

NEW AMERICAN PALEOZOIC OSTRACODA.

PRELIMINARY REVISION OF THE BEYRICHIIDÆ, WITH
DESCRIPTIONS OF NEW GENERA.^a

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INTRODUCTION.

As defined in modern text-books, the Paleozoic family of Ostracoda, Beyrichiidae, embraces a large and constantly growing assemblage of genera and species. The unwieldiness of the typical genus *Beyrichia* became apparent some forty years ago, when T. Rupert Jones, the well-known and highly conservative English authority, and H. B. Holl first suggested the separation of the "simplices" as a distinct generic group under the name *Primitia*.^b At a later date these authors proposed the separation of the less sharply defined "Corrugata" group, typified by *Beyrichia wilckensiana*, under the name *Kladowia*.^c In the same paper they propose the genus *Bollia*.^d and in the next succeeding number of that periodical two other generic groups are distinguished as *Strepula*^e and *Placentula*.^f

Working independently, Jones had also instituted the genus *Kirkbya*^g for a Permian species thought to have relations to the Bey-

^a For previous articles of this series see Jour. Cincinnati Soc. Nat. Hist., XIX, 1900, pp. 179-185, and Proc. U. S. Nat. Mus., XXX, No. 1446, 1906, pp. 149-164, pl. xi.

^b Ann. and Mag. Nat. Hist. (3), XVI, 1865, p. 415.

In 1855 (Ann. and Mag. Nat. Hist. (2), XVI, p. 85), Jones divided *Beyrichia*, as then defined by him, into three groups, (1) "simplices," including the forms subsequently referred to *Primitia* and allied genera; (2) "Corrugatae," with *B. wilckensiana* as the type of the group, and (3) "Jugosae," including, besides *B. Kladowi*, the type of the genus, also certain Ordovician species subsequently referred to *Tetradelta* and *Ctenobolbina* by Ulrich.

^c Ann. and Mag. Nat. Hist. (5), XVII, pp. 347, 362.

^d Idem, p. 360.

^e Idem, p. 403.

^f Idem, p. 407.

^g Trans. Tyneside Nat. Field Club, IV, 1859, pp. 129, 134, 136.

richiidae. Later, in their papers on Carboniferous and Permian Ostracoda, Jones and Kirkby, while maintaining that *Beyrichia* is the genus under which the majority of the late Paleozoic species with grooved or sulcate valves should be placed, yet thought it necessary to distinguish, first the two groups *Beyrichiella* and *Beyrichiopsis*,^a and a few years later *Synophe*.^b Finally, Jones separated the binodose Primitiæ from the more simple types, as *Ulrichia*,^c and the most simple, nonsulcate types, as *Aparchites*.^d

In 1890 the senior author of the present paper published the first results of investigations begun in the hope that they might end in a complete revision of the American Paleozoic Ostracoda. For various reasons the realization of this hope has been greatly delayed, and seems yet far in the future. In the first place the effort to procure material for study proved so overwhelmingly successful that the task assumed proportions quite beyond expectations. The unusual difficulty of the subject was recognized in the beginning, but with this unsuspected expansion of the material its difficulties seemed to grow greater and greater, while the mere description of the new and the revision of the old species has itself become a formidable piece of work. Another distressing obstacle was the necessity of finding some more accurate and satisfactory yet cheap method of illustration than had been employed hitherto. After long experimentation the writers believe they have finally solved the problem to the extent of offering at least serviceable if not uniformly artistic representations of the objects. However, these difficulties might all have been overcome long before this had not other more imperative duties consumed by far the greater part of the time that has elapsed since 1890. With this unavoidable drawback even future progress on the monographical treatment of the Paleozoic Ostracoda must necessarily continue to be somewhat sporadic.

In the first of Ulrich's papers on Ostracoda^e six new genera of Beyrichiidae were proposed. All of these, except *Jonesella*, were based on or include species previously referred to either *Beyrichia* or *Primitia*. Thus *Tetradella* was proposed for the *B. complicata* group, *Ceratopsis* for the horned but otherwise similar group typified by *B. chambersi*, *Ctenobolbina* for the *B. ciliata* group, *Drepanella* for a mostly undescribed section, but including *B. richardsoni*, and *Eurychilina* likewise for a largely undescribed group that was thought to

^a Geol. Mag., 3d Dec., III, 1886, pp. 434, 438.

^b Carboniferous Ostracoda from Ireland, Sci. Trans. Roy. Dublin Soc. (2), VI, 1896, p. 190.

