THE

LOWER SILURIAN OSTRACODA

OF

MINNESOTA.

By E. O. ULRICH.

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CHAPTER VII.

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This order of Crustacea comprises small, generally minute, animals having the entire body enclosed in a shell or carapace consisting of two more or less nearly equal calcareous or corneous valves, united along the back by a membrane, and capable of being opened at their ventral margins. The valves are closed by a subcentral adductor muscle, the attachment of which is marked on their inner sides by a tubercle, a pit or a number of small spots. The body is not segmented but has seven pairs of appendages, of which the first two are antennæ, while they, like the others, are also adapted for creeping and swimming. These appendages, together with the caudal extremity of the short abdomen, are protruded along the ventral margin of the carapace when the valves are opened.

Behind the first two pairs of appendages (antennules and antennæ), is a pair of mandibles, followed by a pair of maxillæ, while the third and fourth pairs may be either legs or jaws. Finally the last two pairs are leg-like and generally stronger than the preceding pairs. The extremity of the abdomen may be bifurcated or consist of a single spinous plate.

As a rule the eyes are well developed, with commonly a small median and two larger lateral ones present. The position of the latter is often indicated on the exterior of the valves by a small "eye tubercle." A distinct heart may be present or absent, but the alimentary and generative organs are well developed.

The Ostracoda, or "water-fleas" as they are often called, are represented by very numerous forms both in fresh water and in the sea. Of the families only the *Cypridæ* are chiefly fresh-water forms, while most of the other families are restricted to marine or brackish waters. Taken as a whole they are to be considered as shallow water inhabitants, and of social habits, being found in great numbers swimming near the surface of the water or creeping over the bottom. Remains of Ostracoda abound

also in nearly all the geological formations, and in some cases so numerously that whole layers are almost composed of their shells. The fossil forms are furthermore of great variety, since, with perhaps a single exception, all the families which have been established for the recent forms have also been recognized in the fossil state, while many types occur in the paleozoic rocks that seemingly are now totally extinct.

With a single exception (*Palæocypris*), only the carapace valves are preserved in the fossil condition, and as these are often very similar in different genera and even families, it is evident that their study and classification is a matter of exceptional difficulty. To discriminate between these small fossils the paleontologist is obliged to rely on small differences in the shape, the relative size of the valves, the characters of the edges and of the hinge, the thickness of the valves, and the surface ornamentation. Among the paleozoic forms the valves are commonly lobed or sulcate and variations in these are usually counted important. A frequent difficulty is to distinguish between the anterior and posterior extremities. When not alike, the thickest end (it is generally also the highest) is considered as the posterior. It must be confessed, however, that this arbitrary determination can be accepted only as provisional. Some working rule like this is necessary until comparison of other details of structure will have furnished us with more reliable criteria upon which to base conclusions.

The carapace as stated consists of two calcareous or corneous valves of compact structure, commonly less than 4 mm. in length, though in a few cases the length exceeds 20 mm. The two valves may be equal (*Tetradella, Primitia,* etc.) or more or less unequal, with either the right or left overlapping the other at the ventral border only (*Leperditia, Leperditella,* etc.), or at the dorsal border as well (*Bythocypris* and *Krausella*), while in others the overlap is entire (*Cytherella*). The hinge or dorsal margin may be straight or arcuate, and, especially among the paleozoic types, is generally simple, though among more recent forms (*Cytheridæ*) hinge teeth and corresponding sockets are not uncommonly developed. The anterior and posterior margins may be broadly or narrowly rounded, pointed or drawn out beak-like; and when the back is straight the ends may join it angularly. The ventral margin is oftenest convex though it is not infrequently straight or gently concave. The sides of the valves in the majority of Ostracoda may be said to be approximately even in contour or convexity but in many cases, especially among paleozoic forms, they are indented and thrown into two or more tubercles, lobes or ridges. The surface of the valves may be smooth and polished or it may be granulose, pitted, reticulose, striated, hirsute or otherwise marked, the effect being in many instances quite ornamental. Finally many of the paleozoic Ostracoda of the family *Beyrichiidæ* have a wide, frill-like false border, which projects considerably beyond the true contact

edges of the valves. The genus *Eurychilina* affords excellent examples of species with a "frill."

As regards the geological or time distribution of the Ostracoda, it is certain that they began in the upper divisions of the Taconic system, if indeed they are not to be reckoned among the earliest fossils known. In the Lower Silurian deposits already they occur in such great numbers and variety, that it is doubtful if the representations of the order at any subsequent time exceeded them in these respects. The predominant types, *Leperditiidæ* and *Beyrichiidæ*, moreover, while holding their own perhaps through the Upper Silurian, were greatly reduced during Devonian and Carboniferous times and are now totally extinct. Some recent families and genera on the other hand were sparingly represented, but taken as a whole the Silurian Ostracoda fauna is decidedly peculiar.*

In the Upper Silurian formations the *Leperditiidæ* and *Beyrichiidæ* still predominated, but the fauna here received decided accessions in the way of genera regarded as belonging to the family *Cypridæ*. The Devonian Ostracoda, though less numerous, are not very different from the Upper Silurian types, most of the old genera being more or less sparingly represented. Several genera (*e. g. Kyammodes*, Jones, and *Barychilina*, Ulrich) are so far to be considered as peculiar to this system of rocks. The Ostracoda fauna of the Carboniferous deposits, on the contrary, while retaining many small species of essentially Silurian genera like *Leperditia*, *Beyrichia* and *Primitia*, which occur associated with the related genera *Beyrichiella* and *Beyrichiopsis* and numerous forms of the previously established types of the *Cypridæ*, nevertheless assumed a distinctive aspect through the strong development of hitherto unknown types of *Cyprinidæ*.

In succeeding formations the Ostracoda are everywhere poorly represented in the Triassic and Jurassic. But in the Cretaceous and Tertiary strata of Europe certain genera, *Cythere* especially, develop an astounding variety and wealth of species. The forms are all small, and this may in part account for the fact that so few have been discovered in American deposits of these ages.

The recent genera having, or believed to have, paleozoic representatives, occur in the various formations as follows: *Cypridina*, *Bradycinetus* and *Philomedes*, in the Carboniferous; *Polycope*, Silurian and Carboniferous; *Cytherella* and *Cythere*, Silurian, Carboniferous and Permian; *Cythereis* and *Cytherideis*, Permian; *Bairdia*, Silurian, Devonian, Carboniferous and Permian; *Bythocypris*, Silurian, Devonian, Carboniferous; *Macrocypris*, Silurian and Carboniferous; *Pontocypris*, Silurian; and *Aglaia*, *Argillœcia* and *Candona*, in the Carboniferous.

*That the Silurian species which are now placed into recent genera actually belong there may well be questioned. In my opinion they do not, yet, as they cannot, with our limited opportunity for comparison, be distinguished, I am obliged to agree that the aims of classification are for the time being sufficiently satisfied.

PROVISIONAL CLASSIFICATION OF THE PALEOZOIC OSTRACODA.

Family LEPERDITIIDÆ.

GENERA: *Leperditia*, Ronault; *Leperditella*, Ulrich; *Isochilina*, Jones; *Aparchites*, Jones; *Schmidtella*, Ulrich; ? *Æchmina*, Jones.

Family BEYRICHIIDÆ.

GENERA: *Beyrichia*, McCoy; *Beyrichiella*, Jones and Kirkby; *Beyrichiopsis*, Jones and Kirkby; *Klœdenia*, Jones and Holl; *Ulrichia*, Jones; *Primitia*, Jones and Holl; *Primitiopsis*, Jones; *Eurychilina*, Ulrich; *Dicranella*, Ulrich; *Halliella*, Ulrich; *Jonesella*, Ulrich; *Bollia*, Jones and Holl; *Ctenobolbina*, Ulrich; *Tetradella*, Ulrich; *Drepanella*, Ulrich; *Placentula*, Jones and Holl; *Kirkbya*, Jones; *Moorea*, Jones and Kirkby; *Strepula*, Jones and Holl; *Macronotella*, Ulrich; *Primitiella*, Ulrich; *Dilobella*, Ulrich.

Family BARYCHILINIDÆ.

GENERA: *Barychilina*, Ulrich; *Kyammodes*, Jones.

Family ENTOMIDÆ.

GENERA: *Entomis*, Jones; *Elpe*, Barrande; *Entomidella*, Jones; ? *Hippa*, Barrande.

Family CYPRIDINIDÆ.

GENERA: *Cypridina*, Milne-Edwards; *Cypridinella*, Jones; *Cypridellina*, Jones; *Sulcuna*, Jones; *Cypridella*, DeKoninck; *Cyprella*, DeK.; *Bradycinetus*, Sars; *Philomedes*, Lilljeborg; *Rhombina*, J.; *Cyprosis* and *Cyprosina*, Jones.

Family ENTOMOCONCHIDÆ.

GENERA: *Entomoconchus*, McCoy; *Offa*, Jones.

Family POLYCOPIDÆ.

GENUS: *Polycope*, Sars.

Family CYTHERELLIDÆ.

GENUS: *Cytherella*, Jones and Bosquet.

Family CYTHERIDÆ.

GENERA: *Cythere*, Müller; *Bythocythere*, Sars; *Carbonia*, Jones; ? *Youngia*, Jones and Kirkby; *Xestoleberis*, Sars.

Family THLIPSURIDÆ.

GENERA: *Thlipsura*, Jones and Holl; *Phreatura*, Jones and Kirkby; *Octonaria*, Jones.

Family CYPRIDÆ.

GENERA: *Aglaia*, Brady; *Candona*, Baird; *Argilloecia*, Sars; *Macrocypris*, Brady; *Bythocypris* Brady; *Bairdia*, McCoy; *Pontocypris*, Sars; *Pachydomella*, Ulrich.

Family BEECHERELLIDÆ.

GENERA: *Beecherella*, Ulrich; *Krausella*, Ulrich.

Family DARWINULIDÆ.

GENUS: *Darwinula*, Jones (Brady and Robertson).

NOT CLASSIFIED.

Cytherellina, Jones and Holl; *Bursulella* and *Bernix*, Jones; *Lepiditta*, *Lepidilla*, *Beyrichona* and *Hipponicharion*, Mathews; *Isoxys*, Walcott.

Order OSTRACODA.

Family LEPERDIITIDÆ.

Genus LEPERDITIA, Ronault.

Leperditia, RONAULT, 1851, Bull. Soc. Geol., France, 2d Ser., vol. 8, p. 377; FR. SCHMIDT, 1873, Mem. Acad. Imp. Sci. St. Petersburg, vol. 21, No. 2; also 1883, *idem*, vol. 31, No. 5; JONES, 1881, Ann. Mag. Nat Hist., 5th ser., vol. 8, p. 332; JONES and KIRKBY, 1887, Proc. Geol. Assoc., vol. 9, p. 503. Also JONES, 1856, 1858, 1884, 1890, 1891; KOLMODIN, 1869 and 1879; KRAUSE, 1877 and 1891; KIESOW, 1884; ZITTEL, 1885; MILLER, 1889; ULRICH, 1890 (not 1892). Previous to 1851 species were referred to *Cytherina*, *Cythere* and *Cypridina*.

Carapace more or less convex, often large, suboblong or semiovate in outline, with an oblique backward swing; dorsal edge straight, often angular at the extremities; ventral outline rounded, sometimes a little produced at the middle; greatest thickness in the ventral half, the lower edge usually being also blunt; valves unequal, the right the larger and overlapping the left; overlap chiefly ventral, simple, or the further entrance of the ventral edge of the left valve is prevented by two or more papillæ set within the overlapping edge of the right; hinge simple. Surface frequently horny in appearance, smooth in most cases, granulose or minutely punctate in others; a small tubercle or "eye-spot" is generally present on the antero-dorsal fourth, and a large, rounded subcentrally situated sunken muscle-spot is seen on the inner side of the valves and not infrequently distinguishable on the exterior also.

Type; *L. brittannica* Ronault.

An excellent account of this genus is given by Dr. Fr. Schmidt (*loc. cit.*) in his two papers on the "Russichen Silurichen Leperditien." According to that author and to Roemer, *L. grandis* Schrenck (*L. gigantea* Roemer) attained a length of 43 mm. This is the largest species of the genus and probably the largest known ostracode. In most of the species the length varies between 8 mm. and 25 mm., while in several other unquestionably congeneric forms the maximum length is less than 4 mm. Besides, a number of minute forms are referred here by Prof. Jones, myself and others, of which it is at least doubtful that they really belong to the genus. Because of their small size and chiefly perhaps because of the imperfection of the specimens, the ventral overlap of the right valve has not been established for them. Nor has the "eye-tubercle" and other peculiarities of the typical species been seen on them. For some at any rate *Aparchites* would offer a more natural reception. Finally, a number of comparatively small species (1.5 mm. to 3.0 mm.) which I have here-

tofore held as belonging to the genus, are now referred to a new genus on the ground that the free edges of their valves are different and the left instead of the right the larger.

Probably seventy-five good species of the genus are known, the greater number of which and all the larger forms, are restricted to the Lower and Upper Silurian deposits. The earliest forms occur in the Taconic, but it is not till we come to the Trenton that the species become numerous.* The Utica slate and Hudson River group species are nearly all small and of doubtful affinities. The same is true of the Devonian and Carboniferous forms, but in no wise of those which are inclosed in Upper Silurian strata, since in this age the genus seems to have attained its greatest development both in the way of size and species.

LEPERDITIA FABULITES *Conrad.*

PLATE XLIII, FIGS. 10–14

Cytherina fabulites CONRAD, 1843, Proc. Acad. Nat. Sci. Phila., vol. i, p. 332.
Leperditia fabulites JONES, 1856, Ann. Mag. Nat. Hist., 2d ser., vol. xvii, p. 89; also 1881, *idem*, 5th ser., vol. viii, p. 342; also 1891, Contri. Can. Micro-Pal., pt. 3, p. 98; WHITFIELD, 1883, Rep. Geol. Sur. Wis., vol. i, p. 160; ULRICH, 1890, Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 173.
Leperditia canadensis, var. *josephiana* JONES, 1858, Ann. Mag. Nat. Hist., ser. 3, vol. i, p. 341; also 1858, Geol. Sur. Can., Dec. 3, p. 94.
Leperditia fabulites var. *josephiana* JONES, 1881, Ann. Mag. Nat. Hist., ser. 3, vol. viii, p 344.
Leperditia josephiana JONES, 1884, Ann. Mag. Nat. Hist., ser. 5, vol. xiv, p. 341.

SIZE.—1.	Beloit, Wis.,	†(E. C.)	Length,	12.4	mm.;	hight,	7.9	mm.;	thickness,	5.0	mm.
2.	Minneapolis	(L. V.)	"	14.0	"	"	8.4	"	"	3.0	"
3.	"	(R. V.)	"	11.7	"	"	7.5	"	"	3.0	"
4.	"	(E. C.)	"	11.5	"	"	7.4	"	"	5.0	"
5.	Dixon, Ill.	(E. C.)	"	12.2	"	"	7.5	"	"	5.5	"
6.	Lavergne, Tenn.	(L. V.)	"	13.2	"	"	8.3	"	"	3.1	"
7.	Lebanon, Tenn.	(E. C.)	"	10.0	"	"	6.5	"	"	4.7	"
8.	"	(E. C.)	"	7.5	"	"	4.7	"	"	3.2	"
9.	"	(E. C.)	"	8.2	"	"	5.2	"	"	3.8	"
10.	"	(E. C.)	"	7.0	"	"	4.7	"	"	3.3	"
11.	"	(E. C.)	"	8.0	"	"	5.0	"			

Carapace of medium size, obliquely subovate, comparatively long, widest posteriorly; ventral curves moderate, strongest just behind the midlength; cardinal line straight, comparing with the length of the valve as 2 is to 3, the two extremities almost equally angular; hight of ends about as 3 is to 4, both obliqely truncate above, the anterior narrowly rounded in the middle; the posterior outline more broadly and evenly curved though having the usual backward swing. Ventral edge of carapace obtuse, scarcely flattened, with a slight furrow on each side near the edge of the

*Considering that the equivalent strata of Kentucky, Tennessee and Canada, contains no less than eleven species of *Leperditia*, it is a little remarkable that only one undoubted species of the genus has so far been discovered in the Trenton series of strata of the northwestern states.

†In giving the size of specimens, their condition is indicated by the abbreviations E. C., R. V., and L. V., signifying, respectively, entire carapace, right valve, and left valve. Where these initials are not used, it is to be understood that the dimensions are of an entire carapace.

right valve in which a row of minute punctæ is generally distinguishable; overlap extending all around the free edges, strongest ventrally; except in rare instances, neither valve has a flange or flattened border, and when present it is in all cases very narrow and undefined; dorsal edge somewhat thickened, especially upon the left side. Surface of valves smooth or very faintly pitted, rather evenly convex with the greatest thickness somewhat beneath the center; a low ridge-like thickening along the posterior half of the dorsal margin of the left valve is to be noticed. Eye tubercle just distinguishable in most cases, rarely so distinct as in the specimen figured, often not to be detected. On the inner surface however it is always marked by a distinct pit. Muscle spot not distinguishable externally except when the specimens are weathered, but on the inner side it is often well marked and surrounded by fine reticulating radial lines, short dorsally, longest post-ventrally. On the inner side of the ventral edge of the right valve there are two rows of small papillæ, three to five in each, the number seeming to increase with age. The purpose of these papillæ, one series of which occurs in the anterior third, the other in the posterior, evidently was to prevent undue overlapping of the valves by presenting an obstacle to the entering ventral edge of the left valve.

Of this species, I have before me no less than five hundred specimens, representing twelve localities in the states of Minnesota, Wisconsin, Illinois, Kentucky and Tennessee. Considering its wide geographical range and abundance, it is remarkably constant in all its characters. That it is so in its outer form is clearly enough shown by the above measurements, taken from representative examples. They show further that the northwestern specimens are on an average about one-third larger than those from Tennessee. In all other respects however they are all practically identical.

In 1890 (*loc. cit.*) I believed it probable that *L. josephiana* Jones, would prove distinct from *L. fabulites*, but it is now quite evident to me, as it also has become to Prof. Jones, that there is no ground whatever for any distinction between them. Compared with other species, the Upper Silurian *L. hisingeri* Schmidt, is not far removed, and the variety *fabulina* from Lake Winnipegosis very similar indeed. Still as pointed out by Prof. Jones there are a number of minor differences between them, and these will no doubt be added to when the later form is fully known. Another closely related form is the *L. wiluiensis* Schmidt, from the Upper Silurian of Russia. Its hinge line is shorter and the antero-ventral curve somewhat fuller, but in other respects, even to the rows of punctæ along the ventral margin, the two species are much alike. *L. linneyi* Ulrich from the Upper Trenton of Kentucky is more obliquely produced posteriorly and has a shorter hinge line, a flatter ventral edge, distinct flanges, and better developed tubercle and muscle spot.

Formation and locality.—Lower Trenton or Birdseye limestone, Minneapolis, St. Paul and Cannon Falls, Minnesota; Mineral Point, Janesville and Beloit, Wisconsin; Rockton and Dixon, Illinois; High Bridge and Frankfort, Kentucky; Lebanon, Lavergne and Murfreesboro, Tennessee; also St. Joseph Island, Lake Huron, and Murray Bay, Canada. It is said to occur in a similar position also in New York.

Genus LEPERDITELLA, n. gen.

Leperditia (part.) ULRICH, 1892, Amer. Geol., vol. x, pp. 263-268.

Carapace leperditoid, ovate or oblong, with a straight back; surface of valves without eye tubercle or distinguishable muscle spot, but a more or less obscure broad depression is generally present in the central part of the dorsal half; left valve a little larger than the other, the free edges of the latter fitting into a groove. Length 1 to 3 mm.

Type: *Leperditia inflata* Ulrich (not *L. inflata* Murchison sp.).

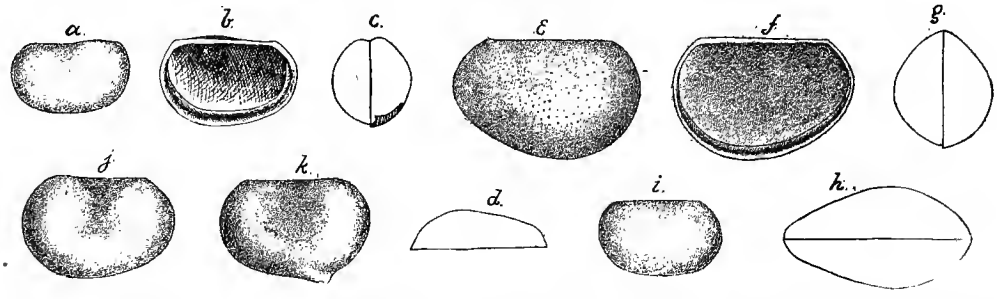

Fig. 46. *a*, small left valve of *Leperditella inflata* Ulrich; *b*, inner side of a larger valve of same, showing the marginal groove; *c*, vertical section in outline of entire carapace of same; *d*, dorsal outline of left valve of same; *e* and *f*, external and internal views of a left valve of *Leperditella mundula* Ulrich; *g* and *h*, outlines in anterior and ventral views of same; *i*, right side of an entire carapace of *Leperditella æquilatera* Ulrich; *j*, right valve of *Leperditella sulcata* Ulrich; *k*, left valve of *L. sulcata* var. *ventricornis* Ulrich. All the figures are magnified 10 diameters, and all the specimens from either the upper or the lower beds of the Birdseye limestone at High Bridge, Kentucky.

This genus is separated from typical Silurian *Leperditia* because the left instead of the right valve overlaps the other, and instead of a simple overlap the ventral edge of the right valve fits into a groove in the left. Furthermore, the eye tubercle and muscle spot of *Leperditia* are not distinguishable externally in *Leperditella*. In certain Carboniferous species of *Leperditia* (*L. carbonaria* Hall, *L. nicklesi* Ulrich and others) the overlap of the valves, though reversed, is very similar to that of the Lower Silurian species here brought together as *Leperditella*. Perhaps they also ought to be distinguished from *Leperditia*.

Leperditella embraces *L. tumida*, *L. mundula*, *L. æquilatera*, *L. inflata*, *L. germana*, *L. sulcata*, and var. *ventricornis* and *L. ? dorsicornis*, all described by me in the American Geologist for November, 1892, as species of *Leperditia*. To these I now add *L. canalis*, *L. persimilis* and *L. macra*. With the exception of *L. ? dorsicornis*, which is from the Hudson River group, all these species occur in strata equivalent to the Birdseye and Black River limestones of New York.

Prof. T. Rupert Jones recently described two species from Canada (Contri. Can. Micro-Pal., pt. 3, 1891), that may be congeneric with these species, viz.: *Leperditia ? obscura* and *Isochilina labellosa*, the latter appearing to be much like *L. tumida*.

LEPERDITELLA CANALIS, *n. sp.*

PLATE XLIII, FIGS. 1–3.

