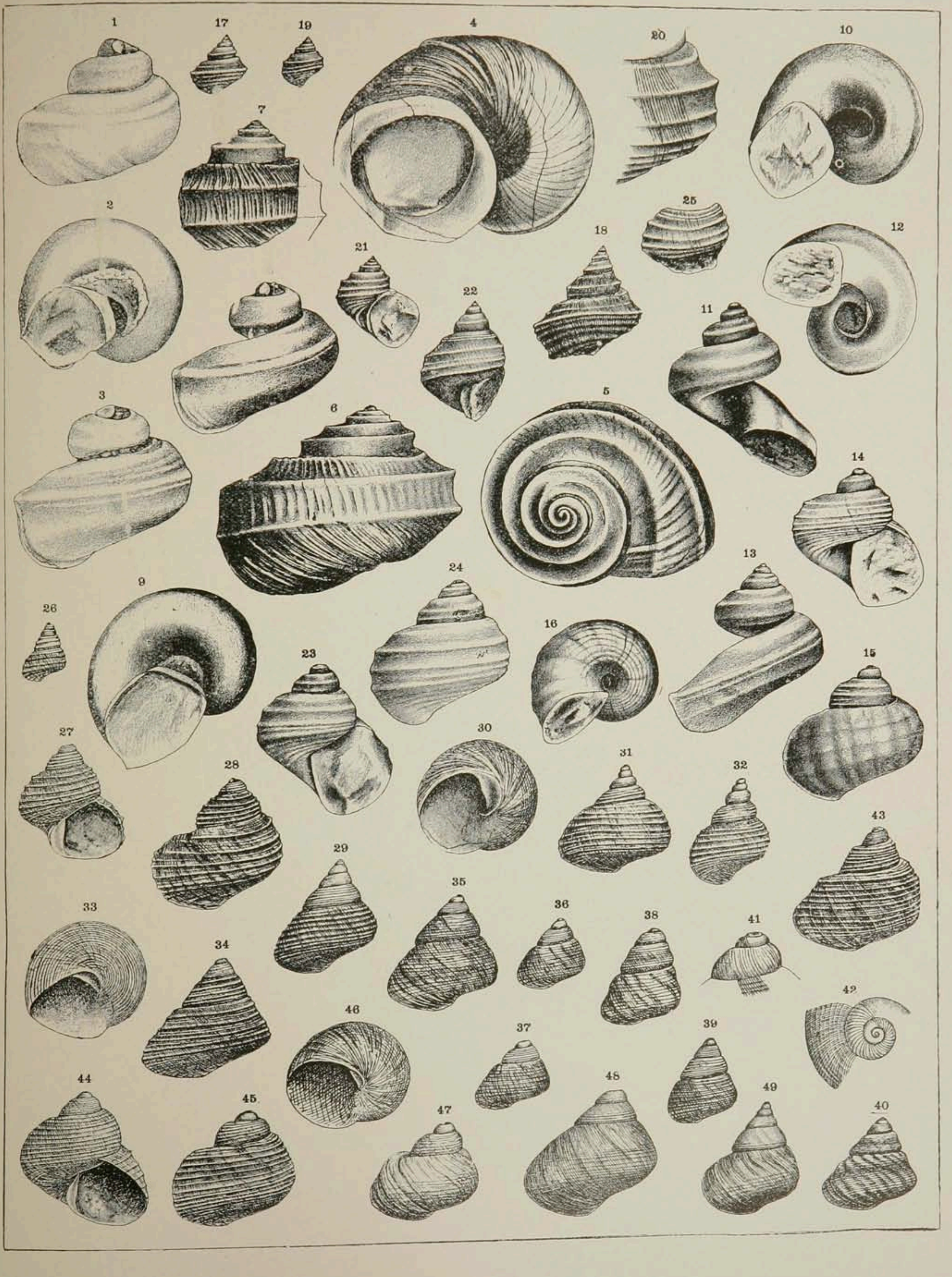

PLATE LXXIX.

PAGE.

Figs. 1 to 5 HOLOPEA INSIGNIS U. and S. 1065

1 and 2 Opposite views of the interior cast of a young shell. The hight is relatively greater than in fully grown individuals. Stones River group, Minneapolis, Minnesota.

3 to 5 Three views of a large cast. This specimen is so sharp and clean that it may be a cast of the exterior rather than of the interior. Stones River group, Cannon Falls, Minnesota.

Fig. 6 HOLOPEA CONCINNULA U. and S. 1066

A cast of the interior, the last whorl with obscure lines of growth. Stones River group, Beloit, Wisconsin.