^c Quart. Journ. Geol. Soc. London, XLVI, 1890, p. 543.

^d Ann. and Mag. Nat. Hist. (6), III, 1889, p. 381.

^e New and Little Known American Paleozoic Ostracoda, Journ. Cincinnati Soc. Nat. Hist., XIX, 1890-91, pp. 104-137, 173-211.

include at least one or two of the broadly margined Primitiæ. In a later publication^a two other simple Beyrichian genera were introduced, namely, *Primitiella* and *Halliella*, both founded on groups of species previously referred to *Primitia*. In the same work two somewhat aberrant Primitian genera, *Dilobella* and *Dicranella*, were also described.

Except *Synaphe*, all of these twenty-one genera have turned out to be reasonably natural generic groupings of the species previously, and in most part since, referred to the Beyrichiida. With the recent multiplication of species through the discovery of new forms, it happens, as might be expected, that many of the species referred to the new genera, in the perhaps pardonable wish to emphasize the importance of the latter, now appear to belong to other not less well defined groups whose discrimination seems equally essential in an adequate classification of the wealth of specific forms now known. Because of the small range of diagnostic characters furnished by the shells, and more the inconstancy of these characters when a great group like Jones's Beyrichiida is considered, it is impossible to formulate a broad family definition without going into undesirable detail. In the classification of living Ostracoda the family groups are based on anatomical modifications, the shells being scarcely considered. In fossil forms, obviously, the systematist is limited to modifications of the carapace. While the paleontologist's classification is, therefore, liable to grave misassociations, it should be remembered that the results of his efforts may be the best obtainable with the criteria available to him.

After a considerable study of living Ostracoda, the writers have been forced to the conviction that students of fossil species, especially those found in Paleozoic rocks, can not expect much help in their labors from even an extensive knowledge of living forms. The Cypridæ, even, which family, perhaps on account of lack of diagnostic characters, is at present thought to range back in time to early Ordovician, may yet be shown to be distinguishable from their presumed Paleozoic representatives. The Leperditiidæ and Beyrichiida, however, stand alone with no recognized close affinities to post-Paleozoic Ostracoda. These fossils, therefore, the paleontologist must work out for himself and do the best he can with the material at his command.

After the foregoing introductory remarks, some attempt to re-define the existing classification of Paleozoic Ostracoda is necessary. As the investigations are far from complete, the attempt must, to a considerable extent, be preliminary to the final effort to be made in

^a Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, pp. 629-693.

the proposed monograph. While confessing its preliminary nature, it should not be supposed that the results here presented are founded on studies of only a part of the species immediately concerned. On the contrary, the authors have taken into account not only every recognizably described or figured Beyrichian, but also a host of unpublished species. If a classification of any family or subfamily could be made final without first, or at the same time, subjecting all related families to a similar close investigation, the following might lay claim to being so. But as it is manifestly impossible to do this without extending the field of study beyond the point attained, the present contribution pretends to nothing better than a report of progress.

ORIENTATION OF THE VALVES.

The feature of the study of Paleozoic Ostracoda, about which the literature of the subject seems to show greatest variability and uncertainty among authors, is the determination of which of the two ends of the carapace and valves is the anterior. The rule most generally applied is to call the thicker end posterior. The present writers are agreed with this as a general principle or rule, but not as a law. Close comparisons, and especially exact analyses of the lobes of Beyrichian forms, showed so many exceptions to the rule that it seemed necessary to seek other and if possible more reliable criteria. The position and trend of the median furrow was the first feature to be investigated. Next the lobes were compared, and finally the outline of the valves. It was found that all three of these features afford more reliable evidence than does the relative thickness of the ends. With the application of these several criteria certainty and uniformity in orientation is attained, which, for purposes of description and comparison, is, after all, the chief essential; but there are no positive means, and perhaps never will be, of determining that the end of the fossil shell here called posterior did not really lodge the cephalic organs of the living animal. Still the propriety of the orientation adopted is supported by plausibility based on facts, the bearing of which seems incontrovertible if not wholly decisive.