SIZE.—Length, 1.78 mm.; hight, 1.22 mm.; thickness (L. V.) 0.59 mm.

Carapace ovate, widest posteriorly, tumid, the point of greatest thickness but little behind and beneath the center; anterior outline semicircular; dorsum straight, not angular in front, and quite obtuse behind, posterior margin somewhat obliquely rounded, scarcely truncated above; near the ventral edge of the left valve a distinct channel or groove, deepest centrally, has suggested the name. Surface smooth.

This species is closely related to *L. tumida* Ulrich, occupying a similar geological position in Kentucky and Tennessee, and of which a right valve is figured for comparison on plate 45, (figs. 13—15). The outline in that species however is not so regularly rounded in front, nor so full antero-ventrally, the greatest convexity is more posterior and scarcely so great, and the dorsal angles more distinct. But the feature particularly relied on in distinguishing the two species is the groove along the ventral border of the left valve in *L. canalis*, the Kentucky form being without this peculiarity.

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

LEPERDITELLA PERSIMILIS, *n. sp.*

PLATE XLIII, FIGS. 4–6.

SIZE.—(E. C.) Length 1.75 mm.; hight 1.23 mm.; thickness 0.8 mm.

Carapace ovate, moderately convex, with the ends nearly equal; no dorsal angle behind but a well marked one in front; ventral overlap distinct; dorsal edge thick, shoulder like; greatest thickness central; suface smooth. The length varies between 1.5 mm. and 2.5 mm.

At first sight this species looks very much like *L. canalis*, but carefully compared they prove quite distinct. The outline is somewhat different being less wide (high) posteriorly, the dorsal angles are reversed, and the dorsal edges much thicker, while the thickness of the carapace is less and the ventral groove, which marks the left valve in that species, wanting. Similar differences distinguish it from *L. tumida*. *Aparchites ellipticus* holds about the same size and is not very different in outline. Still as its valves do not overlap ventrally and as it has no dorsal angles and really

is a very distinct species, there is probably not much danger of confusion between them.

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

LEPERDITELLA MACRA, *n. sp.*

PLATE XLIII, FIGS. 7–9.

SIZE.—(E. C.) Length 1.4 mm., hight 1.08 mm.; thickness 0.55 mm.

Carapace short, scarcely oblique, subovate; dorsal margin straight, four-fifths of entire length of carapace, angles distinct; ends subequal, rounding almost uniformly into the basal outline; carapace moderately convex except in the anterior third, which is strongly compressed, giving a very unusual ventral and dorsal profile; anterior edges thickened, ventral overlap strong; surface smooth.

This species is remarkable for its compressed anterior part, and for its short form, in neither of which features it is equalled by any leperditoid ostracode known to me.

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

LEPERDITELLA GERMANA *Ulrich.*

PLATE XLV, FIGS. 24–26.

Leperditia germana ULRICH, 1892, American Geologist, vol. x, p. 266.

SIZE.—(L. V.) Length 2.17 mm.; hight 1.4 mm.; thickness 0.67 mm.

Carapace subovate, ends nearly equal, the posterior somewhat the wider; back straight for about four-fifths of the entire length, dorsal angles well marked; ventral outline somewhat oblique, most prominent just behind the center; edges rather blunt, with a narrow groove or rim along the free margins of the left and perhaps of both valves. Surface with the greatest convexity in the posterior half, and a broad, undefined depression in front of the center of the dorsal slope.

This form is closely related to *L. mundula* and *L. inflata*, two species from the lower division of the Birdseye limestone in Kentucky. From the first it differs in having the ends more equal, the edges blunter, and the surface more convex in the dorsal half. The narrow marginal rim is wanting in that species, and instead of a simple dorsal depression, that form has a low elevation in the lower part of it. The second differs chiefly in the greater inflation of the posterior half of its dorsal region.

Formation and locality.—This species has so far been met with only in the Lower Blue limestone of the Trenton at Mineral Point, Wisconsin, and Dixon, Illinois, but we know of no reason why it should not occur also at Minneapolis and other localities in the state.

LEPERDITELLA ? DORSICORNIS *Ulrich*.

PLATE XLV, FIGS. 19, 20 and 20*a*.

Leperditia ? (*Primitia*) *dorsicornis* ULRICH, 1892. American Geologist, vol. x, p. 267.

SIZE.—(L. V.) Length 1.72 mm.; hight 1.1 mm.; thickness 0.54 mm.

Valves subelliptical, slightly oblique, the ends subequal, the back straight nearly to the posterior extremity; the latter is generally convex and almost vertical in the upper two-thirds, while in the lower third the outline merges rapidly into the uniformly convex basal margin; anterior end uniformly curved. Surface much the highest in the posterior half, with a part prolonged dorsally into a short and obtusely pointed prominence that bends down close to the hinge line and projects somewhat beyond it. This prominence gives definition to the posterior side of a distinct sulcus extending almost half across the valve from the central part of the dorsal edge, and forward along the latter.

Though having a sulcus, and therefore agreeing in a general way with *Primitia*, I have chosen to arrange this species with *Leperditella* because it seems to represent merely an extreme development from such typical species of the genus as *L. inflata*, *L. germana* and *L. sulcata*. Specifically the present form is readily enough distinguished by the concentration of the dorsal prominence, and greater definition of the sulcus. The form which I called *Primitia glabra*,* and which occurs in the upper beds of the Cincinnati group in Ohio and Indiana, has a similar outline, but it is somewhat smaller and without the dorsal prominence. Still, I would not be surprised to find that it has overlapping valves as in *Leperditella*.

Formation and locality.—The type was found in the Hudson River shales at Savannah, Illinois. As equivalent strata occur near Wykoff and Spring Valley, Minnesota, it is quite likely that the species occurs also in this state.

Genus SCHMIDTELLA Ulrich.

Schmidtella, ULRICH, 1892. American Geologist, vol. x, p. 269.

Carapace small (2 mm. or less in length), short, rounded or subovate, moderately convex, more or less inflated in the dorsal region, this part being the thickest and appearing generally (in an end view), as projecting shoulder-like over and out from the straight hinge line; right valve slightly larger than the left and overlapping it along the ventral margin. No eye tubercle nor sulcus, but a faint central pit and elevation occasionally present.

Type; *S. crassimarginata*, Ulrich.

* Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 134; 1890.

The species which I propose to arrange under this genus might have been placed with *Aparchites*, Jones, were it not that they have overlapping valves. Even without that difference it may be questioned if such an arrangement would have been strictly proper, since no true *Aparchites* is strongly developed or gibbous in the dorsal region. As a rule *Aparchites* is thickest beneath the middle of the valves. The same is true of *Leperditia*, a genus that will, I think, be admitted by all to be distinct from *Schmidtella*. Though still somewhat in doubt respecting the systematic position of the new genus, it seems well to place it provisionally between *Leperditia* and *Aparchites*.

Besides the six Trenton species about to be described, *Schmidtella* will include *Aparchites? obsoletus* and *A. oblongus* of the Upper Silurian rocks of Europe. I refer to the specimens so designated and identified by Dr. Krause* with two British species described by Jones and Holl under *Primitia* in 1865, and more recently (1889) referred to *Aparchites* by Prof. Jones. While I am inclined to question the identity of the British and German specimens, I can scarcely doubt that the latter at least are truly referable to *Schmidtella*.

SCHMIDTELLA CRASSIMARGINATA *Ulrich*.

PLATE XLIII, FIGS. 42–44.

Schmidtella crassimarginata, ULRICH, 1892, Amer. Geol., vol. x, p. 269.

SIZE.—(R. V.) Length 1.80 mm.; hight 1.45 mm.; thickness 0.60† mm.

Valves broadly suboval, very slightly oblique, the dorsal outline more gently arcuate than elsewhere, ends nearly equal though the posterior margin is more curved, especially above, than the anterior, the latter often forming an obtuse angle where it joins the dorsal line; ventral outline uniformly curved, semielliptical; back flattened, slightly convex in a side view, raising very abruptly from and projecting slightly above the nearly straight hinge-line; point of greatest thickness just behind the center of the upper half; a rather conspicuous yet not sharply defined broad furrow around the ends and ventral margin, least distinct posteriorly, produces the thick border that has suggested the specific name. Specimens vary in length from 1.6 mm. to 2.0 mm.

The border is more distinct and wider, and the back more flattened than in any of the other species referred to the genus.

Formation and locality.—Lower Trenton limestone, Mineral Point, Wisconsin, and Dixon, Illinois. Its occurrence in this limestone at Minneapolis is not yet established with certainty.

*Zeitschr. d. Deutsch. geolog. Gesellschaft, 1891, p. 492.

†The dimensions given in the original description are too small, the magnification of the valve measured having been supposed to be 15 diameters when it was only about 10 diameters.

SCHMIDTELLA AFFINIS, *n. sp.*

PLATE XLIII, FIGS. 45–47.

SIZE.—(R. V.) Length 0.97 mm.; hight 0.72 mm.; thickness 0.22 mm.

The largest valve seen has a length of 1.08 mm. and a hight of 0.9 mm.

This species is closely related to *S. crassimarginata*, and at first I was inclined to view it as a later variety of that species. But, considering the great constancy which prevails among the hundreds of valves of *S. crassimarginata* which I have seen, and the equal constancy exhibited by *S. affinis*, it has been thought best to hold them as distinct. Besides I found it difficult to decide to which of the two, *S. crassimarginata* or *S. umbonata*, the present form bore the greater resemblance. Compared with the first of these species, *S. affinis* is smaller, a trifle higher, the flat dorsum narrower, the ends less equal, with the posterior extremity more strongly curved and the basal outline more prominent in the middle. In an end view the profile is less triangular and the ventral edge thinner. The most prominent point of the surface also is more posterior, while the broad border, which is so conspicuous a feature for *S. crassimarginata*, is scarcely developed. For comparison with *S. umbonata* and *S. incompta*, see following descriptions.

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

SCHMIDTELLA UMBONATA, *n. sp.*

PLATE XLV, FIGS. 36–38.

SIZE.—(L. V.) Length 0.8 mm.; hight 0.59 mm.; thickness 0.23 mm.
(R. V.) " 0.8 " " 0.65 " " 0.23 "

Valves ovate, slightly oblique, ends subequal, dorsum umbonate, projecting considerably above the straight hinge line; free margin with a border, narrower and less distinct on the left valve than on the right; greatest convexity near the middle of the valves, the point occasionally marked by a very faint depression or discolored spot.

This abundant species is relatively longer than *S. affinis*, has more nearly equal ends, narrower and better defined border, and more uniformly convex valves. From the much larger *S. crassimarginata* it differs too obviously to require comparison. *S. subrotunda* may be closely related but is much shorter and almost round.

Formation and locality.—Upper third of the Trenton shales, St. Paul and Cannon Falls, Minnesota. A variety, or more likely a closely related species, occurs in great numbers on slabs of Birdseye limestone collected at High Bridge, Kentucky.

SCHMIDTELLA INCOMPTA, *n. sp.*

PLATE XLIII, FIGS. 39–41. PLATE XLV, FIGS. 27, 32 and 33.

SIZE.—(R. V.) Length 1.1 mm.; hight 0.8 mm.; thickness 0.28 mm.
" " 0.9 " " 0.65 " " 0.18 " var. *subæqualis.*

Valves moderately convex, dorsal margin straight, about half as long as the valve; ends nearly or quite equal, ventral outline regularly curved; surface highest a little above and behind the center, the dorsal slope convex but not projecting beyond the hinge line, the ventral slope long, gentle and straight or faintly concave, the wide border being almost obsolete.

Of this species we have two varieties, one occurring in the lower part of the Trenton shales, the other in the upper part of the Galena shales. The earlier or typical form (plate XLV, figs. 27, 32 and 33), is a trifle more convex and blunter at the dorsal edge, slightly shorter and less equilateral than the other. That the Galena variety constantly developed these minute peculiarities is shown by about fifty valves. Should a subordinate name be desirable, it might be called var. *subæqualis.*

The dorsum is less tumid in this species than in any of the preceding. On the whole it may be considered as marking an approach toward *Aparchites.* Still, the prominence of the surface in the post-dorsal third, though not strong, indicates a relation to *S. affinis.* A species occurs in the Birdseye at High Bridge, Kentucky, that seems to be intermediate between this species and *S. umbonata.*

Formation and locality.—Typical form, lower part of the Trenton shales, Fountain, Minnesota; var. *subæqualis*, upper part of the Galena shales near Cannon Falls, Minnesota.

SCHMIDTELLA BREVIS, *n. sp.*

PLATE XLV, FIGS. 34 and 35.

SIZE.—(L. V.) Length 0.8 mm.; hight 0.65 mm.; thickness 0.2 mm.

Valves short, subovate, the oval being formed by drawing out the anterior end; dorsum short, gently arcuate, and projecting slightly above the straight hinge line; border inconspicuous.

In most respects this species is much like its associate, *S. incompta*, but the valves are much shorter, the dorsal outline is not straight, and the anterior margin is more narrowly rounded. *Polycope sublenticularis* Jones, from the Anticosti group, has a similar outline, but seems to be uniformly convex which is not the case with the species under consideration.

Formation and locality.—Rare in the lower part of the Trenton shales near Fountain, Minnesota.

Schmidtella subrotunda.]

SCHMIDTELLA SUBROTUNDA, *n. sp.*

PLATE XLV, FIGS. 39–42.

SIZE.—Length 0.5 mm.; hight 0.43 mm.; thickness 0.3 mm.

Valves small, short, rounded-ovate, rather uniformly convex, with an obscurely defined, narrow border around the ends and ventral margin; near the center a faint depression, and immediately behind it a small elevation.

The generic position of this small species is uncertain. It is placed under *Schmidtella* chiefly because it seems to be related to *S. umbonata*, though much shorter. Its outline is almost exactly as in the *Cytherella? subrotunda* of this report, which was also found associated with it. Possibly they belong to one species. Still, as the type of the *Cytherella* has neither a central pit nor a border, I am for the present obliged to regard them as distinct.

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

Genus APARCHITES, Jones.

Aparchites, JONES, 1889. Ann. and Mag. Nat. Hist., ser. 6, vol. iii, p. 385.

Carapace subovate, oblong, or somewhat rounded, with a straight hinge of variable length; valves subequal; edges thickened, never overlapping, often beveled or chaneled, in other cases simple, and rarely with a narrow flattened border. Surface more or less convex, usually smooth, without sulcus, tubercles or lobes.

Type: *A. whiteavesii* Jones.

The above definition embraces a number of species that had formerly been placed under *Primitia, Isochilina* and *Leperditia*. From the first they are distinguished by the absence of a sulcus, from the second by the absence of the eye-tubercle and certain shallow depressions behind it, and from the third by the absence of the eye-tubercle and the equality of their valves, there being no ventral overlap. From *Leperditella* they are separated by their equal valves, the left overlapping the right in that new genus. Finally, the new genus *Primitiella* includes some very similar carapaces, but these may be distinguished, in most cases very easily, by a broad though quite undefined depression or sulcus in the centro-dorsal region.

The species of *Aparchites* are all small, the average length being between 1.0 mm. and 1.5 mm., while the largest known does not exceed 3.0 mm. The total number of those known, including several undescribed species from Ohio, probably exceeds twenty. These are distributed almost equally between the Lower and Upper Silurian rocks, though in America they are known chiefly from the Trenton and Cincinnati formations.

APARCHITES ELLIPTICUS, *n. sp.*

PLATE XLIII, FIGS. 15–17.

SIZE.—(E. C.) Length 1.97 mm.; hight 1.35 mm.; thickness 0.95 mm. In the largest specimen the length is 2.5 mm.

Carapace rather large for the genus, almost regularly elliptical in outline, the dorsal margin of the left valve more arcuate and projecting above that of the right; edges beveled all around but in the lower part the bevel is turned into a groove by the thickening of the contact edges; surface of valves smooth and rather uniformly convex.

This form, though the hinge is shorter than usual, must still be considered as a typical species of the genus. The general expression of the carapace is much as in the associated *Leperditella persimilis*, but it is somewhat longer, has no dorsal angle, and its valves do not overlap. I know of no American species of *Aparchites* with which it need be compared, the elliptical outline being distinctive, but there are several in the Upper Silurian deposits of Europe that are not far removed. Particularly is this true of the *A. simplex*, from Gothland, described by Prof. Jones in the Ann. and Mag. Nat. Hist., ser. 6, vol. iv, p. 272. That species, however, is smaller (0.9 mm. in length), relatively shorter, and apparently without bevelled edges. Some of the varieties referred to *A. (Primitia) maccoyii* Jones and Holl, are very near, if not identical. But I am not willing to admit the latter without a direct comparison of specimens.

Formation and locality.—Middle third of the Trenton shales, Minneapolis, Minnesota. An imperfect left valve from the Galena shales near Cannon Falls, may belong to this species, but it appears to have been relatively longer and somewhat narrower anteriorly.

APARCHITES GRANILABIATUS *Ulrich.*

PLATE XLV, FIGS. 21–23.

Leperditia granilabiata ULRICH, 1892. American Geologist, vol. x, p. 267.

SIZE.—(L. V.) Length 2.1 mm.; hight 1.5 mm.; thickness 0.6 mm.

Valves high, very little oblique, ventricose in the lower half, somewhat flattened in the upper; outline almost semicircular in the lower two-thirds, the ventral curve being unusually convex; dorsal margin straight, about three-fourths as long as the valve, with angular extremities; border scarcely defined, set with small but prominent papillæ; free edges bevelled strongly inward. Surface covered with minute, regularly arranged granules; near the center a small raised spot.*

Recent comparisons have demonstrated the necessity of excluding species of this type from *Leperditia*. They have shown further that the typical species of *Aparchites*

*In the original description the surface is incorrectly described as punctate.

is really much nearer to the forms now referred to the genus than I was inclined to believe two years ago.

I have eight valves of a closely related species or variety from the lower third of the Trenton shales, at Minneapolis, and another, slightly longer than the rest, from the upper third near Cannon Falls. These specimens are less high than the type of *A. granilabiatus*, the ventral margin being less convex. The anterior end also is a trifle narrower, and the convexity of the valves somewhat less, while none of them show anything of the granulose surface ornament nor of the marginal papillæ. These specimens may provisionally be known as var. NEGLECTUS.

The straight back and dorsal angles will at once distinguish both the species and variety from *A. ellipticus*.

Formation and locality.—Upper third of the Trenton shales, St. Paul, Minnesota. Var. *neglectus* occurs in the lower third of the shales at Minneapolis.

APARCHITES MILLEPUNCTATUS *Ulrich.*

PLATE XLV, FIGS. 16–18.

Leperditia millepunctata ULRICH, 1892. Amer. Geol., vol. x, p. 268.

SIZE.—(R. V.) Length 1.57 mm.; hight 1.0 mm.; thickness 0.42 mm.

Valves subelliptical, dorsal margin long, straight; ends rounded from the dorsal angles, equal; ventral edges bevelled inward; point of greatest convexity a little behind and beneath the middle; surface very finely punctate.

This species is smaller than *A. granilabiatus*, but relatively longer, and more uniformly convex. In its outline it is similar to *Leperditella æquilatera* Ulrich, from the Birdseye limestone of Kentucky (see fig. 46, p. 636), but it is a little higher, has beveled and not overlapping edges, and a punctate surface which is wanting in that species.

Formation and locality.—Lower or middle third of the Trenton shales, near Fountain, Minnesota.

APARCHITES FIMBRIATUS *Ulrich.*

PLATE XLV, FIGS. 10–12.

Leperditia fimbriata ULRICH, 1892. American Geologist, vol. x, p. 268.

SIZE.—(R.V.) Length 1.88 mm.; hight 1.23 mm.; thickness 0.44 mm.

Valves suboval, moderately and almost uniformly convex; back straight, nearly two-thirds as long as the valve; dorsal angles sharp, a slight swelling of the surface immediately beneath them causing them to appear somewhat prominent; ends nearly equally rounded, the posterior a little the wider. The entire ventral border and the ends, excepting the upper third on each side, with a fringe consisting of long, almost paliform, processes, separated by intervals of 0.1 mm. or less.

The peculiar fringe distinguishes this species from all the Lower Silurian Ostracoda know to me.

Formation and locality.—Hudson River group, near Spring Valley, Minnesota.

APARCHITES ARRECTUS, *n. sp.*

PLATE XLIII, FIGS. 35 and 36.

SIZE.—(R. V.) Length 0.81 mm,; hight 0.53 mm.; thickness 0.11 mm.

Valves compressed-convex, scarcely if at all oblique, semiovate, the ends almost vertical in the upper half, the dorsal edge straight and very long; greatest convexity in the lower part of the valves, a large portion of the central part of the surface appearing flattened; free margins minutely toothed; bevel very narrow.

The dentate margin reminds of *A. granilabiatus*, but as the present form is much smaller and not nearly so convex, and as it has a longer hinge line and is much more elongated, it is quite evident that we are dealing with a distinct species. Its smaller size, erect ends and dentate margins distinguish it from *A. millepunctatus*.

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

APARCHITES CHATFIELDENSIS, *n. sp.*

PLATE XLIII, FIGS. 37 and 38.

SIZE.—(L. V.) Length 0.76 mm.; hight 0.46 mm.; thickness 0.32 mm.

Valves compressed-convex, somewhat elongate leperditoid in outline, being widest posteriorly; hinge line long, straight, dorsal angles rounded; posterior outline peculiar in swinging forward more than backward; ventral edge narrowly beveled inward; surface not well preserved but retaining some evidence of having been obscurely pitted.

The posterior outline is different and the thickness of the carapace less than in any other of the elongate species of the genus so far described.

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

APARCHITES MINUTISSIMUS *Hall*, var. TRENTONENSIS, *n. var.*

PLATE XLIII, FIGS. 18–20.

Leperditia (Isochilina) minutissima HALL, 1871, Desc. N. Sp. Foss. Hud. Riv. Gr., p. 7; also 1872, 24th Rep. N. Y. St. Mus. Nat. Hist., p. 231, pl. 8, fig. 13; HALL and WHITFIELD, 1875, Pal. Ohio, vol. ii, p. 102.
Aparchites minutissimus ULRICH, 1889, Contri. Can. Micro-Pal., pt. 2, p. 49.

SIZE.—(R. V.) Length 0.85 mm.; hight 0.54 mm.; thickness 0.16 mm.
(R. V.) " 0.49 " " 0.33 "

Two right valves of the Trenton variety of this species are figured on plate 43. The anterior part is narrower and the dorsal angles duller than in the typical Cin-

cinnati specimens. The surface also is scarcely so convex, or rather it is not thrown up into a point near the center, but is comparatively uniform in curvature.

Aparchites tyrrellii Jones (Contri. Can. Micro-Pal., pt. iii, p. 62; 1891) from the Chazy at Lake Winnipeg, is a closely related, if not identical form. However, as figured by Prof. Jones, it appears to be less convex and the outline not so prominent in the post-ventral region.