Figs. 7 to 10 HOLOPEA APPRESSA U. and S. 1065

7 to 9 Three views of a small but entire cast of the interior, giving a good idea of the peculiarities of the species. Clitambonites bed, Goodhue county, Minnesota.

10 Under side of a larger cast. Geological and Natural History Survey of Minnesota, Museum Register No. 6765.

Figs. 11 and 12 HOLOPEA EXCELSA U. and S. 1067

11 Apertural view of an incomplete cast of the interior. Fusispira bed, Wykoff, Minnesota.

12 Dorsal view of a nearly complete cast from the same locality.

Figs. 13 to 18 HOLOPEA PYRENE Billings 1067

13 and 14 Two views of a cast of the interior, the inner whorls restored. Trenton group, near Cannon Falls, Minnesota.

15 to 18 Four views of a cast of the interior of a young specimen. Fusispira bed, near Cannon Falls, Minnesota.

Fig. 19 HOLOPEA var. PARVULA Ulrich ....

Dorsal view of the largest of three specimens. Upper Trenton, near Burgin, Kentucky.

Figs. 20 and 21 HOLOPEA ROTUNDA U. and S. 1066

20 Perfect silicified shell, showing the aperture, minute umbilicus, and general form of the shell. Trenton group, Hartsville, Tennessee.

21 A much larger specimen, presumably of this species, from the Stones River group at Dixon, Illinois.

Figs. 22 to 25 HOLOPEA AMPLA U. and S. 1065

22 An average example of this species. The specimen is a cast of the interior and shows broad varices of growth and rather obscure traces of revolving lines. Stones River group, Cannon Falls, Minnesota.

23 to 25 Body whorl of a large specimen, strongly marked with wrinkles and lines of growth. The specimen appears to be a cast of the exterior and is from Cannon Falls, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 5836.

Fig. 26 HOLOPEA SIMILIS U. and S. 1066

Dorsal view of an average example of the form which we have separated provisionally from *H. ampla* and *H. obliqua* under this name. Shales of the Black River group, Fillmore county, Minnesota. Geological and Natural History Survey of Minnesota, Museum Register No. 7381.

Figs. 27 and 28 HOLOPEA SUPRAPLANA U. and S. 1068

27 Dorsal view of a cast of the interior. Lower part of Fusispira bed, Kenyon, Minnesota.

28 Apertural view of the largest specimen seen. Though a cast of the interior, it gives a good idea of the strongly inrolled thin inner lip. Kenyon, Minnesota.

(Gastropoda.)