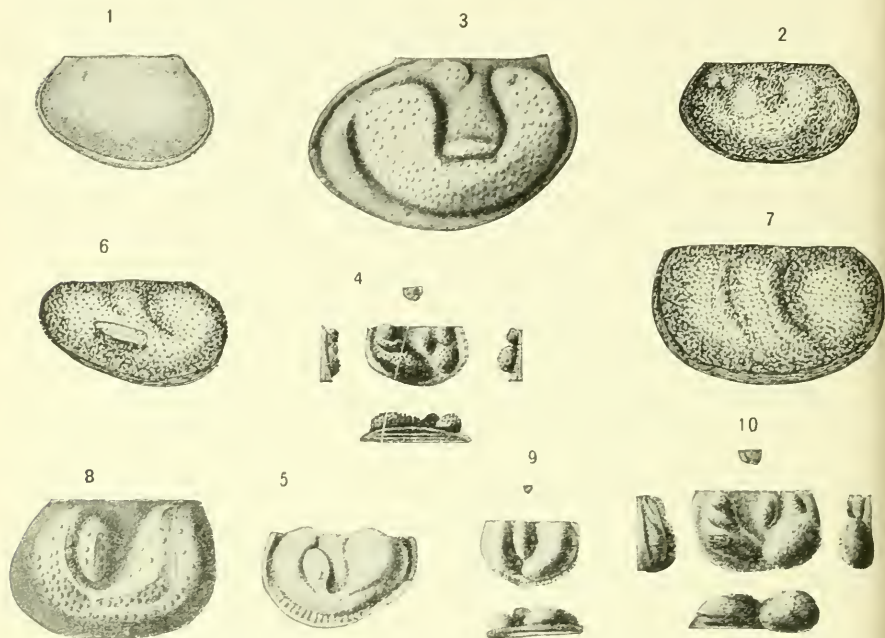
The principal line of evidence on which the orientation of the valves of *Beyrichia* and allied ostracods is based is derived from the position of the eye tubercle and the outline of the valves of *Leperditidae*. That the small tubercle referred to was really connected with the visual organs of the animal of *Leperditia* is universally accepted by paleontologists. Hence we are justified in assuming that its location marks the anterior end of the carapace. Starting with this accepted fact, we note (1) that the eye-bearing end of the valve is almost always narrower than is the other end; (2) that the outline of the valves exhibits a backward swing so that a rec-

tangular line drawn from the middle of the straight cardinal edge divides the area of the valve into two more or less unequal parts of which the posterior is the longer and usually the greater. In other words, the valve is more or less oblique and its outline suggests a parallelogram rather than an oblong. Now, in by far the majority of Primitiidae and Beyrichiidae, the narrower and, rather less generally, the thinner half of the carapace is determined to be anterior also by the retral swing of the outline and the comparative analysis of the nodes, lobes, and furrows.

The retral (parallelogram) swing of the outline is perhaps the most persistent of the criteria, being applicable in even those cases (certain Leperditellidae) in which the valves are without nodes, their surface uniformly convex, and the ends nearly or quite equal in height. In many of the true Beyrichiæ the resulting obliquity of outline and inequality of the ends are both very inconspicuous (as, for instance, *B. kochii*, *B. maccoyiana*, *B. salteriana*), and in this genus it is often necessary in deciding which is the right and which the left valve to rely almost entirely on the correlation of the lobes. The data for this correlation are furnished by species like *Beyrichia clavata*, in which the "swing" and the difference in height of the two ends is sufficient to leave no doubt as to which is the anterior. A study of such a species shows that the median lobe is united below with the larger anterior lobe by means of a low and thin isthmus, and that the posterior lobe, if its ventral extremity extends forward at all, passes beneath this isthmus. It is observed further that the median lobe is located nearer the posterior than the anterior lobe; in other words, that the anterior furrow is almost without exception the wider of the two. Now, bearing these facts in mind, the anterior lobe is recognized at once as the one that is connected below with the median lobe. When this ventral union of the anterior and median lobes is obsolete, as in *B. tuberculata* and its immediate allies, the posterior lobe is usually recognized by the location of the median lobe which, as said, is commonly placed more or less distinctly behind the center of the valve. When this and all other tests seem indecisive, as they may rarely be in a species like *B. browni* Reuter, then it is still possible to orient the valves by comparing minor nodes and furrows on the lobes with similar markings on less difficult species.