Formation and locality.—The small specimen is from the middle third of the Trenton shales near Fountain, the larger from the top of the Galena shales near Cannon Falls, Minnesota.

Family BEYRICHIIDÆ.

Genus PRIMITIELLA, n. gen.

Carapace usually oblong, equivalved, moderately convex; surface smooth or finely punctate; in the dorsal slope a broad, shallow and quite undefined depression represents an undeveloped mesial sulcus.

Type: *P. constricta*, n. sp.

Besides the four new species about to be described, I propose to place in this genus *Leperditia unicornis* Ulrich *(Aparchites*, Ulrich, *Primitia*, Jones*)* and *Primitia whitfieldi* Jones, from the lower part of the Cincinnati group, *Primitia ulrichi* Jones, Utica slate, Canada, and probably the European species, *Primitia matutina* and *beyrichiana* Jones and Holl, *Primitia minuta* Eichwald (as figured by Jones) and *P. elongata*, var. *nuda*, Jones. I am inclined to think that *Isochilina? fabacea* Jones, from the Hamilton of New York, and *Aparchites inornatus* Ulrich also should be placed here. These species constitute a very natural group, distinguished from *Aparchites* by the dorsal depression. They are separated from *Primitia* because they give no adequate idea of that most prolific genus. To be a *Primitia* in my eyes the valves must be provided with a well marked subcentral pit or sulcus.

The Carboniferous genus *Youngia*, Jones and Kirkby, is closely simulated in all respects except the crenulated hinge by *Primitiella limbata.* Possibly that genus is not so far removed from *Primitiella* as we now believe to be the case.

PRIMITIELLA CONSTRICTA, *n. sp.*

PLATE XLIII, FIGS. 48–52.

SIZE.—(E. C.) Kentucky specimen: Length 0.67 mm.; hight 0.36 mm.; thickness 0.24 mm.
Minnesota " " 0.60 " " 0.35 " " 0.21 "
" " " 0.68 " " 0.33 " " 0.22 "

Carapace elongate, subelliptical or subquadrate, the length nearly twice the hight, convex; dorsal margin long, straight, with both extremities angular, or with the anterior one obtuse or rounded; ventral margin nearly parallel with the dorsal,

gently convex, or almost straight in the middle; posterior margin somewhat oblique, and subtruncate above; anterior outline always more curved than the posterior; free edges with a narrow border; surface with a broad, centro-dorsal depression.

The earliest known occurrence of this species is in the lower part of the Birdseye limestone of Kentucky. These specimens differ slightly from the later form in having the border much narrower, the ventral margin straighter and quite parallel with the dorsal, and the anterior outline more rounded. The valves seem also to be a little more convex.

Primitiella elongata, var. *nuda* Jones,* is similar but has straighter ends and sharper dorsal angles.

Formation and locality.—Lower and upper Birdseye limestone, High Bridge, Kentucky, and Lebanon and Lavergne, Tennessee; lower third of the Trenton shales, Minneapolis, St. Paul, and Goodhue county, Minnesota.

PRIMITIELLA LIMBATA, *n. sp.*

PLATE XLIII, FIGS. 53–56.

SIZE.—(E. C.) Length 0.73 mm.; hight 0.38 mm.; thickness 0.20 mm.

The outline is almost as in *P. constricta*, only the ends are less rounded, the posterior one especially being nearly vertical, while the dorsal angles are sharper. The most important difference however lies in the fact that the border continues not only around the free edges but along the dorsal margin as well. The thickness of the carapace is somewhat less, and the surface rises more abruptly from the posterior border. Finally, the mesial depression is more obscure, and often scarcely distinguishable.

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

PRIMITIELLA SIMULANS, *n. sp.*

PLATE XLIII, FIGS. 26–28.

SIZE.—Length 0.73 mm.; hight 0.44 mm.; thickness 0.28 mm.

Valves rather strongly convex, leperditoid in outline, with the dorsal angles rounded; edges without border; a very faint, broad depression near the middle of the dorsal slope, and occasionally an obscure elevation at its base.

In the outline this species is very nearly like *P. minuta* Eichwald and *Aparchites subovatus* and *leperditoides* Jones. Still it is relatively higher than any of these, and the last two are without the dorsal depression. It resembles also *A. minutissimus* Hall, but may be distinguished by its proportionally greater length.

Formation and locality.—Lower part of the Trenton shales, near Fountain, Minnesota.

* Prof. Jones describes this form as a variety of *Primitia elongata* Krause, but since Dr. Krause has shown that his species possess a radially striated false border like that of *Eurychilina? subæquata* Ulrich, the form *nuda* should now be regarded as at least specifically and probably generically distinct from *P elongata*.

PRIMITIELLA FILLMORENSIS, *n. sp.*

PLATE XLV, FIGS. 28–30.

SIZE.—Length 0.55 mm.; hight 0.38 mm.; thickness 0.23 mm.

A small, comparatively short form, with subequal, rounded ends, broadly curved ventral margin and a straight back, the extremities of which however are scarcely angular; mesial depression very shallow but wide, taking up a large portion of the centro-dorsal region; edges simple, or with an obscurely defined, narrow border. Though resembling several species of *Primitia*, from which it is distinguished by the width and shallowness of the mesial depression, I cannot find any described ostracode with which it is strictly identical.

Formation and locality.—Not uncommon in the lower part of the Trenton shales near Fountain, Minnesota.

PRIMITIELLA UNICORNIS *Ulrich.*

PLATE XLIII, FIGS. 75–77.

Leperditia unicornis ULRICH, 1879. Jour. Cin. Soc. Nat. Hist., vol. ii, p. 10, pl. vii, fig. 4.
?Aparchites unicornis ULRICH, 1889. Contri. Can. Micro-Pal., pt. 2, p. 50.
?Primitia unicornis JONES, 1890. Quart. Jour. Geol. Soc., vol. xlvi, p. 7.

SIZE.—Length 1.04.; hight 0.59 mm.; thickness 0.4 mm.

Carapace convex, scarcely oblique, oblong, with a long, straight hinge, and rather well-marked dorsal angles; ventral margin gently arcuate, nearly parallel with the back, the anterior hight of the valves being but little less than the posterior; posterior margin neatly rounded from the dorsal angle; anterior margin obliquely truncated in the upper half, sharply rounded at the middle; a narrow but well-defined border begins at this point and follows the outline to the post-dorsal angle; near the posterior extremity of each valve, usually somewhat beneath the mid-hight, a strong spine projects outwardly or posteriorly; in a dorsal or ventral profile the ends are blunt and the sides of the valves straight or just appreciably concave; in front of the middle of the dorsal slope there is a wide and very faint depression, and in the lower part of this a low swelling is almost invariably distinguishable. Specimens are usually about 1.0 mm. in length. A small variety occurs at Cincinnati, Ohio, averaging between 0.5 and 0.6 mm. in length.

All the American specimens of this species, excepting the valve figured by me from Manitoba *(op. cit.)* are remarkably constant in all their characters. Indeed, out of over fifty free carapaces and valves, I was unable to find one that differed enough from fig. 77 to make it worth the while to prepare drawings of it. Bearing this constancy in mind it is rather surprising to learn that Prof. Jones found considerable variability among the British specimens referred by him to the species. Comparing

his drawings (*op. cit.*, pl. IV, figs. 8—13), with the figure here given on plate XLIII, it would appear that none of his specimens are strictly identical with the typical form of the species. They are all too narrow anteriorly, and three of the figured ones too long. The other three figures (8, 9 and 10) correspond fairly well with that of the Manitoba specimen already referred to, though the posterior spine in the last is stronger. Possibly some of the variability of the Bala specimens is due to crush, or perhaps their margins were covered by the shale. There remains to be added that in all these foreign specimens the border, as well as the slight elevation in the dorsal depression, seems to be wanting. Under the circumstances it would probably be advisable to separate them, if not specifically, at any rate as a variety, from the typical form of the species.

Formation and locality.—Doubtfully identified from a cast of the interior found in a thin bed of shale belonging near the base of the Hudson River group, three miles north of Spring Valley, Minnesota. The typical form occurs abundantly in the lower or Utica horizon of the Cincinnati group at a number of localities in the vicinity of Cincinnati, Ohio. The Manitoba variety is from beds equivalent to the upper divisions of the Cincinnati group at Stony Mountain, while the British specimens described by Prof. Jones are from Bala shales, near Welshpool, Montgomeryshire.

Genus PRIMITIA, Jones and Holl.

Primitia (part.) JONES and HOLL, 1865. Ann. and Mag. Nat. Hist., ser. 3, vol. xvi, p. 415.

Carapace small, varying in outline, usually subovate, but the hinge is always straight; valves equal, never overlapping, generally provided with a narrow border; in, or to one or the other side of, the middle of the dorsal half, a well-marked pit or sulcus; the pit may be rounded and situated subcentrally, or it may be drawn out vertically so as to extend from the dorsal margin half across the valve; on one or both sides of the sulcus the surface may be raised into a low, rounded or ridge-shaped prominence. Surface of valves punctate, reticulate, or without ornament; in rare cases it seems to have been minutely granulose.

As typical species I will mention *P. mundula* Jones, *P. renulina* Jones and Holl, *P. variolata* J. and H., and *P. humilis* J. and H., Upper Silurian; *P. impressa* Ulrich, *P. sancti pauli* Ul., and *P. mammata* Ulr., Lower Silurian, the last two described in this work.

Prior to 1865, species of *Primitia* were referred to *Beyrichia*. For more than twenty years after that date, besides the type of structure to which the genus is now restricted, *Primitia* included (1) "non-sulcate" forms for which Jones in 1889, proposed the genus *Aparchites;* (2) so-called "passage forms" that I now propose to separate as *Primitiella;* (3) forms having the sides of the sulcus elevated into two strong tubercles, for which the genus *Ulrichia* has been established by Prof. Jones; and finally (4) some that may belong to *Eurychilina*, Ulrich, because they have the

broad frill which projects greatly beyond the free contact edges of the valves in species of that genus. As usual, the original conception of *Primitia* was altogether too broad, and as, through the restless efforts of collectors, the species began to multiply, it became clear that they fell naturally into several groups, whose importance increased with time and study till their separation became, at first desirable, then necessary.

Still, *Primitia* retains a large number of species, the greater part of which are nearly equally divided between the Lower and Upper Silurian rocks. Two or three rather doubtful species have been described from primordial strata, but at least five good Devonian species have been discovered and as many more in the Lower Carboniferous, after which the genus seems to have become extinct. With a few exceptions all these species were described in papers by Jones, Jones and Holl, Krause, and Ulrich.

PRIMITIA MINUTISSIMA, *n. sp.*

PLATE XLV, FIG. 31.

SIZE.—Length 0.33 mm.; hight 0.19 mm.

Carapace very small, rather elongate-elliptical in outline, without distinct dorsal angles, the ends rounded and nearly equal, the anterior slightly narrower than the other; valves rather strongly convex; sulcus narrow, sharply defined, extending nearly half across the valve; surface smooth.

This is the smallest *Primitia* known to me. It is evidently related to the British Wenloch species, *P. humilis* Jones and Holl, but is smaller, relatively more convex, with the ends more rounded, and the sulcus narrower. It is not very closely related to any of the known American species.

Formation and locality.—Lower part of the Trenton shales, near Fountain, and at Oxford Mills, Goodhue county, Minnesota.

PRIMITIA UPHAMI, *n. sp.*

PLATE XLIII, FIG. 66.

SIZE.—Length 0.42 mm.; hight 0.27 mm.; thickness 0.15 mm.

Valves small, compressed-convex, slightly oblique, subovate, without distinct dorsal angles; posterior end wider and more broadly rounded than the anterior; ventral margin convex; edges thin, without border; sulcus represented by a rather large, though not very deep depression, situated about in the middle of the dorsal slope; surface marked by small punctæ, arranged in curved lines radiating from the sulcus; in certain lights each row appears as occupying the bottom of a narrow groove.

Though smaller and proportionally higher behind, this neat *Primitia* seems to be more closely related to *P. variolata* Jones and Holl, from the Wenloch of England, than to any American species. Still there is a regularity about the arrangement of the punctæ that is wanting in that species. In *P. trigonalis*, of the same authors and formation, the ornamentation is similar, but in other respects the species are quite different.

Named for Mr. Warren Upham, of the Geological Survey of Minnesota, whose published work has aided materially in advancing our knowledge of American geology.

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

PRIMITIA MAMMATA, *n. sp.*

PLATE XLIII, FIGS. 78–81.

SIZE.—Length 0.51 mm.; hight 0.30 mm ; thickness 0.18 mm.

Valves suboblong, the marginal portions somewhat depressed, while the central parts are slightly swollen beneath and on each side of the sulcus, the latter narrowing dorsally; back straight, dorsal angles rounded; posterior margin strongly rounded in the middle, ventral margin gently convex, subparallel with the hinge line; anterior outline most prominent in the upper part, the whole sweeping slightly backward; edges simple, surface without ornament.

The slight prominence of the surface about the sulcus gives this carapace an appearance that is not shared by any of the more simple forms of the genus. We are somewhat reminded of *P. tumidula* and *P. duplicata*,—indeed, I at first confounded it with the latter. The first is much more convex, shorter and larger, while perfect valves of the second will be distinguished at once by their double borders. *P. centralis* Ulrich, of the Utica horizon of the Cincinnati group, is similar in shape, but has a simply convex surface and the sulcus confined to a subcentral pit.

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

PRIMITIA SANCTI PAULI, *n. sp.*

PLATE XLIII, FIGS. 73 and 74.

SIZE.—Length 0.86 mm.; hight 0.56 mm.; thickness 0.38 mm.

Valves strongly convex, thickest posteriorly, subovate in outline, with a straight back nearly three-fourths as long as the greatest length of the carapace, and rather distinct dorsal angles; ends rounded, subequal, the anterior sometimes a trifle narrower than the posterior; ventral margin broadly convex, free edges with a well-defined, narrow border; sulcus well developed; situated a little in front of the midlength,

slightly oblique, deepest in its lower part, narrowing above by the development of a low swelling on each side, that on the anterior side more prominent than the other; a not very prominent, rounded tubercle near the lower part of the anterior border; excepting the sulcus and the flattened border, the entire surface is beautifully reticulated.

This fine species is probably more closely related to *P. milleri* Ulrich, from the upper beds of the Cincinnati group, than to any other known. The size of *P. milleri* is somewhat greater, its length being usually a little more than 1.0 mm. But the real differences between the two forms are (1) the proportionally greater length of the valves and of the hinge in the Minnesota species; (2) its longer and otherwise different sulcus, and (3) the possession of a rounded, antero-ventrally situated tubercle, which is wanting in the Ohio species.

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

PRIMITIA MICULA, *n. sp.*

PLATE XLIII, FIGS. 69–72.

SIZE.—Length 0.39 mm.; hight 0.25 mm.; thickness 0.23 mm.

This species, though much smaller, seems to be related to *P. sancti pauli.* It is however relatively shorter, with a longer hinge line and stronger dorsal angles. The valve is strongly convex, especially in the posterior half, and the prominences on each side of the curved sulcus are decidedly higher than in the larger species. Again, that species has a rounded tubercle in front which is wanting in *P. micula.* Finally, the surface is only obscurely punctate and not reticulate.

It is perhaps more closely related to *P. tumidula* of the Hudson River shales, but, aside from its much smaller size, it is at once distinguished by the absence of the narrow curved ridge, running a short distance within the ventral margin in that species.

Formation and locality.—Galena shales near Cannon Falls, Minnesota; associated with *P. uphami, Schmidtella affinis* and *Bythocypris cylindrica.*

PRIMITIA CELATA, *n. sp.*

PLATE XLIII, FIGS. 67 and 68.

SIZE.—Length 0.57 mm.; hight 0.33 mm.; thickness 0.30 mm.

Valves with the back long, straight or gently arcuate, the dorsal angles distinct though not sharp, the ends about equally curved though the anterior is somewhat narrower than the posterior; ventral and anterior margins together following a semielliptic. curve; free edges grooved, the true contact margins concealed by a

projecting rim which however is not distinguishable in a side view from the regular slope of the surface except in front; sulcus sharply defined, simple, subcentral, extending less than one-third of the distance across the valve; surface minutely punctate.

The widely grooved edges distinguish this species from several otherwise similar forms occurring in the Upper Silurian of Europe. The projecting rim, which should not be mistaken for an ordinary border, is to be regarded as an undeveloped "frill" and precisely the same as the false border of *Ctenobolbina ciliata* and *Ceratopsis chambersi*. It is developed to a greater degree in the next species, but in *P. tumidula* it appears to have been in a large measure reabsorbed again.

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

PRIMITIA DUPLICATA, *n. sp.*

PLATE XLIII, FIGS. 60 and 61.

SIZE.—Length 0.70 mm.; hight 0.45 mm.; thickness 0.35 mm.

Valves rounded oblong-quadrate, with a long, straight back, rounded dorsal angles, and a distinctly elevated false border. This border projects slightly beyond and completely hides, in a side view, the anterior and ventral contact margins of the valve. Posteriorly however the true edge protrudes, the border here projecting outwardly much more than backward. Within the border the surface is moderately convex, the sulcus not deep yet distinct, and faintly traceable for about two-fifths the hight of the valve. In front of the lower part of the sulcus a small swelling is faintly indicated, while behind its upper two-thirds there is another but much larger low elevation. Surface without ornamentation so far as known.

This interesting species agrees with *P. celata* in having a false border, but as it is more elevated, especially in its posterior part, and as the two forms are quite different in the region of the sulcus, it is not at all likely that they will ever be confused by a careful observer. I know of no form now referred to *Primitia*, unless it be *P. tumidula*, which see, that is sufficiently near *P. duplicata* to require comparison. *Beyrichia initialis*, an associated species, looks considerably like it. It is of about the same size, and has a raised border. A critical examination of the latter however proves that it is not a false border, but the actual margin of the valve bent outward (compare figs. 61 and 83, plate XLIII). Of course the lobing of the valves, though certain similarities may be discovered, is still very different in the two forms. A comparison of their respective figures on plate XLIII will bring out the differences much better than I can define them.

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

PRIMITIA TUMIDULA, *n. sp.*

PLATE XLIII, FIGS. 62–65.

SIZE.—Length 0.73 mm.; hight 0.50 mm.; thickness 0.40 mm.

Valves strongly convex, subquadrate-ovate, back straight, rather long; posterior dorsal angle strong, the anterior more obtuse or rounded; ends nearly equal in hight, but the anterior margin is more curved than the posterior, the latter being somewhat truncated above; sulcus a little in front of, or quite in the middle of the dorsal half, deep, with a strong rounded swelling on each side; the posterior prominence larger and higher than the anterior one, but the latter usually somewhat better defined by a forward swing of the lower part of the sulcus; surface beneath the sulcus prominently convex, and sometimes bearing several small tubercles; a wide concave border, defined in the ventral part by a thin ridge, extending parallel with and some distance within the edge of the valves. This ridge I consider as the remnant of a false border, like the one which is so strongly developed in *P. duplicata.*

At first I thought this species might be the same as *P. cincinnatiensis* Miller sp., but a more careful examination proved it distinct, though perhaps closely related. In the first place its valves are higher, the ventral outline being much more curved. Next, the sulcus is relatively shorter, while the border is not narrow and flat. But the most important difference is the submarginal ridge which is distinguishable even on casts of the interior of *P. tumidula*, but of which not a sign is to be seen on Miller's species. In *P. duplicata* this ridge is much more strongly developed, forming a false border from one dorsal angle to the other. This fact causes the surface of the valves to appear much less convex than it really is, though the greatest thickness is a little less than in *P. tumidula.* But the sulcus in the latter is much deeper, and the tumidity of the surrounding parts greater than in the Trenton species.

Formation and locality.—In a thin bed of shale belonging to the lower part of the Hudson River group, three miles north of Spring Valley, Minnesota.

PRIMITIA GIBBERA, *n. sp.*

PLATE XLIII, FIGS. 57–59.

SIZE.—Length 0.81 mm.; hight 0.45 mm.; thickness 0.36 mm.

Valves somewhat leperditoid in outline, with a straight hinge line, the distance between the dorsal angles about five-ninths of the greatest length of the carapace; ends rounded; valves rather strongly convex, gibbous in the anterior half of the dorsal region; this prominent part is somewhat flattened on the back, and includes a short and rather shallow notch or sulcus. In the specimens at hand the surface slopes uniformly toward the edges and these seem to be simple and without a border;

but, as they are only casts of the interior, a narrow border may have existed on the exterior of the valves.

The gibbous character of the anterior part of the dorsal region, and the shortness as well as lateral position of the sulcus, are the principal peculiarities of the species. In other respects it resembles *P. mundula* and *P. simplex* Jones.

The affinities of this form are rather obscure. There is a suspicious resemblance to *Jonesella? obscura* (plate XLIV, figs. 17—19), but very little to *J. crepidiformis* the type of that genus. It may also be compared with *Placentula inornata* Ulrich, a Cincinnati species.

Formation and locality.—Associated with the preceding.

Genus HALLIELLA, Ulrich.

Halliella, ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii. p. 184.

Similar to *Primitia*, but with a thicker shell, thick and bevelled edges, and usually a larger subcentral sulcus dividing the surface into two lobes. Surface of lobes coarsely sculptured or reticulate.

Types: *H. (Primitia?) sculptilis* and *H. retifera*, Ulrich.

The affinities of this genus are still obscure. Taking *H. labiosa*, we see Primitian characters coupled with those marking *Kirkbya*, and I am really quite undecided as to which are predominant. *H. sculptilis* Ulrich, from the Trenton of Kentucky, is farther removed from *Primitia*, but its long sulcus produces an effect more like *Ctenobolbina* than *Kirkbya*. The same is true, though in a lesser degree, of *H. (Primitia) seminulum* Jones. The Devonian *H. retifera*, though having something to remind of each, is not a *Primitia*, *Beyrichia*, *Ctenobolbina* nor a *Kirkbya*. It is these more or less obscure resemblances to a variety of generic types that makes it so difficult to point out the diagnostic characters of *Halliella*, and I find myself in the somewhat anomalous position of being much better able to say what they are *not* than what they *are*. I must admit also that I am not thoroughly satisfied that the four species now constituting *Halliella* are strictly congeneric. They may be so, but until their natural affinities are better understood, the genus is to be accepted as convenient rather than natural.

HALLIELLA LABIOSA, *n. sp.*

PLATE XLVI, FIGS. 43–46.

SIZE.—Length 0.86 mm.; hight 0.62 mm.; thickness 0.40 mm.

Carapace semielliptical, the lower three-fourths semicircular, the hinge line nearly straight; dorsal edges somewhat thick and bevelled inward; free edges very

thick, in a ventral view resembling lips; surface of valves gently convex within the wide concave border, the central part of the upper half depressed around a narrow pit; in front of the pit occasionally a slight rounded elevation. Surface beautifully marked with small pits closely arranged in concentric lines, usually less curved than the ventral outline of the valves.