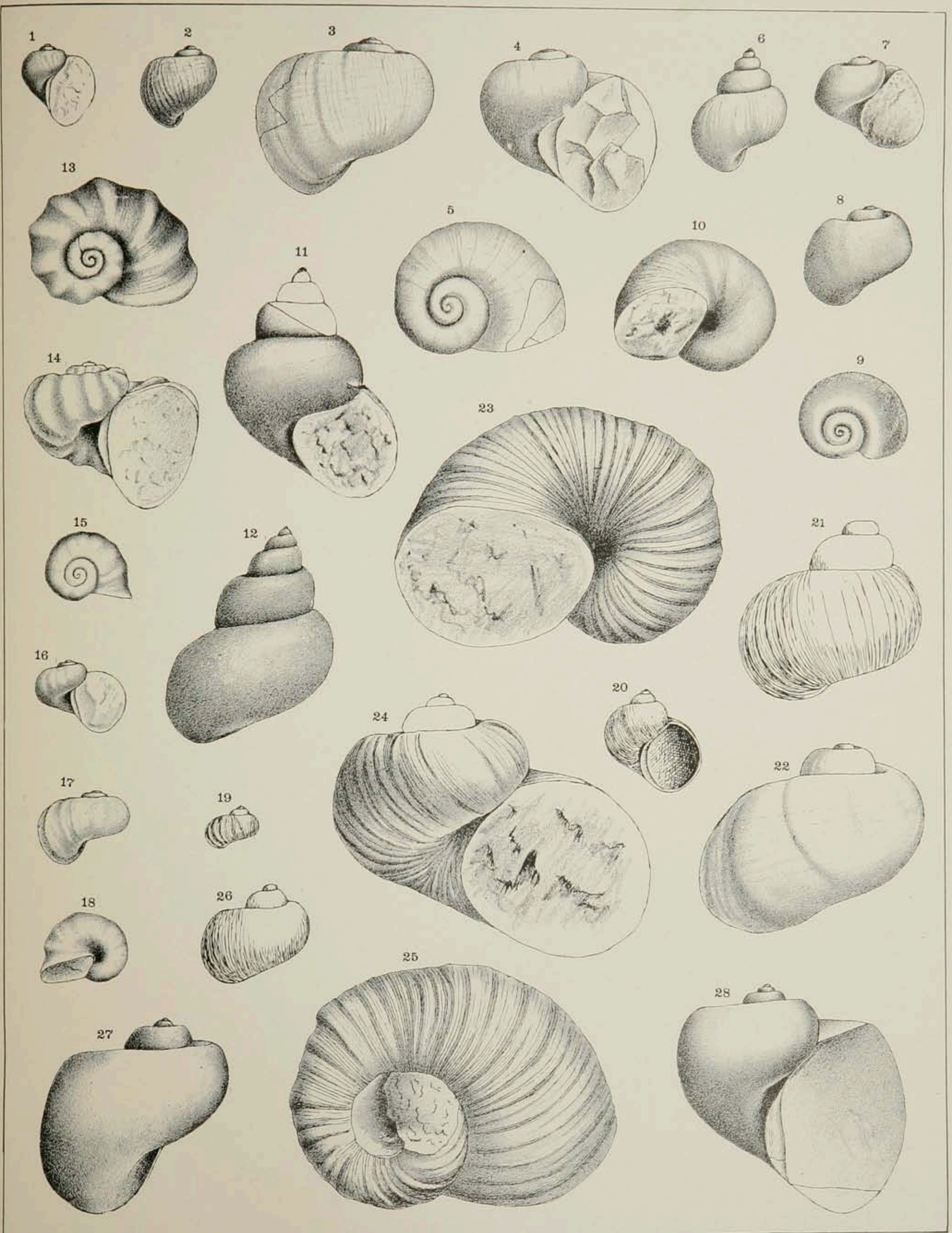

PLATE LXXX.

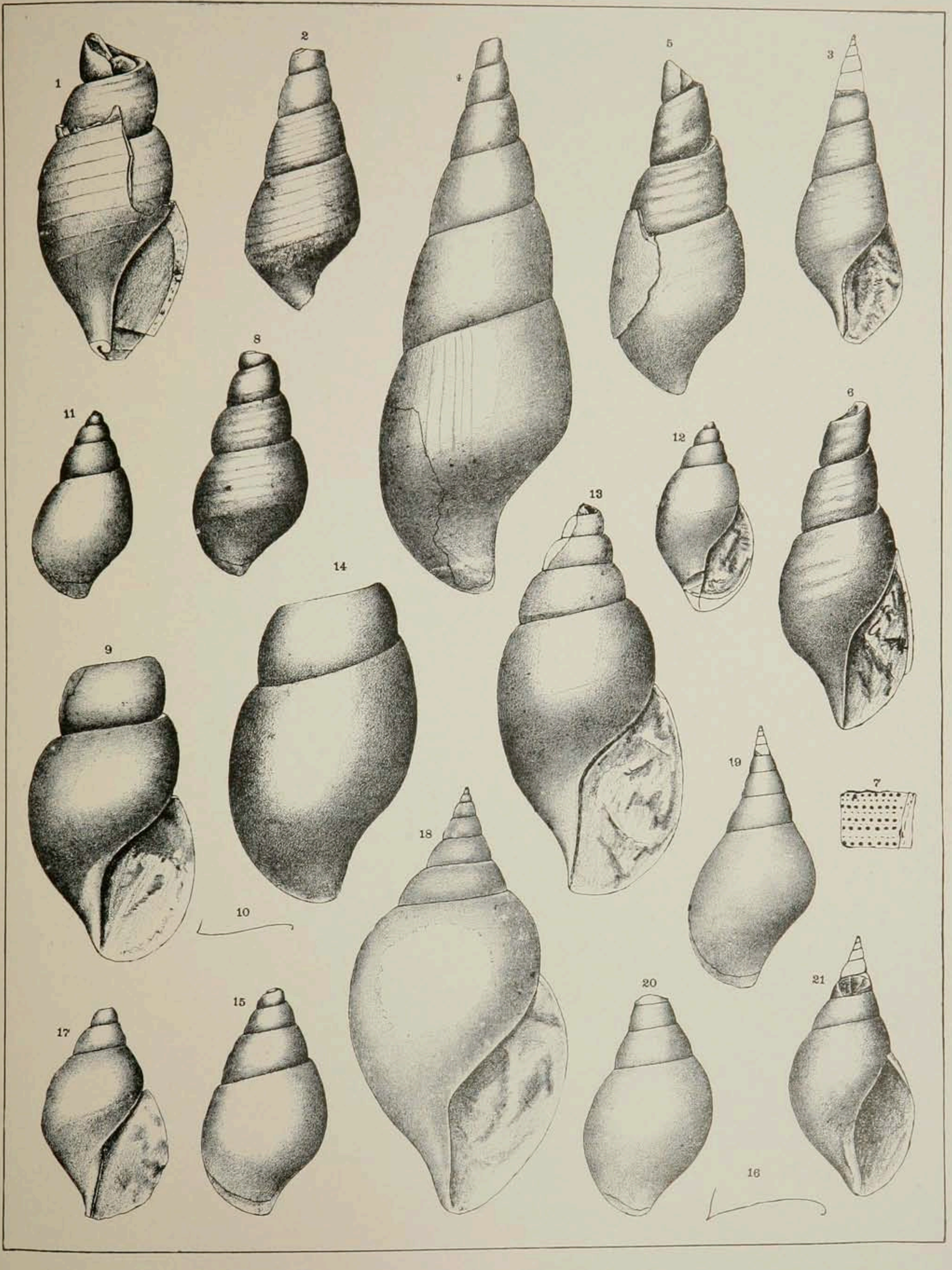
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PLATE LXXXI.