Additional evidence tending to show that the criteria relied on by the writers in orienting the valves of Beyrichiidae is furnished by the Chazy ostracod erroneously referred to *Beyrichia* by Jones under the name *B. clavigera*. This species, though strikingly like a *Beyrichia* in having a median node within the bend of a strongly curved, low ridge, seems yet to belong to the Leperditidae. It has an eye tubercle and agrees in all other respects, save the curved ridge, with species of

Isochilina, and the ridge even is represented in subdued form in *I. subnodosa*. The significant fact in this connection is that in this, we might almost say prophetic species, the above discussed criteria by



FIGS. 1-10.—1. LEFT SIDE OF ENTIRE SPECIMEN $\times 2$ OF *LEPERDITIA FABULITES* (CONRAD). ANTERIOR END INDICATED BY THE SMALL "OCULAR" TUBERCLE, ITS LESSER HEIGHT, AND BACKWARD SWING OF VALVE. 2. LEFT VALVE OF *ISOCHILINA*? *SUBNODOSA* ULRICH, $\times 3$, A NEARLY EQUAL FORM. ANTERIOR SIDE INDICATED BY OCULAR AND OTHER TUBERCLES, THAT WHEN PRESENT ARE ALWAYS IN FRONT HALF OF VALVES. 3. RIGHT VALVE OF *ISOCHILINA*? *CLAVIGERA* (BEYRICHTIA *CLAVIGERA* JONES) $\times 10$, SHOWING THE OCULAR TUBERCLE AND MUSCLE SPOT OF *LEPERDITIDÆ*, THUS DETERMINING WHICH IS THE ANTERIOR SIDE AND INCIDENTALLY AFFORDING A GOOD EXAMPLE OF RETRAL SWING. ORDOVICIAN (CHAZY SHALE), NEAR OTTAWA, CANADA. 4. LEFT VALVE OF *BEYRICHTIA TUBERCLATA* (KLÖDEN) $\times 5$ (AFTER REUTER). ANTERIOR SIDE RECOGNIZED BY ITS INFERIOR HEIGHT, SLIGHT RETRAL SWING, AND BY CORRELATION OF NODES OF VALVE. 5. RIGHT VALVE OF *BEYRICHTIA CLAVATA* KOLMODIN (AFTER KIESOW). ORIENTATION DETERMINED BY SAME CRITERIA AS IN FIGURE 4. 6. LEFT VALVE OF *CTENOBOLBINA ALATA* ULRICH, $\times 18$ (AFTER ULRICH). ANTERIOR END RECOGNIZED BY ITS TAPER AND BY THE RETRAL SWING OF THE OUTLINE. 7. LEFT VALVE OF *CTENOBOLBINA ALATA* (EMMONS), $\times 18$ (AFTER ULRICH). ORIENTATION DETERMINED BY COMPARISON OF LOBES WITH THOSE OF *C. ALATA*, IN WHICH THE ANTERIOR END IS NARROWER AND THE RETRAL SWING MORE PRONOUNCED. 8. *BEYRICHTIA* (*STEUSSLOFFIA*) *LINNARSSONI* (KRAUSE). RIGHT VALVE, $\times 15$ (AFTER REUTER). ORIENTED BY COMPARISON OF LOBES WITH THOSE OF *BEYRICHTIA CLAVATA* AND *B. TUBERCLATA*. 9. *BEYRICHTIA SALTERIANA* JONES, $\times 10$ (AFTER REUTER). THE ENDS BEING ALMOST EXACTLY EQUAL IN THIS SPECIES THE ORIENTATION OF ITS VALVES IS POSSIBLE ONLY BY COMPARISON OF ITS LOBES WITH THOSE OF OTHER *BEYRICHTIA*, LIKE *B. CLAVATA*. IN THESE, OTHER CORROBORATIVE CRITERIA ARE AVAILABLE, SUCH AS THE TAPER OF THE VALVES ANTERIORLY AND THE RETRAL SWING OF THE OUTLINE. ACCORDINGLY THE FIGURE REPRESENTS A RIGHT VALVE. 10. DIFFERENT VIEWS OF A LEFT VALVE OF *BEYRICHTIA TUBERCLATA-BUCHIANA* REUTER, $\times 6$ (AFTER REUTER). THE EXAMPLE FIGURED POSSESSES THE VENTRAL POUCH, WHICH FEATURE REUTER AND OTHER WRITERS REGARD AS DISTINGUISHING THE FEMALE IN *BEYRICHTIA* AND ALLIED GENERA. THE POUCH IS LOCATED INVARIABLY ON THE LOWER PART OF THE POSTERIOR LOBE.

which the right valve is distinguished from the left is supported by the evidence of the eye-tubercle.

Finally, the posterior location of the peculiar ventral pouch that Reuter and others have interpreted, we believe correctly, as ovarian inflations, is wholly in accord with the other criteria.

BEYRICHIA OF AUTHORS.