This is one of the prettiest of the numerous Ostracoda occurring in the Trenton of Minnesota. It is also one of the most easily recognized, the thick, lip-like edges, and the concentric surface markings being unusually distinctive.

Formation and locality.—Near the top of the Galena shales, Goodhue county, Minnesota.

Genus BEYRICHIA, McCoy.

Beyrichia, McCoy, 1846. Synop. Sil. Foss. Ireland, p. 57.

Carapace small, equivalved, oblong or semiovate, with a straight dorsal and convex ventral outline. Typically each valve has two sulci and three lobes, of which the central one is the smallest; the two larger lobes often coalesce ventrally. Surface usually marked with pittings, reticulation, papillæ or other ornament.

Type: *Beyrichia klœdeni* McCoy.

This genus, after *Leperditia*, is the most important of all the generic groups of Paleozoic Ostracoda. Many of the species also, those of the Upper Silurian rocks especially, are comparatively large, specimens over 3 mm. in length being not at all uncommon. The individuals, moreover, are generally abundant, layers of rock in many instances being crowded with, if indeed they are not largely made up of their separated valves.

In the restricted sense in which the genus is here defined, the oldest known species is the Minnesota form about to be described.* It is from the middle third of the Trenton shales (?Black River group). Of the Trenton proper, *B. bella* Walcott, may belong to the genus, and I have a doubtful species from the Utica horizon at Cincinnati, Ohio; but so far we know of no true *Beyrichia* from the Hudson River or Cincinnati group, those referred to the genus from this formation belonging to *Ctenobolbina, Drepanella, Bollia, Tetradella, Ceratella* and *Primitia.* In the Clinton, however, *B. lata* Hall (Vanuxem)† is a good species, and from here on to the close of the Carboniferous system the genus is more or less well represented in every group of strata.

* Prof. T. Rupert Jones has described *Beyrichia holli* from the Minævian flags of Great Britain (Geol. Mag., n. ser., Dec. 2, vol. 8, p. 343; 1881), but the affinities of the fossil seem to me as doubtful.

† Not *Bollia lata* Jones, 1890; Quart. Jour. Geol. Soc., vol. 46, p. 12, pl. 3, figs. 1, 2, 3. The specimens identified by Prof. Jones with *B. lata* are widely different from the typical Clinton form of this species, which is a true *Beyrichia*, but I cannot distinguish them from *Bollia symmetrica* Hall, sp.

BEYRICHIA INITIALIS, *n. sp.*

PLATE XLIII, FIGS. 82 and 83.

SIZE.—Length 0.65 mm.; hight 0.41 mm.: thickness 0.30 mm.

Valves small, somewhat oblong, subquadrate; hinge line straight, nearly as long as the valve; dorsal angles distinct without being sharp; ventral margin but little convex, nearly parallel with the back; ends subequal, neither much curved; free margins with a distinct border or flange, turned outward. Middle lobe situated just above and a little in front of the center, rather low, rounded, not sharply separated from the anterior lobe; mesial sulcus deeper than the anterior, meeting beneath the small lobe; anterior lobe rather small, coalescing ventrally with the much larger posterior lobe, the junction faintly indicated. In the anterior part of the valve the surface is depressed, but in the upper corner a small tubercle is to be noticed.

In this species the isolation of the small lobe has progressed beyond the limits of *Primitia*, and the result is sufficiently close to *Beyrichia* to be included in this genus. An approach toward Beyrichian characters is faintly indicated in *Primitia duplicata* and *P. tumidula*, while the tendency to vary in this direction is much better expressed in certain varieties of *P. cincinnatiensis* Miller, and *P.? parallela* Ulrich.* The latter might be called a *Klœdenia*, Jones and Holl, a genus that, with slight peculiarities of its own, seems to be nothing more than a recognition of one of the more permanent transitional types between *Primitia* and *Beyrichia*.

Specifically, *B. initialis* is not likely to be confounded with any Lower Silurian ostracode known to me. Nor is there any pressing need of comparing it with its much larger Upper Silurian congeners.

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

Genus EURYCHILINA, Ulrich.

Eurychilina, ULRICH, 1889, Contri. to Can. Micro-Pal., pt. 2, p. 52; also 1890, Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 125.

Carapace with a long, straight hinge line; semicircular, oblong-subquadrate, or somewhat rounded in outline; generally with a well-defined subcentral vertical sulcus and a more or less prominent node immediately behind it. Except at the dorsal side, the valves are surrounded by a wide marginal area, externally either flat or convex and usually marked in a radial manner; on the inner side deeply concave, an outer wall being raised almost to the level of the true or closing edge of the valve; area terminated in most cases by a narrow rim-like border. Hinge simple. Surface beautifully reticulated, pitted, granulose or smooth.

Type: *E. reticulata* Ulrich.

*Jour. Cin. Soc. Nat. Hist., vol. 13, pl. 10, figs. 5*a* and 15*a*; 1890

The principal peculiarity of *Eurychilina* is the hollow area surrounding, if not all, at any rate the greater part of the free margins of the valves. In *Primitiopsis*, Jones, a concave area occurs also, but only at the anterior end. This marginal area is not to be compared with the outwardly similar "frill" of *Beyrichiopsis*, Jones and Kirkby, nor to the "false border" of *Ceratella chambersi*, *Ctenobolbina ciliata* or *Primitia duplicata*, since a distinct structure (*i. e.* an outer wall), wanting in those species, is required to form it. Moreover, an equivalent of the "frill" is also present as a narrow terminal border in most of the true species of *Eurychilina*.

I say "true species of *Eurychilina*" because the genus as now understood includes some that are not strictly in accordance with the types. Regarding, of the species referred to the genus in 1890,* *E. reticulata*, *E. subradiata*, *E. longula*, *E. granosa*, *E. manitobensis* and probably *E. æqualis* is in every respect typical, we still have to account for *E. obesa* and *E. striatomarginata* (Miller). After careful examination I am ready to admit that these two species have not the required concave marginal area. In these namely the marginal expansion is nothing more than a simple border or "frill." Now, what is to be done with them? Can they justly be retained under *Eurychilina?* I think not.

In coming to this conclusion I have in mind the fact that a number of "frilled" primitian Ostracoda are known that seem to stand in close relationship with *E. obesa* and *E. striatomarginata*. One of these is here provisionally referred to *Eurychilina* (*E.? subæquata*) while two more are among my undescribed species from the Trenton of New York. In glancing over Dr. Aurel Krause's papers on the Ostracoda which he has found in the Silurian boulders contained in the drift of northern Germany, I notice no less than seven species that strike me as belonging in this connection, viz: *Primitia distans* Krause, *P. excavata* K., *P. elongata* K., *P. plana* K., *P.* (*Ulrichia*) *umbonata* K., *Entomis flabellifera* K., and *Beyrichia radians* K. Of course, if all or a good proportion of these species prove to be congeneric and are to be viewed as a group by themselves and as distinct from *Eurychilina*, a new genus will have to be established for them. I would have proposed a name in this work had I not been assured of soon receiving specimens of Dr. Krause's species. When these arrive I hope to enter upon a more thorough investigation of the *Beyrichiidæ* than I have yet been able to give them.

* Jour. Cin. Soc. Nat. Hist., vol. 13, pp. 125—130.

EURYCHILINA RETICULATA *Ulrich*, and var. INCURVA, *n. var.*

PLATE XLIV, FIGS. 1 and 2.

Eurychilina reticulata ULRICH, 1889. Contri. to Can. Micro-Pal., pt. 2, p. 52, pl. ix, figs. 9, 9*a*.
Not *Eurychilina reticulata* (Ulrich) JONES, 1890, Quart. Jour. Geol. Soc., vol. xlvi, p. 593, pl. xx, figs. 13*a*, 13*b*.

SIZE.—Without marginal area, length 1.83 mm.; hight 0.9 mm.; thickness 0.5 mm.
With " " " 2.40 " " 1.3 "

Valves, excluding the marginal area, nearly semicircular in outline, straight along the dorsal edge, moderately and almost uniformly convex; sulcus deep, extending half way across the body, not as wide as in the next species, its outline more sharply defined behind and below than on the anterior side; above the sulcus expands and becomes very shallow, while at the midlength it is constricted by a rounded prominence on the posterior side; surface, except along the dorsal edge, beautifully reticulate. Marginal area wide, narrowest posteriorly; on the outer side it is flattened or concave, and slopes inwardly, especially at the ends; ventrally the edge rises to form a narrow, wavy, free border; surface marked by radial lines, strongest ventrally, least distinct anteriorly; at its junction with the body of the valve, a more or less elevated, linear ridge is usually present. Internal characters of valves and marginal area almost exactly as in the next species (see plate XLIV, fig. 3.)

This fine species is perhaps the most beautiful of all the Paleozoic Ostracoda known to me, and when in a good state of preservation it is scarcely possible to confound it with any other. Yet, as cited above, Prof. Jones has referred a Devonian specimen from the Corniferous chert of New York to the same species. The characters of the valve figured by him are preserved in an empty mold, which in splitting the rock presented both an inner and an outer cast. Comparing these with the Minnesota species, I am obliged to differ wtih Prof. Jones' determination. Indeed, I doubt if they are even congeneric. The outline of the body of the valve is not semicircular in the Devonian species but has that oblique form which is commonly distinguished as "leperditoid." It is also proportionally a little higher, the reticulate ornament extends to the dorsal edge, the sulcus is shorter and much less defined, being merely a subcentral depression, and there is apparently no rounded prominence behind it. Further, the dimensions given by Prof. Jones show that his specimen is considerably larger than any Lower Silurian example of *E. reticulata* so far seen, the length in the latter rarely, if ever, exceeding 2.5 mm., while that of the Devonian form is stated to be 3.5 mm. These differences, if no others existed, would be sufficient to prove a distinct species.

But they are not all, since his fig. 13*b* shows that the border was convex exteriorly while it should be flat or concave; and in fig. 13*a*, representing an impression of the

inner side of the valve, we see nothing of the outer wall of the marginal area. The last I regard as the most important difference, since, if the facts are correctly represented in Prof. Jones' figures it would remove his species from the typical section of *Eurychilina* to that distinct group of species which is defined on a preceding page in the remarks following the generic description.

Variety INCURVA, n. var. Plate XLIV, Fig. 2.

This subordinate name is proposed for a variety of this species that is rarely associated with more typical specimens in the upper third of the Trenton shales, the highest horizon in which this species is known to occur. The variety is a little smaller than full grown specimens of the typical form, and more rounded in the posterior outline. More striking differences however are seen in the marginal area. This, instead of being concave and curved outward, is convex and incurved, its width is less and more equal, the radii very indistinct and the terminal border more sharply defined. These differences produce a form closely resembling the Kentucky species *E. granosa*. We except of course the ornamentation, the two being very different in this respect.

Formation and locality —Ranges from the lower Trenton limestone to the upper third of the Trenton shales; Minneapolis, St. Paul, Cannon Falls, and near Fountain, Minnesota. The species is not abundant anywhere, only about twenty specimens in all having been seen. Variety *incurva* occurs as far as known only at St. Paul.

EURYCHILINA SUBRADIATA *Ulrich.*

PLATE XLIV, FIGS. 3, 4, 4*a*.

Eurychilina subradiata ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 126.

SIZE.—Without marginal area, length 1.75 mm.; hight 0.9 mm.; thickness 0.50 mm.
With marginal area, length 2.32 mm.; hight 1.3 mm.

Body of valves almost exactly semicircular in outline, with the surface highest along an obtuse ridge-like prominence, running lengthwise across the central portion of the valve and from the summit of which the surface descends with a distinctly concave slope to the thickened dorsal edge; on the opposite or ventral side the slope is more gently concave or flat; anterior extremity compressed; sulcus deep and unusually wide, beginning a little within the dorsal margin and extending half way across the body, its lower and posterior margins thickened and sharply defined; just back of the sulcus a large round tubercle; surface appearing smooth in some specimens, but usually it is pitted as shown in fig. 4. Marginal area nearly flat, the inner edge rising abruptly and forming a low, sloping wall around the body, the outer edge formed by a sharply elevated narrow border; posterior and ventral portions of area holding about the same width, but at the anterior end it is usually much less; external surface of area with more or less obscure radial furrows. Inner side of

marginal area strongly concave, the outer wall well developed and extending from near the post-dorsal angle around the ventral side and about half way up the anterior side. In perfect specimens the dorsal angles are prominent.

The pinched appearance of the central portion of the valves, pitted instead of reticulated surface, stronger tubercle, wider sulcus and more abruptly elevated marginal area, together with other differences readily distinguish this species from *E. reticulata, E. manitobensis* and *E. longula.*

The original types of the species occurred in a hard limestone, and appeared to be without pitting of the surface; but a re-examination proved that the shell is usually exfoliated in specimens obtained by splitting the limestone blocks. The Minnesota specimens are mostly preserved in soft shale and in many cases are very perfect.

Formation and locality.—"Lower Blue limestone" of the Trenton formation, Dixon, Illinois, and Mineral Point, Wisconsin; Birdseye or "Glade" limestone, Lebanon, Tennessee; rather abundant in the lower third of the Trenton shales (Stictoporella bed) at Minneapolis, St. Paul, Cannon Falls and Oxford Mills, Minnesota.

EURYCHILINA VENTROSA, *n. sp.*

PLATE XLV, FIGS. 1–3.

SIZE.—Without marginal area, length 1.82 mm.; hight 1.08 mm.; thickness 0.8 mm.
With marginal area, length 2.40 mm.; hight 1.5 mm.

This species is considerably like *E. subradiata* but the body of the valve is more convex and the outline much more oblique. It is also a little shorter. The marginal area has about the same width in the two species but it does not rise so abruptly and on the whole is convex in *E. ventrosa,* while the ends are not produced above into sharp angles. The border is peculiar also in front where it is bent so as to form an angle of about 45° with the plane of the valves. But the principal peculiarity of the border lies in a strong swelling which takes up its entire ventral part. Surface of valves with obscure traces of large shallow pits. Tubercle strongly developed.

The ventral swelling of the marginal area is a peculiar feature, and so far as I can see, normal. A similar though weaker and longer swelling occurs in four valves found associated with *E. subradiata* at Minneapolis. As these specimens however are typical of that species in all other respects, they probably represent a variety that subsequently changed to the form now called *E. ventrosa.*

Formation and locality.—Upper portion of the Galena shales (base of Fusispira bed) near Cannon Falls, Minnesota.

EURYCHILINA ? SUBÆQUATA, *n. sp.*

PLATE XLV, FIGS. 7–9.

SIZE.—Without border, length 1.55 mm.; hight 0.85 mm.; thickness 0.58 mm.
With border, length 1.80 mm.; hight 1.05 mm.

Valves quadrate-subelliptical in outline, strongly convex, with the dorsal angles obtuse, the ends rounded, and the dorsal and ventral margins nearly parallel. Body of valve rather uniformly convex, with the anterior end a trifle more obliquely rounded than the posterior. Sulcus situated a little behind the center, deep, narrow, beginning at the straight dorsal border and terminating abruptly at a point less than one-third of the hight of the valve beneath it. On each side of the sulcus the surface rises into a low eminence, one, supposed to be the posterior, a little higher than the other. Central portion of surface exhibiting numerous, rather irregularly distributed pustules. Border not defined by an impressed suture line, flattened except at its extreme outer edge where it bends suddenly inward. Its surface presents more or less obscure radial series of minute granules, most distinct on the ventral portion where the border is also the widest.

As stated under the generic description, this is one of a number of species belonging to an undescribed genus. Of these forms *E. ? striatomarginata* Miller, from the uppermost beds of the Cincinnati formation, and *E. ? obesa* Ulrich, from the Birdseye limestone of Kentucky, are probably the nearest. The first is less convex, has a different sulcus and a wider border, marked with fine radiating lines instead of rows of granules. The latter agrees very well in most respects but may be distinguished at once by the absence of any well defined sulcus.

Formation and locality.—Upper third of the Trenton shales (Phylloporina bed), St. Paul, Minnesota.

EURYCHILINA ? SYMMETRICA, *n. sp.*

PLATE XLIV, FIGS. 5–7. PLATE XLV, FIGS. 4–6.

SIZE.—Length 1.8 mm.; hight 1.1 mm.; thickness 0.4 mm.
Length 1.7 mm.; hight 1.08 mm.

Valves subelliptical or somewhat quadrate, equilateral, greatly compressed, 1.6—2.0 mm. in length. Dorsal margin straight or slightly convex, a little shorter than the valve; dorsal angles not very sharp; ventral margin semielliptical, curving neatly into the rounded ends. Body of valve flattened, but rising at two points near the hinge, each situated about midway between the dorsal angles and the center, into two, more or less prominent, large subequal rounded tubercles. These are connected by a thin ridge, the two bulbs and connecting bar resembling the old "bar shot." Surface broadly excavated centrally, and marked with obscure pits. Marginal

area convex, about 0.3 mm. wide along the ventral edge, the width decreasing rapidly in nearing the dorsal angles; ventral two-thirds surmounted by a narrow, crescent-shaped thickening, depressed centrally, and marked with rather large elongated and concentrically arranged pits.

The affinities of this remarkable species are very uncertain, and it is only provisionally placed under *Eurychilina*. Perhaps it can go into the new genus with *E. ? subæquata* and the other species mentioned on p. 659. On the other hand, the two dorsal tubercles may indicate a remote relationship with *Ulrichia*. Whatever position it may ultimately occupy in classification, it is safe to say that it now stands quite alone.

Formation and locality.—Upper third of the Trenton shales (Phylloporina bed), St. Paul and near Cannon Falls, Minnesota.

Genus DICRANELLA, n. gen.

Valves equal, similar to those of *Primitia*, excepting that they have "frilled" margins, while each side of the sulcus is raised into a more or less prominent horn-like process. These prominences are directed dorsally and may be subequal, or the posterior one may be much the smaller.

Type: *D. bicornis*, n. sp.

Though doubtlessly embracing a good generic type, it is as yet scarcely possible to give a satisfactory diagnosis of this new genus. Two of the following species, the type and *D. spinosa*, are certainly congeneric, and the third, *D. marginata*, probably also. But the fourth, *D. ? simplex*, is one of four species which, while closely related among themselves, are, to say the least, only doubtful members of this genus. Two of these four species Prof. T. Rupert Jones recently described as *Ulrichia nicholsoni* and *U. marrii* (Quart. Jour. Geol. Soc., vol. 49, p. 294; 1893) while the third, *Leperditia byrnesi* Miller, he refers (*op. cit.*, vol. 46, p. 12; 1890) to the genus *Æchmina*. According to my estimate of these species, they should not be referred to *Æchmina* because, instead of a single horn-like prominence rising from the center of the dorsal slope, they have two, one subcentral, the other behind it, while between them there is more or less of a notch or sulcus. In *Ulrichia* the two generic knobs are merely rounded prominences or tubercles on the surface of the valves, never horn-like, nor are their apices turned toward or beyond the dorsal margin. The probabilities are that the affinities of *Æchmina* and *Ulrichia* are widely different, and it would be good policy, for the present at least, to restrict their application to forms in which the generic features are sharply defined.

As to these four doubtful species, they are, it seems to me, clearly nearer *Dicranella* than the other genera to which they have been referred. The answer to

the question, are they really congeneric with the typical species?, depends, I should say, entirely upon the significance we attach to the presence or absence of the marginal frill. Believing that further investigations are desirable, I shall not attempt to decide the question now. In the meantime the new species may be known as a doubtful *Dicranella*, while the others had best remain where Prof. Jones has placed them.

DICRANELLA BICORNIS, *n. sp.*

PLATE XLIV, FIG. 26. PLATE XLVI, FIGS. 39–40.

SIZE.—Without border, length 1.5 mm.; hight 0.83 mm.; thickness 0.4 mm.
With border, length 1.8 mm.; hight 1.02 mm.

Valves oblong, straight dorsally, rounded ventrally and at the ends, the latter nearly equal. Two large, subequal, diverging, horn-like processes, angular in cross-section, arise behind the center of the dorsal half and project far beyond the dorsal edge; between their bases a suboval depression; lower half of posterior horn with a large rounded swelling. Outline of valves marked by a sharply defined, linear ridge; beyond this a wide but very thin, smooth border or frill, usually bending outward at the edge; border narrowest anteriorly, widest below.

This species is so easily recognized by its "horns," that comparisons are quite unnecessary.

Formation and locality.—Lower and middle thirds of the Trenton shales (Stictoporella and Rhinidictya beds), Minneapolis and St. Paul, Minnesota.

DICRANELLA SPINOSA, *n. sp.*

PLATE XLIV, FIG. 23. PLATE XLVI, FIG. 41.

SIZE.—Length (including border) 1.5 mm.; hight 0.8 mm.; thickness 0.45 mm.

This species is similar to *D. bicornis* but the valves are a little longer, and the "horns" begin lower down on the valves and are not carinated, while the posterior one is shorter, and seems not to extend beyond the rounded swelling. The border also seems not to have been developed anteriorly, while along the ventral edge it is usually replaced by a series of spines. Posteriorly it has about the same width as in *D. bicornis*, but is ornamented with radial furrows instead of being plain.

Formation and locality.—Middle third of the Trenton shales (Rhinidictya bed), Minneapolis, Minn.

DICRANELLA MARGINATA, *n. sp.*

PLATE XLIV, FIGS. 27–28.

SIZE.—Length 1.7 mm.; hight 1.22 mm ; thickness 1.0 mm.

In this species the valves are much higher, especially in the posterior part, than in the two preceding species, the border, though wanting anteriorly, is much thicker and projects outward as much as downward or forward, while, instead of horn-like processes, we have two very unequal lobes, the posterior of which is comparatively very small, failing to reach the dorsal edge by a distance almost equalling its length, the anterior one (centrally situated) large, swollen in the middle, high and obtusely pointed above, the extremity reaching the dorsal edge or projecting slightly beyond it. The whole carapace also is thicker and has a more robust appearance. The peculiarities are strongly marked and conspicuous, and it does not seem likely that collectors will experience any trouble in recognizing the species.

Formation and locality.—Lower part of the Trenton shales (Rhinidictya bed), near Fountain, Minnesota.

DICRANELLA ? SIMPLEX, *n. sp.*

PLATE XLIV, FIGS. 24–25. PLATE XLVI, FIG. 42.

SIZE.—Length 0.98 mm.; hight 0.67 mm.; thickness 0.35 mm.

Valves moderately convex, subelliptical; dorsal angles rounded, hinge line rather short; ends equal, rounded; ventral margin rather strongly convex; edges simple, without border. A strongly elevated, oblique, conical prominence just within and behind the center of the dorsal edge; another large tubercle, in this case rounded instead of conical and ovate in outline, near the center of the posterior half and like the other reaching the dorsal edge; between the two a rather deep sulcus. A third tubercle, of irregular form and nearly as large as the second, occurs just within the upper half of the posterior edge.