		PAGE.
Figs. 1 and 2	SUBULITES sp. undet. (? ELONGATUS Conrad)..	
	Lateral view of a cast of the interior and top of same, showing the peculiar termination of interior casts of species of *Subulites*. Trenton group, Ottawa, Canada.	
Fig. 3	SUBULITES CANADENSIS Ulrich..	1071
	Figure of a cast of the interior, restored at both extremities from other specimens. Black River group, Ottawa, Canada.	
Figs. 4 and 5	SUBULITES CONRADI U. and S..	1071
4	Cast of the interior; from the Stones River group, Cannon Falls, Minnesota. The relative narrowness of the shell, especially of the basal part, is the most important of the distinctive features of this species.	
5	Basal outline of lips.	
Figs. 6 to 8	SUBULITES DIXONENSIS U. and S..	1071
6	Lateral view of a partial cast of the interior, showing the anterior outline of the outer lip.	
7	Another view of same showing the form of the aperture, which is relatively wider below than in the other species, and the comparatively abrupt basal taper of the volutions. Stones River group, Dixon, Illinois.	
8	Outline of lower and outer lips as seen from below.	
Figs. 9 to 11	SUBULITES BELOITENSIS U. and S...	1072
9	Entire cast of the interior.* The mouth is very similar to that of *S. canadensis* (see fig. 3), but the shell as a whole is more slender, while the sides of the whorls are practically flat instead of gently convex.	
10	Lower part of same specimen in another view, for comparison with fig. 6. Stones River group, Beloit, Wisconsin.	
11	Outline of lower and outer lips as seen from below.	
Figs. 12 to 15	SUBULITES PERGRACILIS U. and S...	1072
12	Apertural view of a fragment, with the lower extremity and the spire restored in outline.	
13 and 14	Two views of another fragment, the first showing the peculiar band along the suture, the second the aperture.	
15	Three lines, the lower representing the basal outline of fig. 12, the middle one the basal outline of fig. 14, the upper one part of the greatest circumference of the body whorl. Trenton group, Fusispira bed, Wykoff, Minnesota.	
Figs. 16 and 17	SUBULITES PARVUS Ulrich..	1072
	Opposite views of a cast of the interior. Stones River group, High Bridge, Kentucky.	
Figs. 18 and 19	SUBULITES NANUS Ulrich...	1072
	Opposite views of the larger of two specimens of this small species. Stones River group ("Glade limestone"), Lebanon, Tennessee.	
Fig. 20	SUBULITES sp. undet..	
	Fragmentary example of a curved species; from the Fusispira bed at Wykoff, Minnesota.	
Figs. 21 and 22	CYRTOSPIRA BICURVATA Ulrich..	1074
	Opposite views of the unique specimen upon which the species is founded. Stones River group, High Bridge, Kentucky.	
Fig. 23	CYRTOSPIRA WYKOFFENSIS U. and S..	1074
	Apertural view of the type specimen, the apex restored in the figure. Fusispira bed, Wykoff, Minnesota.	

* We believe this specimen is composed of parts of two individuals. However that may be, it gives a correct idea of the species and therefore may justly stand as the type.

PAGE.

Figs. 24 and 25 CYRTOSPIRA TORTILIS Ulrich........ 1074

Opposite views of a silicified shell of this species. Lower division of the Stones River group, Murfreesboro, Tennessee.