This species is evidently related to the Cincinnati form first called *Leperditia byrnesi* by Mr. Miller, and recently referred to *Æchmina* by Prof. Jones. That species however has only one posterior tubercle and a central oblique spine, while *D. ? simplex* has all three. The outline of the latter also is more convex ventrally. Of Minnesota Ostracoda, there is none sufficiently like it to require comparisons.

Formation and locality.—Lower part of the Trenton shales (Rhinidictya bed), near Fountain, Minn.

Genus JONESELLA Ulrich.

Jonesella ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 121.

Carapace small, equivalved, moderately convex, oblong-subovate; hinge straight. Valves with a curved ridge on the posterior half or two-thirds. This ridge may be variously modified, but in the typical species it is thin and bent like a horseshoe, in another the anterior arm is horizontal instead of vertical, while in a third the two arms are divided. Edges simple or faintly bordered.

Type: *J. crepidiformis* Ulrich.

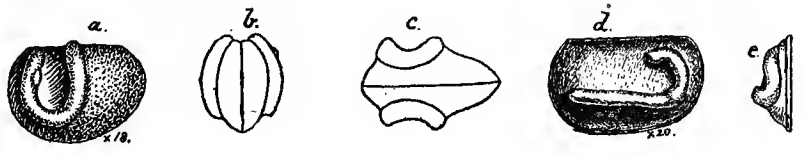

Fig. 47.—*a*, *b*, *c*, lateral, posterior, and ventral views of an entire carapace of *Jonesella crepidiformis* Ulrich; *d*, left valve of *J. pedigera* Ulrich; all about × 20. Both species are from the lower beds of the Cincinnati group at Covington, Kentucky.

The affinities of this genus, which includes so far as known only Lower Silurian species, appear to be with *Bollia*, Jones and Holl. But the horseshoe ridge in all true species of that genus is subcentral, while the edges of the valves are thickened into a more or less well-developed marginal ridge, no trace of which is apparent in *Jonesella*. The new species about to be described is peculiar in the faint development of the loop, and in the shortness of the horseshoe. In *J. crepidiformis*, as may be seen in the above cut, the ridge takes up the greater part of the posterior half. Still, a general agreement of parts between the two species is obvious, so that *J. obscura* may well be accepted as an incipient *Jonesella*. On the other hand, the prominent upper extremities of the bent ridge, remind considerably of certain species of *Ulrichia*, but as the whole carapace recalls *Bollia* quite as much, if not more, it is to be assumed that these resemblances indicate family relationship rather than generic. As usual with early types of life, the Lower Silurian Ostracoda are apt to be of a composite nature, and the determination of the really significant features of such forms, so far as generic and specific alliances are concerned, is never certain except through minute genealogical investigations. But this touches upon too large a subject for the present work.

In the original work on the genus I included a Minnesota species, under the name of *J. crassa*, that I shall now place elsewhere, because it seems to belong to another line of development, namely, it is closely related to *Ctenobolbina fulcrata*. For further remarks on this and related species see under *Ctenobolbina*.

JONESELLA OBSCURA, *n. sp.*

PLATE XLIV, FIGS. 17–19.

SIZE.—Length 0.68 mm.; hight 0.43 mm.; thickness 0.3 mm.

Valves moderately convex, subovate, sometimes obscurely quadrate; hinge rather short, straight centrally, more or less rounded at the ends; ventral margin gently convex, nearly parallel with the dorsal. Horseshoe ridge comparatively small, almost entirely within the post-dorsal fourth, its arms terminating near the dorsal margin in two rounded elevations, the connecting loop but little elevated and in most cases obscure; beneath the loop another but very faint loop-like elevation of the surface may be noticed.

The horseshoe ridge is much smaller and the bent portion much less distinct than in *J. crepidiformis.*

Formation and locality.—Galena shales (Clitambonites bed), near Cannon Falls, Minnesota.

Genus BOLLIA, Jones and Holl.

Bollia, JONES and HOLL, 1886. Ann. Mag. Nat. Hist., ser. 5, vol. xvii, p. 360

Valves subequal, oblong or somewhat rounded, with rounded and nearly equal ends and a straight hinge line; surface punctate or smooth, and bearing a large loop-like or more or less horseshoe-shaped ridge; from the edges the surface rises into a more or less well-developed, angular or rounded marginal ridge; the outer and inner ridge often come close together ventrally, but rarely, if ever, coalesce; horseshoe ridge of nearly equal strength throughout, or the ends may be bulbous and the connecting bent portion relatively very thin and low.

Type: *B. uniflexa* Jones and Holl.

This genus is easily recognized by the inner or horseshoe ridge, which always occupies a subcentral position with respect to the ends of the valves. The species are numerous and while they may be said to adhere rather strictly to the generic type, it is still true that they may be divided into three distinguishable groups. In the first or typical section, the outer rim or ridge is not strong, while the inner ridge has bulbous ends and is on the whole larger though the bent connecting portion is narrow. In the second section, of which *B. vinei* Jones and Holl, may be considered as typical, both the inner and outer ridges are relatively thin and small, even the ends of the horseshoe ridge being but little, when at all, thicker than the rest. The third section, of which *B. persulcata* Ulrich and *B. regularis* Emmons sp., are both, though in somewhat different ways, representative, includes species in which the inner ridge is thick without being bulbous at its ends, the marginal ridge swollen,

sometimes thicker at one end than the other, and the depressions or sulci between the ridges relatively narrow. These species pass over into, and the section ought to include, some of the so-called quadri-jugate *Beyrichiæ*.* Their relations to *Tetradella* will be considered in the remarks under that genus.

Bollia subæquata, *n. sp.*

PLATE XLVI, FIGS. 26–29.

Size.—Length, 0.64 mm.; hight, 0.50 mm.; thickness 0.22 mm.
Length, 0.59 mm.; hight, 0.42 mm.; thickness, 0.20 mm.
Length, 0.40 mm.; hight, 0.32 mm.

Valves compressed, subovate in outline, straight above; length of hinge somewhat variable, shortest, apparently, in old examples; dorsal angles more or less distinct; edges of valves thick, forming a sharply-defined, thin marginal ridge; inner ridge thin, rather long, U-shaped, one of the arms with a slight swelling near or at its upper extremity; surface between the ridges flat and without ornament.

The small valves of this species remind somewhat of *Moorea punctata*, but as that form has no inner or horseshoe ridge they are distinguished very easily. *Tetradella quadrilirata* is a larger form and has the inner ridges joined below with the marginal ridge. The nearest allies occur in the Upper Silurian deposits of Europe, but it is distinct from them all.

Formation and locality.—Galena shales (Clitambonites bed), near Cannon Falls, Minnesota.

Bollia unguloidea, *n. sp.*

PLATE XLVI, FIGS. 23–25.

Size.—Length 0.6 mm.; hight 0.4 mm.; thickness 0.35 mm.

Valves subovate, with equal rounded ends, a rather short, straight hinge, and illy defined dorsal angles; marginal ridge thick, rounded, a little wider at one end than at the other; inner ridge strong, one end swollen, the other small and failing to reach the dorsal edge; interspace between the two ridges very narrow.

* With the exception of several very doubtful species described by Krause, the known species fall into these sections, as follows:

Section 1.	Section 2.	Section 3.
B. pumila Ulrich, L. Sil.	*B. subæquata* Ulrich, L. Sil.	*B. unguloidea* Ulrich, L. Sil.
B. uniflexia Jones and Holl, U. Sil.	*B. semilunata* Jones, Antic.	*B. regularis* Emmons sp., L. Sil.
B. bicollina J. and H., U. Sil.	*B. vinei*, Jones and Holl, U. Sil.	*B. persulcata* Ulrich, L. Sil.
?*B. interrupta* Jones, U. Sil.	*B. vinei* var. *mitis* J. and H., U. Sil.	*B. duplex* Krause, U. Sil.
B. bilobata Jones, Dev.	*B. semicircularis* Krause, U. Sil.	*B. symmetrica* Hall sp., U. Sil.
B. hindi Jones, Dev.	*B. rotundata* Krause, U. Sil.	*Beyrichia clarki* Jones, U. Sil.
B. obesa Ulrich, Dev.		*Beyrichia halli* Jones, U Sil.
B. granifera Ulrich, L. Carb.		*B. ungula* Jones, Dev.
		?*Beyrichia devonica* Jones, Dev.
		Beyrichia subquadrata Jones, Dev.

This species, though smaller and distinct, resembles the Devonian *B. ungula* Jones, more closely than any other of the genus known. *B. persulcata* of the Cincinnati rocks is perhaps as near as any of the Silurian forms, but there are so many differences between them that it is unnecessary to enter into comparisons. In *B. subœquata*, which belongs to another section of the genus, both the inner and outer ridges are much thinner.

Formation and locality.—Associated with the preceding in the Galena shales, in Goodhue county, Minnesota.

Genus DREPANELLA, Ulrich.

Drepanella (*Depranella* in error) Ulrich, 1890, Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 117.

Carapace equivalved, compressed-convex, somewhat oblong, the outline between subquadrate and subelliptical; dorsal border straight, ventral outline gently convex; ends subequal, the posterior somewhat truncated above, the anterior generally more rounded. Running nearly parallel with and close to the posterior and ventral edges, a sharply elevated, sickle-shaped ridge. Central and dorsal regions of valves with two principal, simple or divided, nodes or ridges. Surface smooth or reticulate. Size of carapace usually about 2.5 mm. long by 1.5 mm. high.

Type: *D. crassinoda* Ulrich,

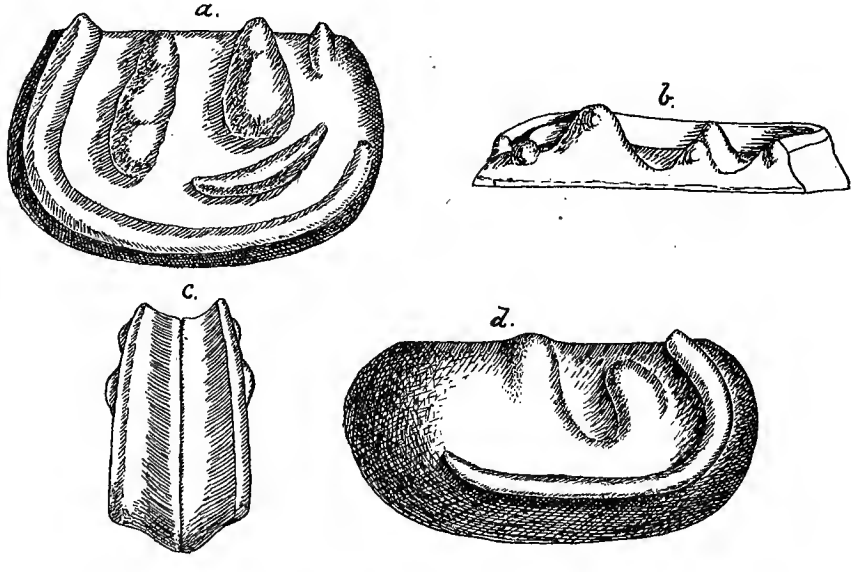

Fig. 48.—*a*, *b*, lateral and dorsal views of a right valve of *Drepanella crassinoda* Ulrich, from the Birdseye limestone at High Bridge, Kentucky; *c*, a left valve of *D. ampla*, var. *elongata* Ulrich, from the same formation and locality, introduced for comparison with *D. bigeneris*; *d*, right valve of *D. macra* Ulrich, from the same formation at Dixon, Illinois; all × 20. The last probably occurs also in Minnesota.

Of this genus only Lower Silurian species are known. Taking the six species and varieties upon which the genus was founded, we have a sharply defined generic

group. With these we may include, without materially altering our conception of the genus, the new *D. bilateralis*, although in this species the characteristic sickle-shaped marginal ridge is wanting posteriorly. But the other Minnesota species, *D. bigeneris*, is certainly a remarkable form. In size and general appearance it agrees very well with *D. crassinoda* and *D. ampla* having the sickle-shaped ridge well developed, and two large centro-dorsal nodes, separated by a depression, as in the latter species. But the peculiar feature is that these nodes are prolonged below and united by a slender connection, giving us precisely the horseshoe ridge of a *Bollia*. The question arising at once is, why should the species not be viewed as a *Bollia*, rather than a *Drepanella*.

I have decided for *Drepanella* on what I believe to be good genealogical grounds. In the first place, aside from the ventral connection of the nodes, all the characters of the species are those of *Drepanella*. The marginal ridge, it is true, runs farther up on the anterior end than on any of the other species, yet its extremity is thin and the mere fact that it is a trifle longer than usual cannot be of much consequence. But the most important evidence on the question is furnished by *D. ampla* var. *elongate*, of which a copy of the original figure is given above. In this variety, namely, there is a well defined depression between the nodes precisely as in *D. bigeneris*, and all that is required to produce the loop of the latter, is a slight raising of the nodes, together with the lower border of the depression. This is not, I believe, supposing too much, for a ventral coalescence of the anterior and posterior lobes or nodes is not by any means restricted to *Bollia*. Indeed it occurred under one form or another, among many types of *Beyrichiidæ*. That this is true, a glance at plate XLIV may suffice to prove. One form is shown in fig. 4, another, and widely different, in fig. 6, while 8, 10, 12, 15, 17, 20, 23, 26, and 27 illustrate other types of the same condition.

DREPANELLA BILATERALIS, *n. sp.*

PLATE XLVI, FIGS. 35–38.

SIZE.—Greatest length 2.7 mm.; length of hinge 2.15 mm.; greatest hight 1.64 mm.; greatest thickness, about 1.3 mm.; thickness, not including nodes and ridge, about 0.6 mm.

Valves suboval or oblong-subquadrate, compressed; dorsal margin straight; distinctly angular at the extremities; anterior end a trifle narrower, and the outline less convex than the posterior; ventral margin nearly straight centrally. Running parallel with and close to the ventral margin a strong ridge, somewhat thickened at each end, but not continuing up the posterior end as in the other species. Above this two irregularly triangular and very prominent large nodes extend to the dorsal edge, beyond which their pointed extremities occasionally project. The last is true also of a small central tubercle.

The form, prominence and bilaterally symmetrical disposition of the nodes and ridge give this species a very distinct and striking appearance, and among all the numerous Silurian Ostracoda not one is known with which it might be confused.

Formation and locality.—Upper third of the Trenton shales (Phylloporina bed), St. Paul and near Cannon Falls, Minnesota.

DREPANELLA BIGENERIS, *n. sp.*

PLATE XLIV, FIGS. 20–22.

SIZE.—Length 2.3 mm.; hight 1.36 mm.; greatest thickness 0.95 mm.; average thickness, not including nodes and ridges, about 0.5 mm.; thickness of posterior and ventral edges about 0.6 mm.

Valves oblong-subquadrate, longest in the lower half, the ends nearly equal and converging slightly in the upper half; back straight, the posterior extremity subangular, the anterior rounded; ventral outline very gently convex; marginal or "sickle-shaped" ridge sharply defined, extending farther up on the anterior side than in any of the other species of the genus. Two thick nodes or lobes, the anterior one the longer and more prominent, are connected below by a narrow loop-like thickening of the lower border of the median depression or sulcus, the whole producing precisely the effect of the "horseshoe" ridge of *Bollia*.

My reasons for placing this fine species under *Drepanella* instead of *Bollia* are given in the remarks following the generic description. The specific characters are well marked and conspicuous, so that there is little difficulty in distinguishing the species from the rest of the Minnesota Ostracoda.

Formation and locality.—Lower limestone of the Trenton formation, Minneapolis and St. Paul, Minnesota.

Genus DILOBELLA, n. gen.

Carapace small, equivalved, subovate or somewhat reniform in outline, the back straight or faintly concave; valves bilobed, the lobes subequal, very large, and almost completely separated by a deep subcentral vertical sulcus; edges thin, simple; surface smooth.

Type: *D. typa*, n. sp.

I find myself obliged to erect a new genus for this remarkable ostracode. A slight resemblance to certain forms of *Bollia* may be noticed, but the lobes are altogether too large for that genus. That it cannot belong to either *Entomis*, *Entomidella* nor *Ctenobolbina*, the only other genera with which it might be compared must be evident to anyone who has paid attention to this class of fossils. As to its affinities, they are obscure. Because of the slight basal connection between the lobes, it may be regarded provisionally as an extravagant development of the *Bollia* type of structure.

DILOBELLA TYPA, *n. sp.*

PLATE XLVI, FIGS. 30–34.

SIZE.—Length 1.0 mm.; hight 0.8 mm.; greatest thickness 0.52 mm.
Length 0.9 mm.; hight 0.75 mm.

Valves varying somewhat in outline, some being obscurely quadrate or subovate, others short-reniform; dorsal outline more or less concave at the middle and rounded or subangular at the ends; ventral margin strongly convex, the lower half of the outline being in some cases almost semicircular. A deep, subcentral, vertical sulcus divides the valves into two large subequal lobes. These are very prominent, especially at their centers, and rise abruptly from the flattened borders. At the base an obscure connection between the lobes may be noticed.

When the valves are not perfectly cleared from the matrix, some difficulty may be experienced in distinguishing them from the associated *Ctenobolbina crassa*, which also has a deep sulcus. But in that species the sulcus is curved and does not divide the lobes ventrally, and the valves are longer and differently shaped. In fact the two species differ so greatly that I cannot conceive how good specimens might be confounded.

Formation and locality.—Upper third of the Trenton shales (Phylloporina bed), St. Paul, Minnesota.

Genus CTENOBOLBINA, Ulrich.

Ctenobolbina, ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 108.

Carapace small, elongate-suboval, strongly convex, the posterior two-fifths more or less decidedly bulbous or subglobular, and separated from the remainder by a deep, narrow and more or less oblique sulcus extending with a gentle curve from the dorsal margin more than half the distance across the valves toward the postero-ventral border. The anterior three-fifths often with another oblique but less impressed sulcus. Valves equal, the dorsal margin straight, hingement simple, the ventral edge thick, and the true contact margins generally concealed, in a lateral view, by a "frill" or flattened false border; surface granulose, smooth, or punctate.

Type: *C. (Beyrichia) ciliata* Emmons sp.

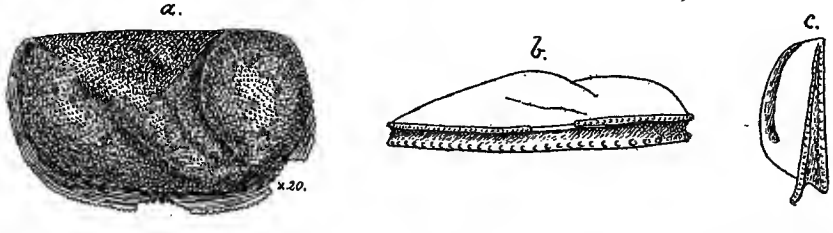

Fig. 49.—*a*, *b*, *c*, lateral, posterior, and ventral views of a left valve of *Ctenobolbina ciliata* var. *emaciata* Ulrich, × 20; shales of the Hudson River group, Savannah, Illinois. This species probably occurs also in the equivalent shales near Spring Valley, Minnesota.

This genus includes a well marked group of paleozoic Ostracoda, distinguished, in its typical development, from all the other genera of the family by the bulbous character of the posterior end. A small isolated middle lobe, which is the most persistent character of *Beyrichia* and *Klœdenia*, is, except in one case, never present, the central lobe or ridge, when one has been divided off from the anterior swelling of the surface, being united ventrally with the large posterior lobe. A small lobe is isolated in *C. tumida* Ulrich, but as the posterior half is decidedly bulbous in this species it may be advisable to leave it with this genus. Still, I have fully satisfied myself that it is a close ally, perhaps a progenitor of the Clinton *Beyrichia lata* Vanuxem, and that is not far from *B. klœdini* McCoy.

Ctenobolbina has its best development in the Cincinnati group, from which four or five good species and two varieties have been described. Two Trenton species, differing from the Cincinnati types in the lesser development of the posterior bulb, are found in Minnesota. *C. punctata* Ulrich, of the Niagara, retains the generic characters very well, as does also *C. papillosa* Ulrich, of the Devonian, while *C. informis* Ulrich, also Devonian, reminds of the Trenton *C. crassa*. *C. minima*, of the Hamilton, is much like *C. bispinosa* from Cincinnati, and both are almost primitian in their simplicity. Of European species I know of only one that has the characters of *Ctenobolbina* clearly developed. This is the *Beyrichia guillieri* Fromelin, as figured by Jones, in 1890, (Quart. Jour. Geol. Soc., vol 46, pl. 21, figs. 2*a*, *b*, *c*). It is closely related to *C. ciliata* and occurs in the Lower Silurian strata of France. Another, that is as much of a *Ctenobolbina* as *C. crassa*, *C. fulcrata* and *C. informis*, is the *Bollia? auricularis* Jones and Holl, from the Wenlock of England. Indeed, these four species are closely related and cannot justly be separated generically, so that I propose to refer the Wenlock species also to this genus. Prof. Jones concedes in a letter to me that the *auricularis* is not a *Bollia*, and a close comparison with the Minnesota species mentioned proves to me that my former opinion of the British species, when I thought that it might belong to *Halliella* (Jour. Cin. Soc. Nat. Hist., vol. 13, p. 185), is erroneous.

Ctenobolbina fulcrata, *n. sp.*

PLATE XLIV, FIGS. 8–11.

Size.—Length 1.2 mm.; hight 0.78 mm.; thickness 0.56 mm.
Length 1.2 mm.; hight 0.80 mm.; thickness 0.60 mm.

Valves obliquely subovate, highest posteriorly, with the back straight and the dorsal angles usually well defined. Posterior bulb comparatively narrow; sulcus deep, wide, oblique, curving backward below; anterior lobe undivided, larger than the posterior, in some specimens less oblique than in others; ventral and posterior sides

of lobes terminating in a thin, flat or raised, border, supported in the hinder part by five, equidistant ribs or walls, thus forming as many small cavities in the posterior edge of each valve; surface smooth.

The small cavities in the posterior half of the edge remind of *Tetradella quadrilirata*, but here the resemblance ceases for they are widely different in all other respects. These cavities and the relative narrowness of the posterior bulb, together with other peculiarities, distinguish *C. fulcrata* from *C. duryi* Miller sp., a Cincinnati species that resembles fig. 8 more closely than does any other one of the genus. When however it comes to actual relationship, the next to be described is doubtless the nearest.

Formation and locality.—Upper third of the Trenton shales (Phylloporina beds), St. Paul and Cannon Falls, Minnesota.

Ctenobolbina crassa *Ulrich.*

PLATE XLIV, FIGS. 12–16.

Jonesella crassa Ulrich, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 123.

Size.—Length 0.94 mm.; hight 0.60 mm ; thickness 0.60 mm.
Length 0.80 mm.; hight 0.52 mm.; thickness 0.46 mm.

This species is closely related to *C. fulcrata*, and when the edges are obscured by the matrix, it is difficult to distinguish from one of the varieties of that species. But when the posterior edge is visible the difficulties vanish, there being no supports nor cavities in the thick edge of *C. crassa* (compare figs. 13 and 16 with fig. 9, pl. 44.) Among other differences I may mention that in *C. crassa* the valves are constantly a little smaller, the sulcus wider, and the lobes more prominent, especially at the ventral edge. The lobes are also more compact and ridge-like, producing an effect that reminds so much of the "horseshoe" ridge of *Jonesella*, that I at first regarded the species as belonging to that genus. But that was before I knew of its close relationship with *C. fulcrata.*

Formation and locality.—Associated with the preceding in the upper third of the Trenton shales at St. Paul and Cannon Falls, Minnesota.

Genus CERATOPSIS, n. gen.

Tetradella (part.) Ulrich, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 112.
Beyrichia (part.) Barrande, Hall and Whitfeld, Miller, Jones, and other authors.

Valves somewhat obliquely subovate, widest posteriorly, straight dorsally, with a thick rounded semicircular marginal ridge, and two submedium ridges extending obliquely upward from the marginal ridge, the anterior one reaching the dorsal edge, the other shorter and smaller; post-dorsal end of marginal ridge raised into a strong

spine-like, or a mushroom-shaped process, beaded or fimbriated along one edge or around the flattened top. Free edges of carapace as in *Ctenobolbina*, being thick, and having "false borders."

Type: *Beyrichia chambersi* S. A. Miller.

This genus is related to *Ctenobolbina* on the one hand and *Tetradella* on the other, while it is distinguished from both, as well as from all known genera, by the remarkable post-dorsal process. The species of *Ceratopsis* are all Lower Silurian and, with the exception of *Beyrichia hastata* Barrande, a Bohemian species evidently of this genus, all American. *C. chambersi* is rarely met with in the middle third and rather commonly in the upper third of the Trenton shales in Minnesota. Recently I have also detected a few specimens in the upper part of the Trenton in Kentucky, but the most typical and abundant development of the species occurs in the lower two hundred feet of the Cincinnati group. Variety *robusta* applies to a reappearance of the species in the upper beds of this group in Ohio and Minnesota. *C. oculifera* (*Beyrichia*, Hall) though very abundant, seems to be restricted to the upper one hundred feet of strata exposed in the Cincinnati hills. In this form the elevated process took the shape of a thick-stemmed mushroom, the gently convex cap of which is beautifully fringed at the edge. A new species, which I propose to call *C. intermedia*, occurs at the base of the Cincinnati formation near Covington, Kentucky. In this the process forms a curved spine on which the fimbria is arranged in a semicircular manner, the effect being very nearly intermediate between that exhibited in *C. chambersi* and *C. oculifera*. For further remarks on this genus see under *Tetradella*.

CERATOPSIS CHAMBERSI *Miller*.

PLATE XLVI, FIGS. 19–22.

Beyrichia chambersi MILLER, 1874. Cin. Quar. Jour. Sci., vol. i, p. 234.
Tetradella chambersi ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 112.

SIZE.—Length 1.5 mm.; hight 1.03 mm.; thickness 0.6 mm.
Length 1.8 mm.; hight 1.10 mm.

The principal distinguishing feature of this abundant species is the spine-like form of the post-dorsal process. In the typical variety, of which fig. 19 is a fair example, the post-medium ridge is short and small. It is so in all the Trenton specimens and in the Lower Cincinnati group types of the species. Figure 22 is peculiar in having the upper end of this ridge separately developed as a small rounded node. It is the only case of the kind seen, and may be abnormal.

Variety ROBUSTA, *n. var.*

Beyrichia chambersi HALL and WHITFIELD, Pal. Ohio, vol. ii, p. 104, pl. 4, figs. 11, 12, not strictly *B. chambersi* Miller.

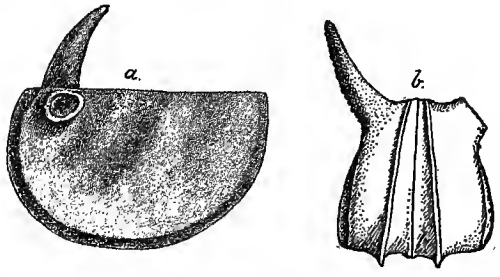

Fig. 50.—Lateral and posterior views of an entire carapace of this variety from the shales of the Hudson River group, near Spring Valley, Minnesota.

This designation is proposed for the variety which occurs in the upper beds of the Cincinnati group at numerous localities in Ohio, Indiana, and Kentucky, and in the equivalent Hudson River group strata of Minnesota. So far as known it is not to be found below the horizon of *Orthis subquadrata* Hall, and *Rhynchotreta capax* Conrad. It differs from the typical form of the species in having all the ridges somewhat thicker, and the post-median one much larger. In many cases the latter is nearly or quite equal to the anterior ridge, and extends like it entirely across the valve. The ventral portion of the carapace also is thicker, and the marginal ridge subangular where the contour turns abruptly inward to the false border.

Formation and locality.—The typical form of the species is rare in the middle and common in the upper third of the Trenton shales at Minneapolis, St. Paul and Cannon Falls. As yet, it has not been detected in any of the divisions of the Galena, but in the lower beds of the Cincinnati group it is a common fossil. The var. *robusta* was found in the upper part of the Hudson River shales near Spring Valley, Minnesota, and occurs abundantly in the upper beds of the Cincinnati group at Waynesville and Oxford, Ohio, Richmond and Versailles, Indiana, and many other localities in these states.

Genus TETRADELLA Ulrich.

Tetradella (part.) ULRICH, 1890. Jour. Cin. Soc. Nat. Hist. vol. xiii, p. 112.
Strepula, ULRICH, 1889. Contri. to Can. Micro.-Pal., pt. 2, pp. 54, 56, not of Jones and Holl. "Trisulcate" and "quadrijugate" *Beyrichia* (part.) of authors.

Carapace somewhat oblong, often subquadrate, never tumid, with the hinge line straight. Surface depressed, with a semicircular marginal ridge; within the enclosed space, two, simple or slightly modified, equal or unequal, and more or less nearly vertical ridges unite below with the marginal ridge and extend upward from it, one in many cases failing to reach the dorsal margin. Free edges usually with a simple flattened border; in one case (*T. subquadrata*) thick and with the contact margins concealed by a "false border." Surface smooth or granulose.

Type: *T.* (*Beyrichia*) *quadrilirata* Hall and Whitfield.

In the original definition of this genus (*loc. cit.*) I included as a section the species that I now separate as *Ceratopsis*, under which name they have been distinguished in my private collection since 1881. I have been led to alter the opinion expressed in 1890, respecting the desirability of generically recognizing the distinguishing peculiarity of *Ceratopsis* by repeated comparison among the constantly increasing typical species of the genus. Of the fifteen good, and four somewhat doubtful species of *Tetradella* now known, not one shows the remotest sign of the "horns" of *Ceratopsis*. This horn-like process is a structural peculiarity, and while it may be analogous or even homologous with the central horn of *Æchmina* and the two horns of *Dicranella*, it is more highly organized, and surely deserves generic recognition when this rank is accorded to the more simple process in the two cases mentioned. In 1890 I thought it just possible that the feature might prove inconstant, if not abnormal, but that is now quite out of the question since it is as constant as any peculiarity can be, being repeated in thousands of examples of each of the three American species, during unusually long geological ranges, and with a persistency of specific marking that would be most extraordinary if the feature was not of structural importance.

The affinities of *Tetradella* seem to be with *Ctenobolbina* on the one hand and the "trisulcate" species of *Beyrichia*, which as I have shown on page 668, are generically distinct from *Beyrichia* and provisionally to be viewed as a section of *Bollia*, on the other. In the former, however, there are only two or three ridges instead of four, the space occupied by the two posterior ridges in *Tetradella* being representedby a single large bulb. The valves also are more convex, especially when, as is generally the case, the anterior sulcus is wanting or but feebly developed, and the free edges are thicker, while the "false border," which is almost unknown in the present genus, is generally well developed in *Ctenobolbina*.

The resemblance to the trisulcate *Beyrichia* is more marked and may prove troublesome to those who have not made a special study of the Ostracoda. Still, I remember no case now, in which one more or less well marked difference cannot be made out. Namely, in the "trisulcatæ" the arrangement of the sulci and ridges is approximately symmetrical and bilateral, the central sulcus being vertical, while the two lateral sulci curve outwardly. In *Tetradella*, however, this symmetrical arrangement is not evident since it is generally the case that *all* the sulci curve more or less posteriorly (*i. e.* starting from the dorsal margin).

But the principal reason for separating these forms from *Tetradella* is a genealogical one. The "trisulcate" or "quadrijugate" *Beyrichia*, namely, are regarded as a development from the third section of *Bollia* described on page 668, and which

includes *B. unguloidea*, *B. persulcata*, *B. regularis*, etc. A good demonstration of this line of development may be established already from known species. Compare, for instance, *B. regularis* Emmons sp., Lower Silurian, and *Beyrichia clarki* Jones, *B. halli*, Jones, *B. hieroglyphica* Krause, *B. trisulcata* Hall, and *Klœdenia kiesowi* Krause, Upper Silurian, and it is clear that the change from the first to the last was nothing more than a gradual coalescence of the ventral curves of the inner and outer ridges and the consequent obsolescence of the sulci.

That *B. trisulcata* and similar forms could not have been developed from the typical trilobed (bisulcate) *Beyrichia*, nor from *Klœdenia* is perfectly clear to me, since it would be necessary to assume a division of the small or middle lobe of those genera, which I think I am safe in declaring, never took place.

Tetradella is essentially a Lower Silurian genus, nearly all the typical species being restricted to strata belonging to, or equivalent to the Trenton and Cincinnati formations. In America we have *T. quadrilirata* Hall and Whitfield, and var. *simplex* Ulrich, *T. lunatifera* and *T. subquadrata* Ulrich. Of European species doubtlessly belonging to *Tetradella* I may mention *Beyrichia complicata* Salter, *B. ribeiriana* Jones, *B. affinis* J., *B. bussacensis* J., *B. lacunata* J., *B. marchica* Krause, *B. erratica* K., *B. palmata* K., *T. signata* K., *T. carinata* K., and *T. harpa* K. As somewhat doubtful Upper Silurian representatives, we may regard four species figured by Dr. Krause, viz.: *Beyrichia digitata* K., *B. dissecta* K., *B. mamillosa* K., and *B. nodulosa* Boll. In the first the ridges do not appear to unite ventrally, and in the last the anterior pair are peculiarly twisted together, while in the second and third all the ridges are divided into nodes, two nodes taking the place of each ridge.

TETRADELLA QUADRILIRATA *Hall* and *Whitfield*, and varieties.

PLATE XLVI, FIGS. 1–11.

Beyrichia quadrilirata H. and W., 1875. Pal. Ohio, vol. ii, p. 105.
Beyrichia regularis MILLER, 1875. Cin. Quart. Jour. Sci., vol. ii, p. 351. Not *B. regularis* Emmons
Strepula quadrilirata ULRICH, 1889. Contri, to Can. Micro. Pal., pt. ii, p. 54.
Tetradella quadrilirata ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 122.

SIZE.—Length 1.10 mm.; hight 0.75 mm.; thickness 0.42 mm.
Length 0.94 mm.; hight 0.62 mm.; thickness 0.38 mm.
Length 1.13 mm.; hight 0.70 mm.; thickness 0.55 mm.

Figures 1 to 3 are taken from a representative specimen of the species as it occurs in the Trenton shales of Minnesota. It is also very nearly identical with the typical form which is found so abundantly in the upper beds of the Cincinnati group in Ohio and Indiana. The original of fig. 4 is from the Birdseye limestone at High Bridge, Kentucky. This is somewhat shorter and more oblique than usual. Figure 7 represents a variety, not uncommon at Minneapolis, in which the antero-median

ridge has a decided thickening above, and is less distinctly divided below. The two posterior ridges also are not entirely distinct. In the majority of these lower Trenton representatives of the species a delicate ridge or raised line is to be noticed just within the posterior portion of the marginal ridge. This is wanting, as far as observed, in the Ohio specimens, but in the related *T. lunatifera* this small ridge is represented by one that is quite as strong as the marginal ridge itself.

Figures 9 to 11 are taken from a variety of which several examples were collected at Fountain, Minnesota. These are thicker ventrally than usual (see the last of the series of measurements given above), longer, and have an unusually wide flattened border, turned outward at the edge. Some slight differences may also be noticed in the characters of the median ridges, but the most striking of all their peculiarities is the absence of the five marginal cavities. In some respects these specimens agree very well with the var. *simplex* described by the author from Hudson River shales in Manitoba, but as they are not identical another subordinate name might appropriately be applied to them.

Formation and locality.—Birdseye limestone, High Bridge, Kentucky; middle and upper third of the Trenton shales, Minneapolis, St. Paul, Cannon Falls, Fountain, and other localities in Minnesota; upper beds of the Cincinnati group at Clarksville, Blanchester, Waynesville and Oxford, in Ohio, Richmond and Versailles in Indiana.

TETRADELLA LUNATIFERA *Ulrich.*

PLATE XLVI, FIGS. 12–14.

Strepula lunatifera ULRICH, 1889. Contri. to Can. Micro.-Pal., ii, p. 56.
Tetradella lunatifera ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 112.

Fig. 51.—Two valves of *T. lunatifera* from the Galena shales near Cannon Falls, x22; showing differences in the ridges.

SIZE.—Length 1.28 mm.; hight 0.75 mm.; thickness 0.58 mm.

This species is in a general way much like *T. quadrilirata* but differs more or less obviously from that, as well as from all other species now referred to the genus, in having in all six ridges instead of the usual four. Two of this number however were produced by division of the posterior and antero-median ridges. All four of the inner ridges may be, as shown in the above cut, separate except at their lower ends where they unite with the marginal ridge. In others (see plate XLVI, fig. 12) the antero-median pair may be so near each other as to form practically but a single ridge. In others again this pair is united above and below but bent in such a manner that they enclose a crescent-shaped hollow space. Finally, in a few cases

among Ohio and Manitoba specimens, the ventral connection between the inner and marginal ridges is obsolete.

The Minnesota specimens, although from a much lower horizon than the types, cannot be distinguished from them even as a good variety.

Formation and locality.—Galena shales (Nematopora beds), near Cannon Falls, Minnesota; upper beds of the Cincinnati or Hudson River formation at Oxford, Ohio, and Stony Mountain, Manitoba.

Genus MOOREA, Jones and Kirkby.

Moorea, JONES and KIRKBY, 1867. Quart. Jour. Geol. Soc., vol. xxiii, p. 494; 1869, Ann. Mag. Nat. Hist., ser. 4, vol. iii, p. 225, and 1886, ser. 5, vol. xviii, p. 261; 1887, Proc. Geol. Assoc., vol. ix, p. 508.

Carapace very small, more or less oblong or ovate, with the valves compressed, rather thick shelled, smooth, punctate or granulose, and bounded by a raised marginal ridge; the ridge may be developed only at each end, or it may continue all around. Within the marginal ridge, the flat or gently convex surface shows no trace of a sulcus, pit, nor of lobes.

Types: *M. obesa* and *M. tenuis* Jones and Kirkby.

This genus is now for the first time recognized in Lower Silurian rocks, and two of the species to be described fairly illustrate the characters of the genus. The third, *M.? perplexa*, is of doubtful affinities. A fourth species, *M. smithii*, has been described by Prof. T. Rupert Jones from the Wenlock. This seems to be a questionable *Moorea*, the carapace being too convex and blunt at the ends, while the ridge, which should be submarginal, is here central and bifurcated posteriorly. A fifth species, *M. kirkbyi*, described from the Corniferous limestone of Ontario by the same author, is not far removed from *M. angularis*, while in the sixth *M. bicornuta* Ulrich, from the Hamilton, the anterior end bears two spines. *M. granosa* Ulrich, from the Chester group of Kentucky, is peculiar in having a granulose marginal ridge and a rounded subcentral spot outlined by a row of minute papillæ. The original types are from the Carboniferous rocks of southern England.

All these species are distinguished from *Kirkbya*, Jones, certain species of which they greatly resembly, by the absence of a central pit. Some also resemble *Placentula* Jones and Holl, and certain species of *Bollia*, but the first of these genera has a small dorsal loop and sulcus, while the latter always has a horseshoe-shaped ridge of which no trace is to be observed in *Moorea*. The valves in the new genus *Macronotella* are more convex and without the marginal ridge.

MOOREA ANGULARIS, *n. sp.*

PLATE XLIII, FIG 89. PLATE XLVI, FIGS. 15–16.

SIZE.—Length 0.67 mm.; hight 0.40 mm.; thickness 0.23 mm.; length of hinge line 0.65 mm.

Valves compressed, suboblong, slightly leperditoid in outline, the posterior end a little wider than the anterior; hinge line straight, nearly or quite as long as the greatest length of the valve, with the dorsal angles acute; beneath them the outline is nearly semicircular; ridge thin, almost marginal, strongest ventrally, wanting or scarcely distinguishable dorsally; surface smooth, nearly flat.

Two specimens only have been seen of this species. Both are figured, the one from Minneapolis on plate XLIII, the other, from Fountain, on plate XLVI. The latter is the larger of the two and differs from the other, which is to be regarded as the type, in several respects. Possibly it is distinct, but as it has evidently suffered from weathering or maceration, the differences may not be normal, hence I perfer for the present to classify it as an *imperfect* valve of *M. angularis.*

The almost flat, though thick-edged valves of this species, cannot be mistaken, so that comparisons are quite unnecessary.

Formation and locality.—Middle third (Rhinidictya bed) of the Trenton shales, Minneapolis, and near Fountain, Minnesota.

MOOREA PUNCTATA, *n. sp.*

PLATE XLIII, FIGS. 84–88.

SIZE.—Length 0.40 mm.; hight 0.24 mm.; thickness 0.18 mm.
Length 0.50 mm.; hight 0.32 mm.; thickness 0.22 mm.

Valves somewhat oblong-quadrate, the hinge nearly straight, about one-fifth shorter than the greatest length of the carapace; dorsal angles distinct; ends subequal; not strongly rounded, sometimes obliquely truncate above; marginal ridge developed along the anterior, ventral and posterior borders, thinnest and least prominent ventrally, thickest and somewhat club-shaped posteriorly, the ends terminating abruptly before reaching the dorsal angles; ridge usually continuous, but occasionally incomplete ventrally. Within the ridge the surface is flat and minutely punctate; above it descends abruptly to the hinge line.

A neat little species, reminding considerably of *Placentula excavata* Jones and Holl, and of species of *Bollia* like *B. vinei* J. and H., or *B. subæquata.* It is smaller than *Moorea angularis*, has less pronounced dorsal angles, a punctate surface, and different marginal ridge.

Formation and locality.—Upper third (Phylloporina bed) of the Trenton shales, St. Paul, Minnesota.

MOOREA ? PERPLEXA, *n. sp.*

PLATE XLVI, FIGS. 17 and 18.

SIZE.—Length 0.85 mm.; hight 0.62 mm..

The figures present such a remarkable valve that I am quite unable to account for its peculiarities. Unfortunately the original of the drawings, which were made four years ago, has been mislaid or lost, so that I am obliged to publish them without a final verification of the characters shown. It may really be a *Moorea*, but I doubt it. Or it may be related to *Placentula*. With more material its affinities may become clear, and it is the hope that collectors will search for and perhaps succeed in rediscovering the species, that has induced me to retain it in my report.

Formation and locality.—Middle third (Rhinidictya bed) of the Trenton shales, near Fountain, Minnesota.

Genus MACRONOTELLA, n. gen.

Carapace convex, semicircular or semiovate, with a long, nearly straight, hinge; valves equal, full centro-dorsally, without ridges or a sulcus, but exhibiting a smooth subcentral spot where the ornament is omitted; surface, in the only species known, coarsely punctate.

Type: *M. scofieldi*, n. sp.

I saw no way to escape the responsibility of erecting a new genus for the following species without forcing it into one of several that I am fully persuaded ought not to receive it. The long hinge, semicircular outline, and almost perfectly equal ends, rendering it difficult to distinguish one from the other, give it an expression peculiarly its own. *Kirkbya permiana* Jones, it is true, has a somewhat similar form, but like all the species of that genus, it has also a marginal ridge and a subcentral pit, neither of which are present in the species under consideration. Still, the smooth spot mentioned above probably represents the pit of *Kirkbya*, and it is with this genus that I think the affinities of *Macronotella* lie rather than with either *Aparchites* or *Isochilina*. The *Isochilina rectangularis* Ulrich (Jour. Cin. Soc. Nat. Hist., vol. 13, p. 182; 1890) from the Devonian at the falls of the Ohio, may be congeneric with *M. scofieldi*, there being some similarity in their outlines, but as the surface of the Devonian form is perfectly smooth and not inflated centro-dorsally, I hesitate to say it is.

MACRONOTELLA SCOFIELDI, *n. sp.*

PLATE XLIII, FIGS. 30–34.

SIZE.—Fig. 30. Length 1.57 mm.; hight 1.05 mm.; thickness 0.78 mm.
Fig. 33. Length 2.20 mm.; hight 1.33 mm.; thickness 1.05 mm.

Valves varying in length, semiovate or nearly semicircular, the dorsal outline not quite straight, being somewhat prominent centrally; free edges with a sharply impressed furrow, forming a beveled border; surface strongly convex, rather full in the centro-dorsal region, and marked, except on the ends and along the ventral border, by rather large and somewhat distant pits; a row of these pits, more closely arranged than usual, encircles a smooth subcentral spot.

Of the two specimens figured, the smaller is from Minnesota, the other from Kentucky. The latter, it will be observed, is not only larger, but also proportionally longer at the hinge line. The smooth spot, furthermore, is less centrally situated. I attach no importance to these differences, believing that they are quite within the ordinary limits of local, if not individual variation.

Named for Mr. W. H. Scofield, of Cannon Falls, Minnesota, to whom not only the author, but the Geological Survey of the state as a whole, is indebted for much valuable assistance. He has been particularly active in the development of the paleontology and stratigraphy of the Lower Silurian rocks of the state.

Formation and locality.—Lower Trenton limestone, near Cannon Falls, Minnesota; Birdseye limestone, High Bridge, Kentucky.

Family CYTHERELLIDÆ.

Genus CYTHERELLA, Jones and Bosquet.

Cytherella JONES, 1848, Subgenus of *Cythere;* Monog. Entom. Cret. Form., p. 28; BOSQUET, 1852, as a distinct genus; Desc. Entom. Foss. Terr. Tert., p. 10.
JONES and KIRKBY, 1867.
JONES, KIRKBY and BRADY, 1884. Monog. Carb. Etom., Pal. Soc. p. 70.