Figs. 26 and 27 FUSISPIRA PLANULATA U. and S.. 1078

Opposite views of the type of this species. The specimen is an excellent cast of the interior from the Fusispira bed of the Trenton at Eagle Point, Iowa.

Figs. 28 to 31 FUSISPIRA ANGUSTA U. and S... 1079

28 Apertural view of the lower whorls of a large specimen. It is a cast of the interior, but as the shell was not very thick, it gives a good idea of the external form ofthe volutions and mouth. Clitambonites bed, Cannon Falls, Minnesota.

29 Dorsal view of a more complete cast, from the same locality, showing the comparatively great hight of the volutions

30 A third cast having somewhat deeper sutures than usual. Cannon Falls, Minnesota.

31 Somewhat loosely coiled cast of the interior, from the same bed and locality.

Fig. 32 FUSISPIRA ANGUSTA var. SUBPLANA U. and S 1079

Ventral view of one of the two specimens upon which this variety is founded. Clitambonites bed, near Cannon Falls, Minnesota.

Figs. 33,34,36,37 SUBULITES, sp. undet... 1073

33 Testiferous fragment with banded suture line. Black River group (Ctenodonta bed), Chatfield, Minnesota.

34 Apical portion of a shell, preserved partly as a cast of the interior. Stones River group, High Bridge, Kentucky.

36 An imperfect, macerated shell from High Bridge, Kentucky.

37 Interior cast of the spire showing that the apical whorls are not filled with solid material as in the more typical species of *Subulites*. Stones River group, Beloit, Wisconsin.

Fig. 35 SUBULITES REGULARIS Ulriet... 1072

(See also plate LXXXII, figs. 47 and 48.)

35 Interior cast of the last volution, showing the long and remarkably slender canal. High Bridge, Kentucky.

Figs. 38 and 39 FUSISPIRA SUBFUSIFORMIS Hall 1077

Opposite views of an incomplete cast of the interior, showing the convex whorls and rather wide mouth which are characteristic of this species. Fusispira bed, Goodhue county, Minnesota.

Figs. 40 and 41 MEEKOSPIRA SUBCONICA U. and S... 1080

Two views of the type of this species. Richmond group, near Spring Valley, Minnesota.

(Gastropoda.)

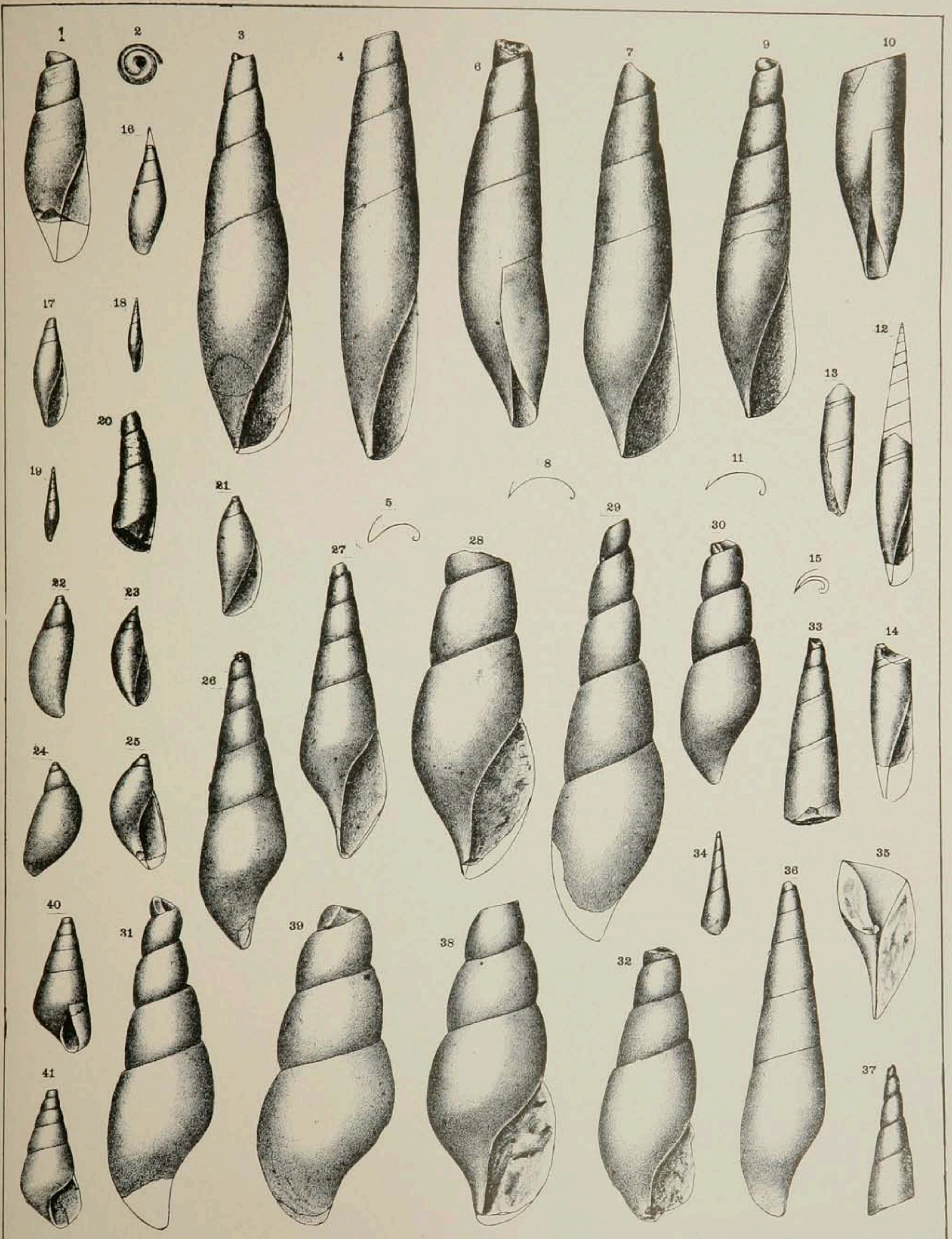
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PLATE LXXXII.