Carapace oblong or ovate, compressed, especially in front; smooth or pitted; valves thick and unequal, the right being much the larger and having its edge grooved or rabbeted all round on the inner side for the reception of the edge of the left valve; muscle-spot indicated by a roundish depression near the center of the valve externally, and by a corresponding thickening within. Length 0.5—1.4 mm.

Type: *Cytherella ovata* Rœmer sp.

This genus was founded upon Cretaceous, Tertiary and recent species, but no less than twenty Carboniferous forms, chiefly European, have been described as congeneric with the type by Jones, Kirkby, Brady and Ulrich. So far as their affinities may be determined from the carapace alone, the greater part if not all of

these appear to be within the limits of the genus. Prof. Jones has also referred several Lower and Upper Silurian species to the genus, but here, it seems to me, the generic relations are in every case at least doubtful. The following two species at any rate, are almost certainly not *Cytherella*, yet they must be placed here because their known characters are more in accordance with this genus than with any of the others that have been established.

At present the principal diagnostic feature of *Cytherella*, that is, with the paleontologist, is the rabbeted edge of the right valve. This peculiarity, if my memory is not at fault, has not yet been shown to exist in any of the Silurian species hitherto referred to the genus. It does however exist, and very strongly developed too, in an undescribed species from the lower beds of the Cincinnati group. In this species, however, unless all the specimens seen (about twenty) are of one valve only, the edges of *both* valves are about equally grooved.

For remarks on *Cytherellina*, Jones and Holl, see under *Bythocypris* and *B. cylindrica*.

CYTHERELLA ? SUBROTUNDA, *n. sp.*

PLATE XLIV, FIG. 43.

SIZE.—Length 0.5 mm.; hight 0.45 mm.

This species is founded upon a single carapace attached to the surface of a fragment of the zoarium of *Pachydictya foliata*. The smaller valve is exposed to view, and around it the overlapping edge of the larger, presumably the right valve, is distinctly defined. The outline is broad-oval, almost circular, and as near as can be determined, the surface of the smaller valve is moderately and quite uniformly convex, and exhibits neither a central depression, a tubercle, nor markings of any kind. The specimen was found in association with valves described on a preceding page as *Schmidtella? subrotunda*. They are distinguished by a small, subcentral tubercle, but as they have the same rounded outline, it is possible that a better preserved series of specimens may show them all to belong to one species. That the synonomy may, in case the possibility is converted into a fact, be simplified, I have used the same specific name for both.

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

CYTHERELLA? RUGOSA *Jones*, and var. ARCTA, *n. var.*

PLATE XLIII, FIGS. 21–25.

Cytheropsis rugosa JONES, 1858. Ann. Mag. Nat. Hist., ser. 3, vol. i, p. 254, pl. x, figs. 3 and 4; also 1858. Geol. Sur. Can., decade iii, p. 100.
Cytherella? rugosa JONES, 1891. Contri. Can. Micro.-Pal., pt. iii, p. 99.

SIZE.—Length 0.9 mm.; hight 0.58 mm.; thickness about 0.34 mm. Var. *arcta*, length 0.96 mm.; hight 0.53 mm. Prof. Jones' type specimen is said to be 0.83 mm. long, and 0.54 mm. high.

Carapace small, blunt at the ends; outline subreniform, rounded at both ends, the anterior one narrower than the other; of the upper and lower margins, one is nearly straight; the other strongly convex. Surface coarsely pitted, the pitting extending over all parts except a small spot situated, if we consider the straight margin as dorsal, beneath the center of the valves.

Fig. 25 represents a variety differing from the typical form in having the anterior end drawn out. It may be called variety *arcta*.

The generic position of this species is very doubtful. The typical form resembles *Aparchites minutissimus*, var. *trentonensis*, figured on the same plate, but the outline of var. *arcta* is much more like that of *Bythocypris cylindrica* Hall (see plate XLIV). It seems very doubtful to me that the species belongs to *Cytherella*, but as I am unable to suggest a better arrangement, I have adopted Prof. Jones' latest suggestion.

Formation and locality.—Top of the Galena shales (Nematopora bed), near Cannon Falls, Minnesota. Variety *arcta* is from the middle division of the Galena (Fusispira bed) near the same locality.

Family CYPRIDÆ.

Genus BYTHOCYPRIS, Brady.

Bythocypris, BRADY, 1880. Rept. Ostracoda, "Challenger," p. 45; JONES and KIRKBY, 1886, Ann. Mag. Nat. Hist., ser. 5, vol. xviii, p. 250; also 1887, Proc. Geologist Assoc., vol. ix, p. 510; JONES, 1887, Ann. Mag. Nat. Hist., ser. 5, vol. xix, p. 184; ULRICH, 1890, Jour. Cin. Soc. Nat. Hist., vol. xiii, p. 196.

Carapace smooth, more or less reniform; left valve larger than the right, overlapping it on both the dorsal and ventral margins; dorsal margin strongly convex, ventral margin usually straight or slightly concave.

This is a recent genus into which a number of Paleozic Ostracoda have been placed by Prof. T. Rupert Jones and others. Whether this extension of the genus is justified or not, I am unprepared to say. It seems to me, however, that some of the species might with equal propriety be referred to other genera of the marine *Cypridæ*. But as I have not given the subject the thought and time which its great difficulty necessitates, my present judgment can have little value when opposed to that of Prof. Jones.

Respecting the species about to be described and those which I have in previous papers referred to *Bythocypris*, it is sufficient to say that in nearly every instance they agree closely with one or another of the species which Prof. Jones has placed under the genus.

It may be well to call attention to the fact that the Silurian genus *Cytherellina*, Jones and Holl,* is founded upon species very similar externally to some of the Silurian *Bythocyprides*. Whether any of the latter have the obscure internal thickenings of the test which are said to characterize *Cytherellina* is unknown, but considering the similarity of their external features, it seems a little strange that Prof. Jones has not remarked upon it in his more recent writings.

BYTHOCYPRIS CYLINDRICA *Hall.*

PLATE XLIV, FIGS. 29–35.

Leperditia (Isochilina) cylindrica HALL, 1872, Twenty-fourth Rep. St. Cab. N. Y., p. 231, pl. VIII, fig. 12; HALL and WHITFIELD, 1875, Pal. Ohio, vol. ii, p. 101, pl. IV, fig. 5. (Figured in reversed position.)
Isochilina cylindrica MILLER, 1875. Cin. Quart. Jour. Sci., vol ii, p. 351.
Bythocypris cylindrica ULRICH, 1889. Contri. Can. Micro.-Pal., p. 2, p. 48. (Not pl. IX, fig. 6.)
Primitia minuta (part.) (EICHWALD) JONES, 1890. Quart. Jour. Geol. Soc., vol. xvi, p. 7, pl. III, figs. 18 and 19; not figs. 21–23.

SIZE.—Length 1.30 mm.; hight 0.65 mm.; thickness 0.5 mm.
Length 0.71 mm.; hight 0.32 mm.; thickness 0.23 mm.

As the characters of this species have been quite generally misinterpreted, I have taken the trouble to illustrate them as far as shown in three typical examples. Of the two series of measurements given above, the first may be regarded as a fair average for fully grown specimens, while the other is taken from one of the smallest seen. The length usually varies between 1.0 and 1.2 mm., and occasionally it reaches 1.5 mm. Figures 29, 32 and 34, though differing as much in their outlines as any in hundreds of valves, are but little unlike each other, and thus prove, in this respect at any rate, the constancy of the species. The greatest variability noticed is a slight one in the relative degree in which the central third of the ventral slope is flattened or hollowed out. It is never much, yet always distinguishable. The valves are slightly unequal, the left, being the larger, overlapping the right on both the dorsal and ventral margins.

On the inner side of the valves (fig. 32) a subcentral thickening of the test is noticeable. Though slight, it covers considerable space, especially in its vertical extent, and is of such a nature that it would cause a shallow vertical furrow on casts

* Ann. Mag. Nat. Hist., ser. 4, vol. iii, 1869. In this paper the authors redescribe the type species, *siliqua*, which Jones had in 1855 described from casts of the interior as a *Beyrichia*, and the new varieties *grandis*, *tersa* and *ovata*. The last is similar to *Bythocypris curta* of this report, but is not so equilateral, having the anterior end more produced; while the typical form of *C. siliqua* greatly resembles *B. cylindrica* Hall, sp.

of the interior. This internal thickening recalls *Cytherellina siliqua* Jones, which this species also resembles in its external characters, but the casts of that species are marked with two sulci instead of one. Still, I am not all satisfied that these two forms are not strictly congeneric. The sulcus in the casts of *B. cylindrica* being just behind the center, it corresponds with the posterior one of the two in the *Cytherellina*. As to the anterior one, would its absence be of any great consequence? While it does not seem to me now that it would be, it is deemed wisest to defer a decision on the point, since the verdict would necessarily involve many others of the paleozoic species now referred to *Bythocypris*. Of the latter, *B. testacella* Jones, from the Wenlock of England, differs chiefly in being more elongate and less broadly rounded posteriorly.

In the Canadian publication above cited, I referred a valve from the Hudson River group of Manitoba, to this species. That the identification was incorrect, I am now fully convinced. The figure, which was probably drawn in a reversed position, shows a left valve, agreeing very closely with the Wenlock species *B. concinna* Jones. Perhaps it should be referred to that species, but it would be well to await the discovery of more conclusive evidence before such a course is finally decided upon.

It is scarcely necessary to show why *B. cylindrica* is neither a *Primitia* nor a *Leperditia*. As to its identity with Eichwald's *Cypridina*, later *Leperditia minuta*, which Prof. Jones refers to *Primitia* (*loc. cit.*) and I to the new genus *Primitiella*, is a question that it seems to me can be answered only in the negative. The *minuta*, as figured by Prof. Jones from Russian examples of the species, has dorsal angles with a long straight back, giving it on the whole a decided primitian aspect, which certainly is not the case with the true *B. cylindrica*. In the same paper Prof. Jones figures two Cincinnati specimens, presumably of the latter species, to show their similarity or identity with the Russian *P. minuta*. He represents them as having a straight hinge and obtuse dorsal angles, the valves being figured, according to my interpretation, in a reversed position. As to these features I can only say that I have never seen any specimen in which they were present; and this can scarcely be because of a lack of material, for, of all the Cincinnati Ostracoda, *B. cylindrica* is by far the most abundant. Prof. Jones' figures being like Hall's figure of the species, is it not possible that the drawing of the former was biased by an examination of the latter?

Formation and locality.—Rare in the Galena shales near Cannon Falls, Minnesota. Very abundant in the lower beds of the Cincinnati group, at numerous points in the vicinity of Cincinnati, Ohio. Very large specimens, 2.0 mm. and more in length, occur in the upper beds of the same formation. These were referred to the species by Dr. S. A. Miller, but are not taken into account here because they are probably distinct.

BYTHOCYPRIS (?) CURTA, *n. sp.*

PLATE XLIV, FIGS. 36–38.

SIZE.—Length 1.03 mm.; hight 0.75 mm.; thickness 0.48 mm. A larger specimen has a length of about 1.5 mm.

This is an unusually short, subovate form, the ends being nearly equal and, with the dorsal margin, forming an almost regular elliptic curve; ventral outline straight centrally; surface smooth; valves moderately and uniformly convex, one larger and strongly overlapping the other above, below and at one end. The end having no overlap is slightly narrower than the other.

The subequality of the ends, especially as regards thickness, makes it difficult if not impossible to determine with certainty which is the right and which the left valve. As a *Bythocypris* the larger of the two must be on the left side, and if this is correct for the species, then the blunter of the two ends would be the anterior. In *Macrocypris*, a genus containing mostly elongate species, the right valve overlaps, but the carapace in the present species is too short for that genus. Of known species *B. ovata* Jones and Holl, a Wenlock form originally described as a variety of *Cytherellina siliqua*,* may be nearest, but differs like all other species of *Bythocypris* in being longer.

Formation and locality.—Middle third (Rhinidictya bed) of the Trenton shales, St. Paul, Minnesota.

BYTHOCYPRIS GRANTI, *n. sp.*

PLATE XLIV, FIGS. 39–42.

SIZE.—Length 1.40 mm.; hight 0.68 mm.; thickness 0.7 mm.
Length 1.17 mm.; hight 0.57 mm.; thickness 0.6 mm.

Valves strongly convex, especially so ventrally, somewhat elongate elliptical in outline, the ventral margin convex but not so much as the dorsal, the ends subequally rounded but with the posterior one a little blunter than the anterior; surface smooth.

This species is readily distinguished from *B. cylindrica* Hall, by its more equal ends and convex basal outline. It seems to be closely related to *B. concinna* Jones, of the Wenlock shales of England, but the outline is a little different and the valves thicker in the ventral part. The left valves of *Krausella inæqualis* and *K. arcuata* are somewhat similar yet not enough so to render confusion between them at all likely.

The species is named for the promising geologist, Dr. Ulysses S. Grant, of the Geological Survey of Minnesota.

Formation and locality.—Middle third (Rhinidictya bed) of the Trenton shales, St. Paul and Minneapolis, Minnesota.

*Ann. Mag. Nat. Hist., ser. 4, vol. iii, pl. XIV, fig. 4; 1869.

BYTHOCYPRIS (?) ROBUSTA, *n. sp.*

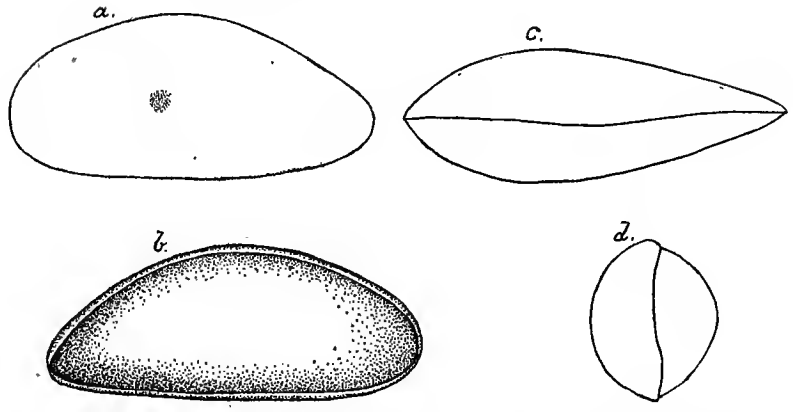

Fig. 52.—*a*, a left valve, with somewhat blunter ends than usual, showing position of subcentral spot; *b*, right side of entire carapace; *c* and *d*, ventral and posterior outline views of same; lower Trenton ("Lower Blue limestone"), Dixon, Illinois.

SIZE.—Length 2.5 mm.; hight 1.05 mm.; thickness 0.87 mm.

Carapace elongate, subelliptical or obscurely triangular, the outline convex dorsally and nearly straight or gently arcuate ventrally; anterior end strongly rounded and somewhat higher (blunter) than the posterior. In a ventral view the outline is wedge-shaped, the higher or anterior end being much more attenuate than the other. Valves rather strongly convex, unequal, the left overlapping the right all around except at the posterior extremity; dorsal edge of left valve somewhat thickened; posterior extremity of right (smaller) valve subacute; surface smooth; each valve occasionally showing a small discolored spot a short distance in front of the center.

The affinities of this fine species are doubtful. It is not a true *Bythocypris*, nor is it any more like either *Macrocypris* or *Pontocypris*. Perhaps it should be placed under *Bairdia* since it resembles certain species that have been referred to that genus by Jones and Holl. Yet, after a careful comparison with numerous Devonian and Carboniferous species of *Bairdia*, I have come to doubt the propriety of recognizing that genus in any of the known Lower Silurian species. The acuminate posterior extremity of the right valve reminds as much of the new genus *Krausella*, and it is an alliance with this genus that I would favor more than with *Bairdia*.

Specifically, *B.? robusta* will be distinguished at once from all known Lower Silurian *Cypridæ* by its large size.

Formation and locality.—Lower Trenton limestone, Dixon, Illinois, where it was found abundantly in association with *Krausella inæqualis* and *Schmidtella crassimarginata*.

Family BEECHERELLIDÆ.

Genus KRAUSELLA, n. gen.

Carapace small (1.5 to 2.5 mm. in length), somewhat elongate, subelliptical, obscurely triangular or semiovate in outline, the dorsal margin more convex than the ventral, the latter straight or but gently convex; with moderately thick and very unequal valves; right valve the smaller, drawn out posteriorly into a strong spine-like process; left valve overlapping the right all around.

Type: *Krausella inæqualis*, n. sp.

At present I am acquainted with only four species that should be placed in this genus, viz.: the two about to be described, *Bairdia anticostiensis* Jones (Quart. Jour. Geol. Soc., vol. xlvi, p. 548; 1890) from the Hudson River or Cincinnati formation of the island of Anticosti, and an undescribed form (near *K. arcuata*) which is rarely met with in the upper beds of the same formation in Ohio and Indiana. These species do not agree with *Bairdia* since the spine-like process is not formed by the tapering ends of *both* valves, but is restricted to the right valve, the left valve being rounded posteriorly and resembling the corresponding valve of a thick-shelled *Bythocypris*. We have therefore the difference that while the two valves of a *Bairdia* are similar in outline, they are quite different posteriorly in *Krausella*.

The spine-like process reminds of some of the species placed by the author under his genus *Beecherella*.* If there is any true relationship between *Krausella* and *Beecherella*, and I confess that I am strongly inclined to believe there is, then the *Beecherellas* were probably all described and figured in a reversed position. Another thing that has become more evident than formerly is that more than one generic type has been included under *Beecherella*. Considering the strongly marked peculiarities of the type species, *B. carinata*, it seems probable that we shall eventually find it desirable to restrict the genus to it.

Of *B. subtumida* we know only the right valve, and this is exceedingly like the same valve of *Krausella arcuata*. Still, I hesitate to say that it should be referred to the present genus since it may be shown that it, like *B. cristata*, has the posterior spine on the overlapping instead of the smaller valve. In the last species namely, the right valve seems to overlap the left, though the overlap is very slight and scarcely distinguishable. Should the relations of the valves (with respect to overlap) in these two species prove to be really the reverse of what we know to be the case in *Krausella*, a distinct generic grouping for them would probably be justifiable.

* American Geologist, vol. viii, pp. 197-204, pl. 2, October, 1891. In this paper the author describes the new genus *Beecherella*, with six new species and one variety, all derived from the Lower Helderberg strata of New York.

Beecherella ovata is too imperfectly known to be referred to any genus definitely, but *B. navicula* and *B. angularis* are generically distinct from *B. carinata* as well as from *B. subtumida* and the species of *Krausella.* Leaving out *B. ovata.* we have then at least three and probably four, more or less closely related generic groups, which it seems to me may be justly referred to collectively as the *Beecherellidæ.*

KRAUSELLA INÆQUALIS, *n. sp.*

PLATE XLIV, FIGS. 44–46.

SIZE.—Length 2.3 mm.; hight 1.17 mm.; thickness 0.8 mm.

Carapace elongate-subelliptical, the ventral outline longer and straighter than the dorsal, the ends, excluding the posterior spine, subequal and most prominent in the lower half; outline in a ventral view elongate rhomboidal, in an end view subtriangular, the lower part being very thick. Valves thick, very unequal, the larger (left) strongly overlapping the other; basally the left valve turns inward abruptly, causing a decided flattening of the ventral edge; right valve moderately convex, with the dorsal and ventral margins subparallel, the dorsal edge being less curved than in the left valve; behind it is drawn out into a strong blunt spine-like process, the point of which extends a short distance beyond the edge of the opposite valve. Surface of valves without markings of any kind so far as observed.

This is a well marked species, distinguished chiefly by the great ventral thickness and relatively high position of the posterior spine. The latter may be a little lower and the dorsal outline somewhat more convex than in the specimen illustrated on plate XLIV. The inequality of the two valves is so great that, unless found in their natural position, they would scarcely be suspected of belonging together.

Formation and locality.—Lower Trenton limestone, Dixon, Illinois. (Stone's River group, Vanuxemia bed).

KRAUSELLA ARCUATA, *n. sp.*

PLATE XLIV, FIGS. 47–53.

SIZE.—Length 1.9 mm.; hight 0.82 mm.; thickness about 0.58 mm.
Length 1.7 mm.; hight 0.70 mm.
Length 1.8 mm.; hight 0.70 mm.

In this species the outline is nearly semicircular or semielliptical, the basal line being straighter and the dorsal margin more arcuate than in *K. inæqualis.* The posterior spine also is more slender and situated lower, the point in some instances being almost on a line with the ventral edge of the right valve. Finally, the left valve is more uniformly convex, the upper half of the surface being fuller, while the

ventral portion is much less prominent. Of all these differences the most striking and perhaps the only important one is the last.

Bairdia, or as it should now be called, *Krausella anticostiensis* Jones, sp., is represented as having a much blunter anterior outline, but in the Cincinnati formation of Ohio and Indiana we have a species that comes much nearer, the anterior end of the right valve being quite as narrow, only the most prominent point is higher.

Formation and locality.—Lower third of the Trenton shales, Minneapolis, Minnesota; lower Trenton limestone, Mineral Point, Wisconsin, and Dixon, Illinois; Birdseye limestone, High Bridge, Kentucky.

PLATE XLIII.

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

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PLATE XLIII.—*Continued.*

PAGE.

Figs. 48 to 52. PRIMITIELLA CONSTRICTA, n. gen. et sp. 647
48 and 49. Three views of a right valve; from the base of the Birdseye limestone at High Bridge, Kentucky. In this form the anterior end is rounded and the border scarcely developed.
50. Two views of a right valve, representing the prevailing form of the species in Minnesota.
51 and 52. Lateral and dorsal views of a longer right valve, from the lower third of the Trenton shales at Minneapolis, on which a small raised spot, situated just behind the center of the valve, is barely distinguishable.

Figs. 53 to 56. PRIMITIELLA LIMBATA, n. sp. 648
53. Interior of a right valve.
54. Anterior and lateral views of another right valve.
55 and 56. Lateral and dorsal views of a left valve. Lower third of the Trenton shales, Minneapolis, Minn.

Figs. 57 to 59. PRIMITIA GIBBERA, n. sp. 655
Three views of a left valve. Hudson River shales, near Spring Valley, Minnesota.

Figs. 60 to 61. PRIMITIA DUPLICATA, n. sp. 654
Lateral and ventral views of a left valve. Middle third of the Trenton shales, Minneapolis, Minn.

Figs. 62 to 65. PRIMITIA TUMIDULA, n. sp. 655
62 to 64. Three views of the exterior of a left valve, obtained by an impression in gutta percha from a natural mold. Hudson River shales, near Spring Valley, Minn.
65. Cast of the interior of another left valve, from the same locality.

Fig. 66. PRIMITIA UPHAMI, n. sp. 651
Three views of a right valve. Galena shales, Cannon Falls, Minnesota.

Figs. 67 and 68. PRIMITIA CELATA, n. sp. 653
The exterior and a ventral view of a right valve. Middle third of the Trenton shales, Minneapolis, Minn.