PAGE.

Figs. 1 and 2 TRYBLIDIUM MODESTUM U. and S. 826
Two views, dorsal and profile, of the specimen described.

Figs. 3 and 4 ARCHINACELLA PEROVALIS Whitfield sp. 830
Dorsal and profile views of a cast of the interior from Minneapolis. (After Sardeson, who called it *Metoptoma explanata.*)

Figs. 5 and 6 ARCHINACELLA RUGATINA Ulrich 835
Two views of a cast, apparently of the exterior, from Middletown, Ohio.

Figs. 7 to 9 SCENELLA MAGNIFICA U. and S. 839
Three views, in outline and restored at the apex, of the specimen described.

Fig. 10 SCENELLA OBTUSA Sardeson sp. 841
Dorsal view of a cast of the interior, from Minneapolis. (After Sardeson, who called it *Conchopeltis obtusa.*)

Figs. 11 to 15 STENOTHECA EXSERTA Sardeson sp. 842
11 and 12 Two views of a small specimen presumably of this species; Minneapolis. Geological and Natural History Survey of Minnesota, Museum Register No. 715.
13 Outline view of a large specimen from Beloit, Wisconsin, belonging to the collection of the University of Wisconsin.
14 and 15 Copies of Sardeson's original figures of his *Tryblidium exsertum*, founded upon a specimen from the "Blue limestone" at Minneapolis.

Figs. 16 to 20 SALPINGOSTOMA SCULPTILIS U. and S. 902
16 Lateral view of a partial cast of the interior from which the greater part of the apertural expansion has been broken away; Goodhue county, Minnesota.
17 and 18 Lateral and dorsal views of a more complete cast of the exterior, showing the greater part of the expanded aperture, the dorsal slit and surface sculpture; from Goodhue county. Geological and Natural History Survey of Minnesota, Museum Register No. 7462.
19 Portion of same, ×5, showing slit-band and sculpture.
20 Transverse section of inner half of last whorl of a cast of the interior from Fillmore county, Minnesota.

Figs. 21 and 22 SALPINGOSTOMA IMBRICATA U. and S. 902
Two views of the specimen described.

Figs. 23 to 25 OXYDISCUS SUBACUTUS, n. sp. (Ulrich.) 913
(See also plate LXII, Figs. 62—65.)
23 Lateral view in outline, each volution embracing about one-half of the preceding one.
24 Ventral view of same, ×2, to correct fig. 62 on pl. LXII.
25 Side view of a similar specimen, ×2, showing the slender inner whorls. Both specimens are from Danville, Kentucky.

Figs. 26 to 28 OXYDISCUS CRISTATUS Safford sp. 914
26 Lateral view of the smallest of four specimens; Jackson county, Tennessee. Collection of Prof. J. M. Safford.
27 Similar view of the largest specimen; Lindsley's Hill, Tennessee. In this example the outer part of the last whorl is free from the dorsal keel of the preceding whorl.
28 Portion of the dorsal keel of a large specimen, broken like fig. 27, showing the posterior extremity of the long slit; Nashville, Tennessee.

Figs. 29 to 31 CŒLOCAULUS NEGLECTUS U. and S. 1020
29 and 30 Lateral and basal views of the specimen described; near Cannon Falls, Minnesota.
31 Upper two whorls of same, ×2.5, to show the rounded terminus more clearly.

Figs. 32 to 34 HELICOTOMA GRANOSA Ulrich 1035
32 The upper side of a small specimen, ×3, from High Bridge, Kentucky.
33 Profile view of same, ×3, showing the surface granulation more clearly than in fig. 32.
34 Upper side of same, natural size.

Figs. 35 to 38 LIOSPIRA ABRUPTA U. and S. 995
35 Under side of an average example. Murfreesboro, Tennessee.
36 Upper side of another specimen.
37 Profile views, ×2, the lower line giving the form for the original of fig. 35, the line above it for that of fig. 36. The spire is sometimes more depressed. The line on the right of the figure is intended to show the contour of the "band" and peripherial portion of the whorls.
38 Oblique view of the umbilicus, ×2, showing the crescent-shaped reflexion of the inner lip.

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Figs. 39 to 41 LIOSPIRA DECIPIENS Ulrich 998

39 Upper side, showing slender volutions and distinct peripheral band; Murfreesboro, Tennessee.

40 Lower side of same, with the apertural portions restored. The umbilicus is filled with shell-matter as in *L. micula*, *L. progne* and other species of the genus. (See plates LXVIII and LXIX.)

41 Profile of same, natural size; also outline of upper surface and periphery of last whorl, intended especially to show the band in transverse section.

Figs. 42 to 44 LIOSPIRA MODESTA Ulrich 995

Three views, ×2, of a specimen from the Ctenodonta bed at Chatfield, Minnesota. Since page 995, on which this shell is referred to as possibly belonging to *L. abrupta*, was printed, we have decided that it is sufficiently distinct to bear a name of its own. We propose, therefore, to call it *L. modesta*.

Fig. 45 MACLURINA MANITOBENSIS Whiteaves sp. 1041

Inner whorls on the flat side of a specimen from Olmsted county, Minnesota, ×2.

Fig. 46 MACLURINA CUNEATA Whitfield sp. 1042

Vertical section of a very young example, magnified nearly two diameters, showing that the inner whorls are widely umbilicated. The specimen is imbedded in the rock filling the outer whorl of the specimen of *M. manitobensis* showing the inner whorls as represented in fig. 45.

Figs. 47 and 48 SUBULITES REGULARIS U. and S. 1072

(See also plate LXXXI, fig. 35.)

47 Ventral view of a young specimen; High Bridge, Kentucky.

48 Side view of a large specimen, from the same locality.

Figs. 49 to 54 STROPHOSTYLUS TEXTILIS U. and S. 1064

49 Cast of the interior from St. Paul, Minnesota, showing the usual form and several of the strong obliquely transverse furrows which occur so frequently, especially on interior casts, in this species.

50 A more depressed cast from Fillmore county, retaining traces of external markings.

51 Ventral view of a testiferous example from the vicinity of Cannon Falls, Minnesota.

52 Dorsal view of an incomplete shell from the same locality. The surface markings are beautifully preserved on this specimen.

53 View of a specimen from Chatfield, Minnesota, from which a part of the last whorl was removed so as to show the spirally twisted folds of the columella.

54 Surface of last whorl of original of fig. 52, ×5.

Figs. 55 to 61 CYCLONEMA GRACILE Ulrich, and varieties 1062

55 to 57 Three specimens of the typical form of this species, showing considerable difference in their respective apical angles, Newport, Kentucky.

58 Ventral view of a specimen, from the same locality, referred to this species with some doubt. It may be an extreme form of *C. sublæve* (plate LXXVIII, figs. 48 and 49), but the upper whorls are more convex than in any of the numerous specimens of that species before us.

59 Dorsal view of a rather small but perfect specimen of a form that, on account of the constant presence of delicate revolving lines, may be distinguished as var. *striatellum*. It occurs with the other varieties at Cincinnati.

60 and 61 Two views of the apical whorls of same, ×5.

Figs. 62 to 64 CYCLONEMA (?HOLOPEA) LIMATUM Ulrich 1063

62 and 63 Opposite views of an excellently preserved example of this *Holopea*-like shell. The surface on portions of the specimen is polished, and here exhibits traces of revolving lines as shown in the figures.