Figs. 69 to 72. PRIMITIA MICULA, n. sp. 653
69 to 71. Three views of a right valve. Galena shales, near Cannon Falls, Minnesota.
72. Interior of a left valve, from the same locality, supposed to belong to this species. The outline is somewhat different from the preceding, but there is reason to believe that the valve is imperfect at the antero-ventral margin.

Figs. 73 and 74. PRIMITIA SANCTI PAULI, n. sp. 652
Two views of a right valve. Upper third of the Trenton shales, St. Paul, Minn.

Figs. 75 to 77. PRIMITIELLA UNICORNIS Ulrich. 649
Three views of a right valve, from the lower or Utica horizon of the Cincinnati group at Covington, Kentucky. The specimen is one of the original types of the species.

Figs. 78 to 81. PRIMITIA MAMMATA, n. sp. 652
Dorsal, lateral and ventral views of a right valve. Lower third of the Trenton shales, Minneapolis, Minn.

Figs. 82 and 83. BEYRICHIA INITIALIS, n. sp. 658
Lateral and ventral views of a left valve. Middle third of the Trenton shales, Minneapolis.

Figs. 84 to 88. MOOREA PUNCTATA, n. sp. 682
84. A right valve.
85 to 87. Three views of a left valve.
88. Another left valve in which the marginal ridge is twice interrupted along the ventral border. Upper third of the Trenton shales, St. Paul, Minnesota.

Fig. 89. MOOREA ANGULARIS, n. sp. 682
(See also plate XLVI, figs. 15 and 16.)
Side and ventral views of a right valve. Middle third of the Trenton shales, Minneapolis, Minn.

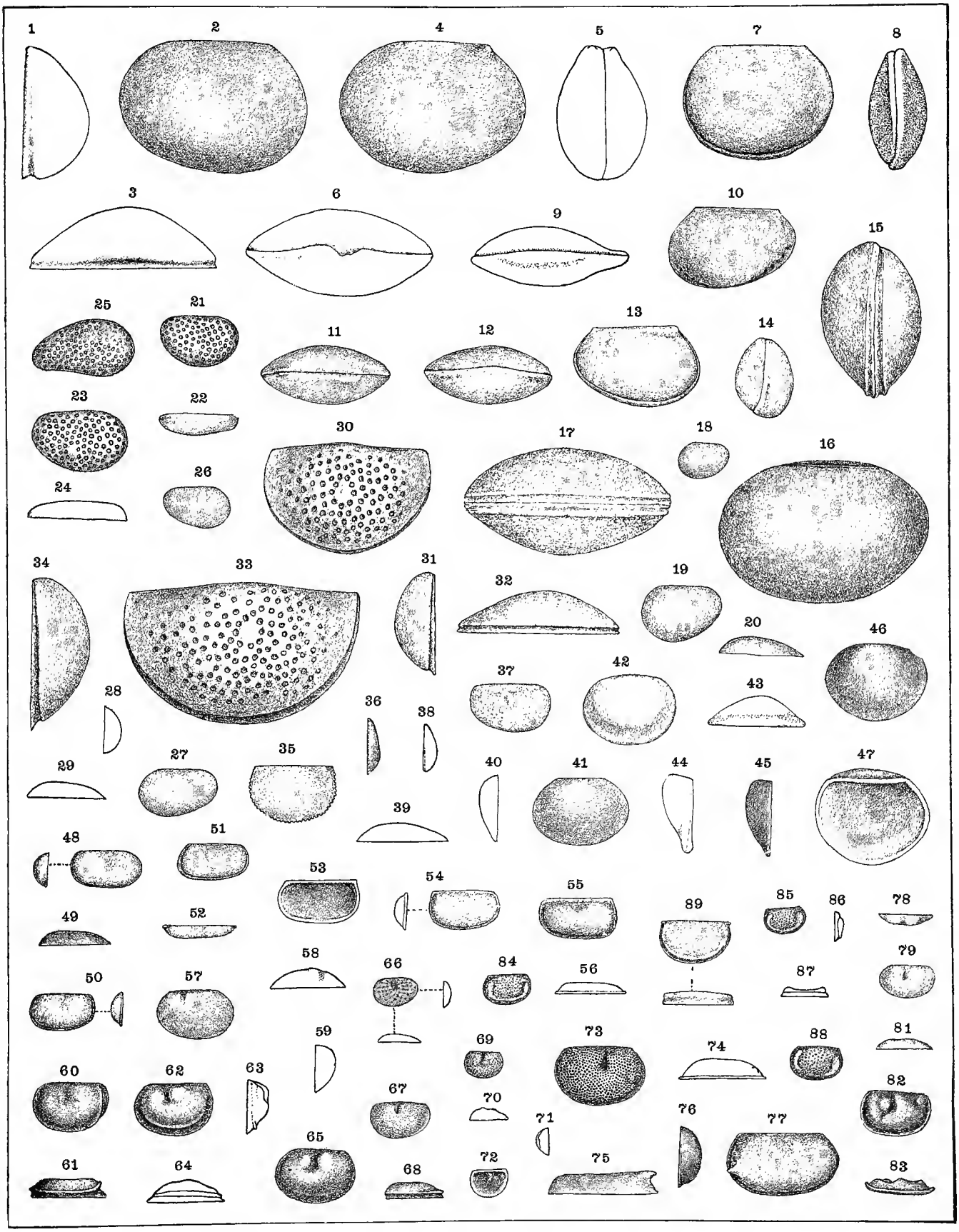
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PLATE XLIV.

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

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Fig. 1. EURYCHILINA RETICULATA Ulrich..... 660
A perfect left valve of this species. Lower third of the Trenton shales, Fillmore county, Minnesota.

Fig. 2. EURYCHILINA RETICULATA, var. INCURVA, n. var..... 660
Left valve from the upper third of the Trenton shales at St. Paul, Minnesota.

Figs. 3 and 4. EURYCHILINA SUBRADIATA Ulrich..... 661
3. Interior of a perfect right valve.
4. Nearly perfect left valve, showing the usual characters of the species as it occurs in Minnesota.
4*a*. Section of same across central portion of valve.
Lower third of the Trenton shales, Minneapolis, Minn.

Figs. 5 to 7. EURYCHILINA (?) SYMMETRICA, n. sp..... 663
(See also plate XLV, figs. 4–6.)
5. Interior of a right valve.
6 and 7. Exterior and anterior views of a more elongate left (?) valve.
Upper third of the Trenton shales, St. Paul, Minn.

Figs. 8 to 11. CTENOBOLBINA FULCRATA, n. sp..... 674
8 and 9. Lateral and posterior views of a left valve, presenting the usual characters of the species.
10 and 11. Lateral and dorsal views of a right valve, resembling in certain respects the next species.
Upper third of the Trenton shales, St. Paul, Minnesota.

Figs. 12 to 16. CTENOBOLBINA CRASSA Ulrich..... 675
12 to 14. Lateral, posterior, and dorsal views of a left valve. This is the original type of the species. Upper third of the Trenton shales, St Paul, Minnesota.
15 to 16. Lateral and posterior views of another left valve from the same locality, differing in several respects from the type.

Figs. 17 to 19. JONESELLA OBSCURA, n. sp..... 668
Left and right valves and an interior view of the first. The "horseshoe" ridge is very obscure in its lower curved part. Galena shales, Cannon Falls, Minn.

Figs. 20 to 22. DREPANELLA BIGENERIS, n. sp..... 672
20 and 21. Side and posterior views of a left valve. Lower Trenton limestone, Minneapolis, Minnesota.
22. Longitudinal sectional view across the central part of the same.

Fig. 23. DICRANELLA SPINOSA, n. sp..... 665
(See also plate XLVI, fig. 41.)
A left valve of this species. Middle third of the Trenton shales, Minneapolis, Minnesota.

Figs. 24 and 25. DICRANELLA (?) SIMPLEX, n. sp..... 666
(See also plate XLVI, fig. 42.)
Lateral and posterior views of a left valve. Galena shales, Cannon Falls, Minn. In fig. 24 the oblique spine on the left side of the center appears scarcely prominent enough.

Fig. 26. DICRANELLA BICORNIS, n. gen. et sp..... 665
(See also plate XLVI, figs. 39 and 40,)
A right valve wanting only the posterior part of the marginal frill. Middle third of the Trenton shales, Minneapolis, Minnesota.

Figs. 27 and 28. DICRANELLA MARGINATA, n. sp..... 666
Lateral and posterior views of a right valve. Trenton shales, near Fountain, Minnesota.

Figs. 29 to 35. BYTHOCYPRIS CYLINDRICA Hall, sp..... 687
29 to 31. The left side, dorsal, and posterior views of an average example of this species. Lower beds of the Cincinnati group, Cincinnati, Ohio.
32. View of the interior of a right valve, showing a slight central thickening of the test. From the same locality.
33. Ventral view of a complete carapace; also from Cincinnati, Ohio.
34 and 35. Lateral and dorsal views of a small right valve, which is also a little narrower than usual. Galena shales, Cannon Falls, Minn.

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PLATE XLIV. – *Continued.*

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Figs. 36 to 38. BYTHOCYPRIS (?) CURTA, n. sp. 689
Lateral, ventral, and anterior views of a rather small specimen. Middle third of the Trenton shales, St. Paul, Minnesota.

Figs. 39 to 42. BYTHOCYPRIS GRANTI, n. sp. 689
39. A large left valve. Middle third of the Trenton shales, St. Paul, Minnesota.
40 to 42. Lateral, anterior and ventral views of a smaller right valve, from the same locality.

Fig. 43. CYTHERELLA (?) SUBROTUNDA, n. sp. 685
The left side of the complete carapace upon which the species is founded. Lower third of the Trenton shales, Minneapolis, Minnesota.

Figs. 44 to 46. KRAUSELLA INÆQUALIS, n. gen. et sp. 692
Three views of an entire carapace. Lower Trenton limestone, Dixon, Illinois.

Figs. 47 to 53. KRAUSELLA ARCUATA, n. sp. 692
47 to 49. Three views of the smaller (right) valve. Birdseye limestone, High Bridge, Kentucky. Relatively higher than the northwestern specimens.
50. Right valve from the lower third of the Trenton shales at Minneapolis, Minn.
51 and 52. Lateral and ventral views of another right valve. Lower Trenton limestone, Mineral Point, Wisconsin.
53. View of the interior of a left valve. Also a vertical section through center of same. High Bridge, Kentucky.

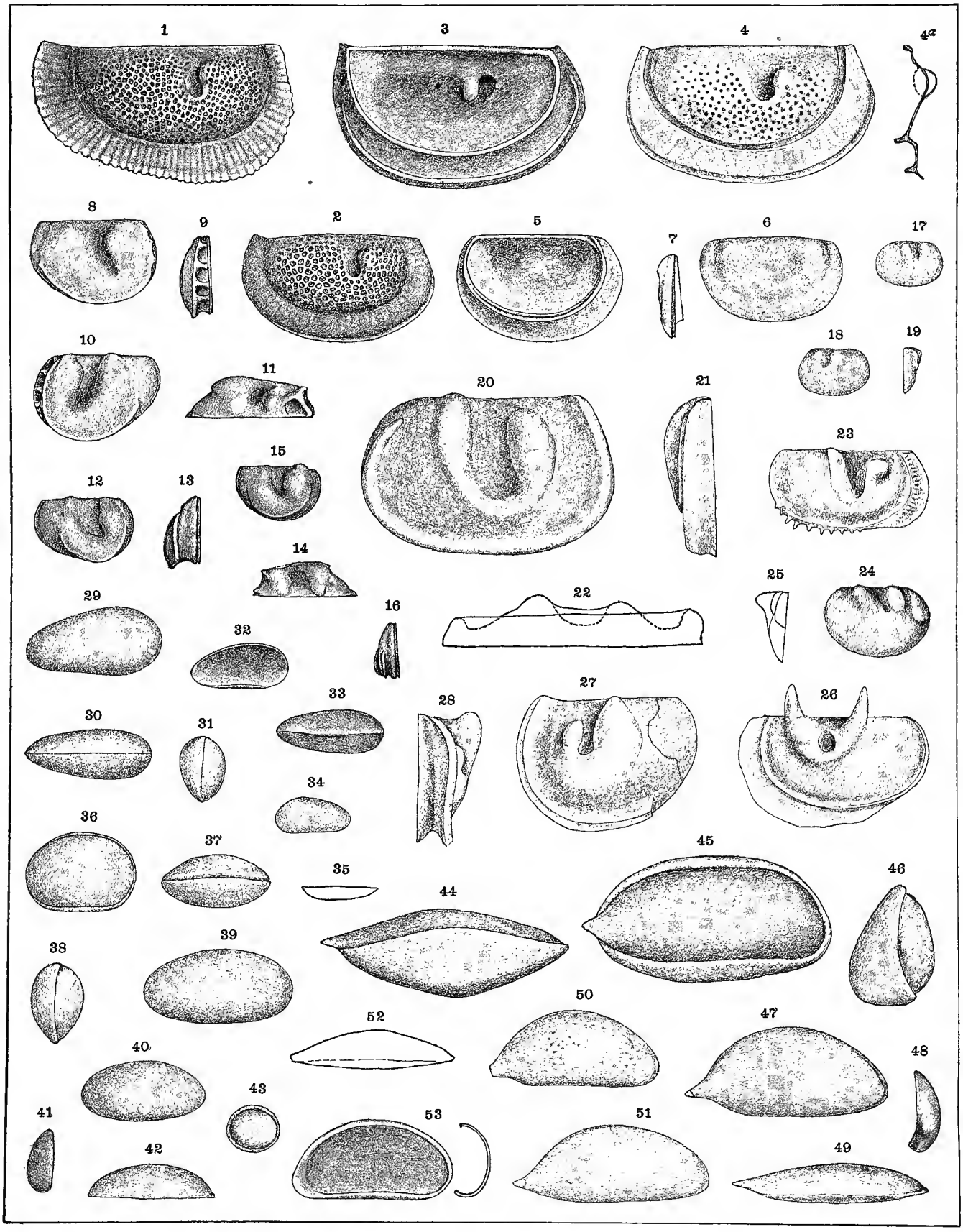
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PLATE XLV.

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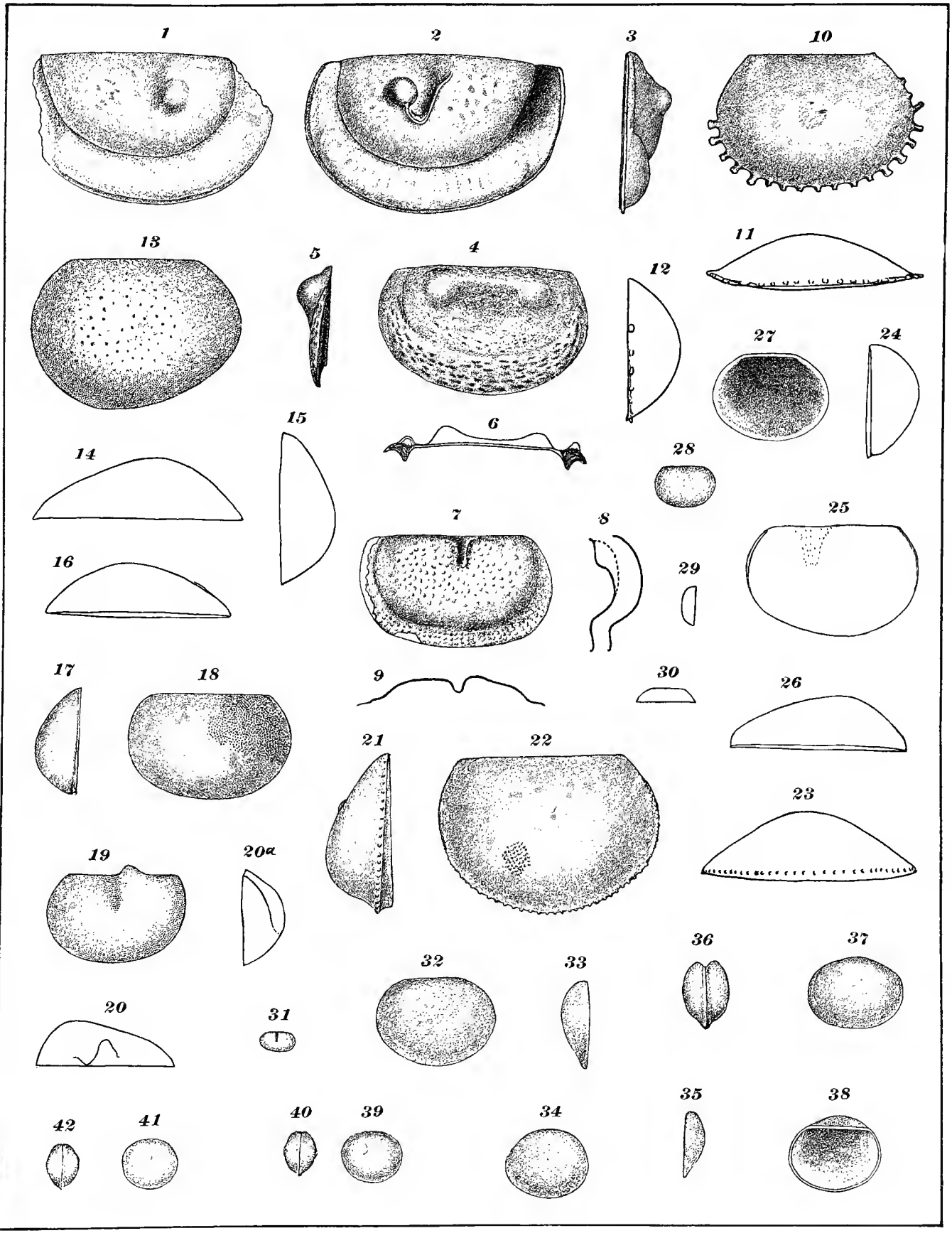
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PLATE XLVI.

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

PAGE.

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

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

4. Another right valve. Birdseye limestone, High Bridge, Kentucky.

5. Inner side of a right valve. Minneapolis.

6 to 8. Three views of a left valve, differing from the usual form in unimportant particulars. Minneapolis.

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

Figs. 12 to 14. TETRADELLA LUNATIFERA Ulrich 680

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

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

(See also plate XLIII, fig. 89)

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

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

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

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

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

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

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

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

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

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

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

28. A small valve from the same locality.

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

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

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

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

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

36 and 38. Ventral and posterior views of a left valve.

37. Interior of a right valve.

Upper third of the Trenton shales, St. Paul, Minnesota.

Figs. 39 and 40. DICRANELLA BICORNIS, n. gen. et. sp. 665

(See also plate XLIV, fig. 26.)

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

Fig. 41. DICRANELLA SPINOSA, n. sp. 665

(See also plate XLIV, fig. 23.)

Posterior view of a left valve.

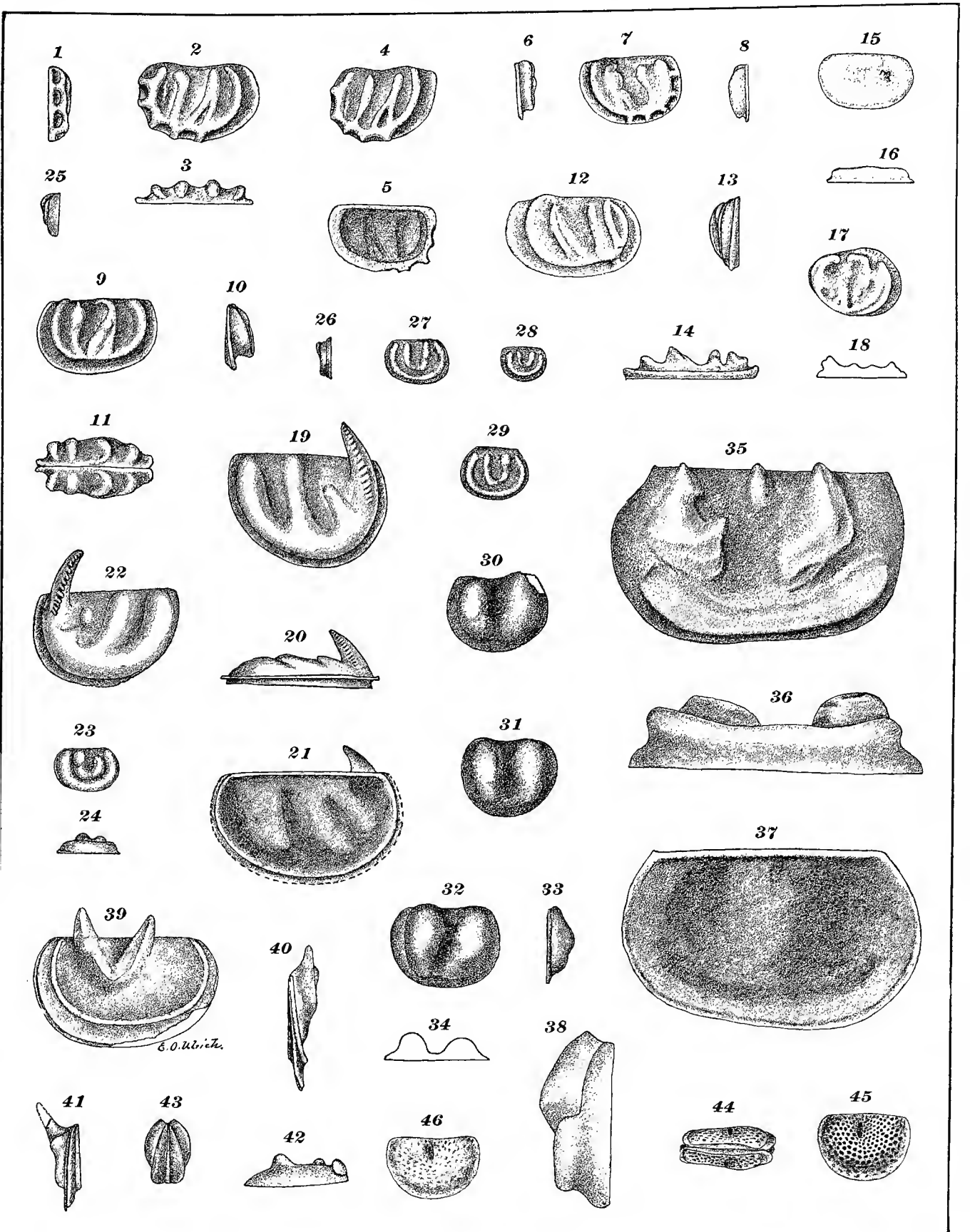
Fig. 42. DICRANELLA (?) SIMPLEX, n. sp. 666

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

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

43 to 45. Anterior, dorsal, and left side views of an entire carapace. Galena shales near Cannon Falls, Minnesota.

46. Somewhat weathered and relatively longer left valve: from the same locality.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E.O.Ulrich.