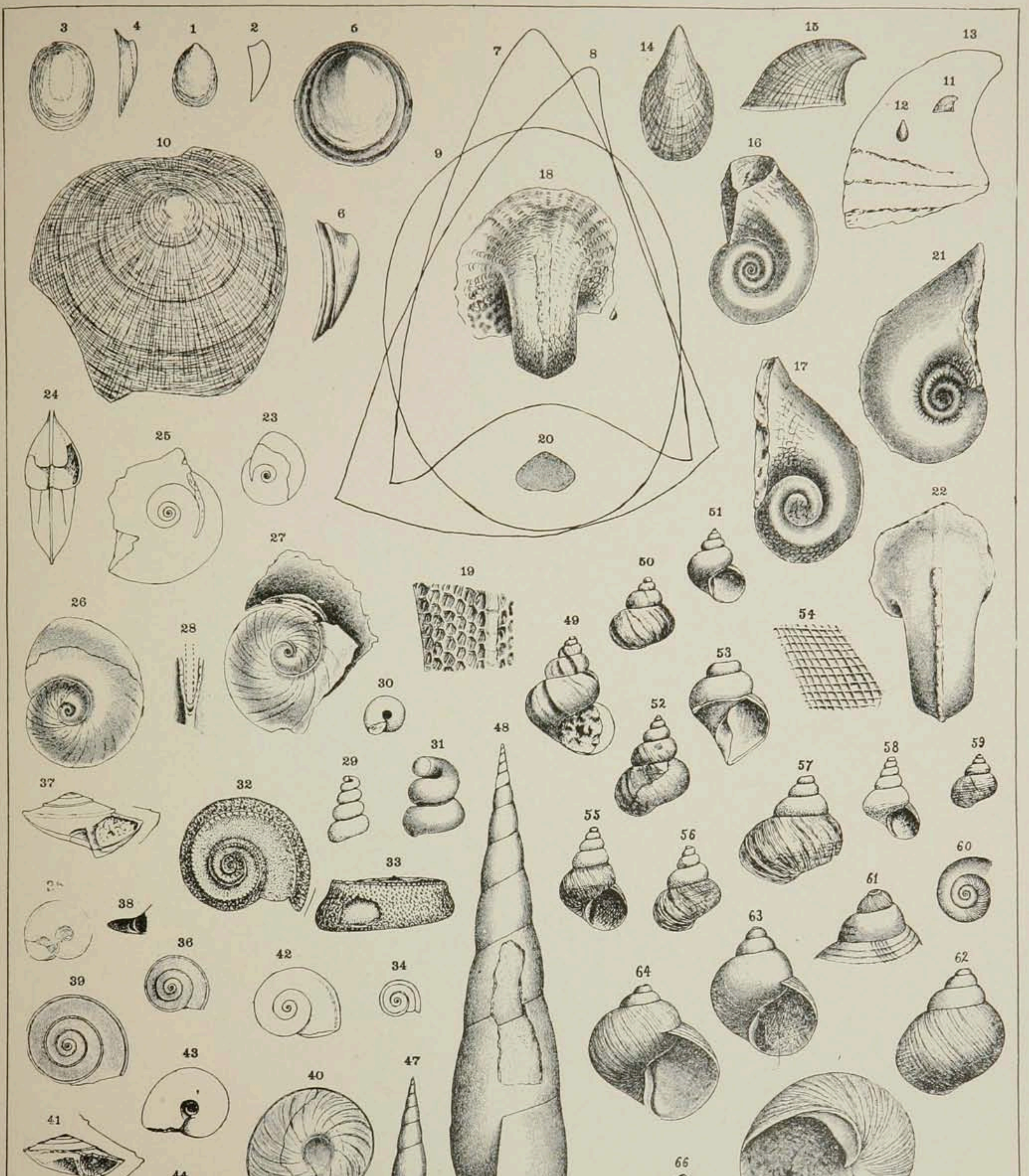
64 Ventral view of a more ventricose individual. Both specimens were found in the vicinity of Cincinnati, Ohio.

Figs. 65 to 67 CYCLONEMA TRANSVERSUM Ulrich 1062

65 Dorsal view of the strongly marked specimen regarded as the type of this species; Covington, Kentucky. The two upper whorls are restored in the figure.

66 and 67 Dorsal and basal views of a larger specimen which, while agreeing in probably all essential respects with the preceding, has a smoother surface with faint indications of revolving lines on the periphery.

(Gastropoda.)



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The most important reference is given first; others follow in numerical order. Each scientific name is indexed for every page on which it occurs. Synonyms, and also the figures referring to the pages on which they are mentioned, are in italics. An asterisk after a page reference signifies that an illustration of the form in question is given on that page. A page reference in bold face type signifies that on this page the form is described.