The genus *Beyrichia* was founded by McCoy in 1846.^a His "rough sketch" of the valves of the Irish species that first convinced McCoy that these fossils were bivalved crustacea and not trilobites gives a crude idea of the common Silurian form subsequently identified by Jones and others with *B. klædeni* McCoy. As McCoy ranks "*Battus tuberculatus*" of Klæden as a synonym of his *Beyrichia klædeni*, and as the two forms are distinguishable species, it is difficult to decide which of the two should rank as the genotype. However, as they are unquestionably congeneric, the point is of little consequence.

Subsequent authors have referred a considerable variety of Ostracoda to the genus. In fact, for many years it served as the temporary lodging place for nearly all of the Paleozoic species with furrowed or ridged valves. As noted above, a large part of these has been removed and distributed among other genera, but at the present writing no less than 150 species and varieties are still credited to *Beyrichia*. Many of these remaining species are not strictly congeneric with the type and hence will be removed, chiefly to new genera and to the long misunderstood *Klædenia*, the other more obvious departures from the generic type having been already mostly weeded out through the efforts of Jones, Holl, Kirkby, Krause, and Ulrich.

The genus *Klædenia* constitutes a close ally of the typical *Beyrichiæ*. The practical discrimination of the two groups, in certain cases at least, suggests that the boundary is artificial and probably results in occasional unnatural associations. But it is impossible to wholly escape this condition in any classification that is not too involved to be practical. Therefore, since the distinctive characters relied on in separating the two groups operate, as a rule, in apparent accord with genetic lines, *Klædenia* is accepted, with some justifiable modifications of the original diagnosis, as a useful designation. The comparatively few species about which there is doubt are provisionally left with *Beyrichia*.

Accepting *Beyrichia klædeni* and *B. tuberculata* as the types of the genus, and bearing in mind the ground to be occupied by the revised *Klædenia*, the restricted genus *Beyrichia* may be defined as follows:

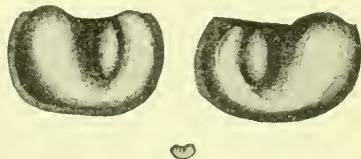


FIG. 11.—COPY OF MCCOY'S ORIGINAL SKETCHES OF BEYRICHIA KLÆDENI.

^a Syn. Sil. Foss. Ireland, p. 57.

Genus BEYRICHIA McCoy, emended.

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

Beyrichia BELL and FORBES, in Burmeister's Org. Tril., London, Suppl. App., p. 124.

Beyrichia MCCOY, Brit. Pal. Rocks and Foss., 1854, p. 135.

Beyrichia (part) JONES, Ann. and Mag. Nat. Hist. (2), XVI, 1855, p. 85.

Beyrichia (part) HALL, Nat. Hist. New York, Pal., III, 1859 [1861], p. 377.

Beyrichia (part) BARRANDE, Syst. Sil. du Centre Boheme, I, Suppl., 1872, p. 490.

Beyrichia (part) ZITTEL, Handbuch d. Pal., II, 1885, p. 553.

Beyrichia REUTER, Zeits. d. d. geol. Gesell., XXXVII, 1885, p. 628.

Beyrichia (part) JONES and HOLL, Ann. and Mag. Nat. Hist. (5), XVII, 1886, pp. 338, 345.

Beyrichia JONES and KIRKBY, Proc. Geol. Assoc., IX, 1886, p. 505.

Bollia (part) JONES, Ann. and Mag. Nat. Hist. (5), XIX, 1887, p. 408.

Beyrichia VERWORN, Zeits. d. d. geol. Gesell., XXXIX, 1887, p. 27.

Beyrichia (part) KRAUSE, Zeits. d. d. geol. Gesell., XLI, 1889, p. 17.

Bollia (part) KRAUSE, Zeits. d. d. geol. Gesell., XLI, 1889, pp. 13, 14.

Beyrichia MILLER, North Amer. Geol. and Pal., 1889, p. 534.

Beyrichia VOGDES, Annals New York Acad. Sci., V, 1889, p. 8.

Ctenobolbina (part) ULRICH, Jour. Cincinnati Soc. Nat. Hist., XIII, 1890, p. 111.

Strepsula (part) KRAUSE, Zeits. d. d. geol. Gesell., XLIII, 1891, p. 498.

Beyrichia (part) ULRICH, Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, p. 657.

Beyrichia KOKEN, Die Leitfossilien, 1896, p. 40.

Beyrichia GURICH, Verh. d. Russ.-Kais. Mineral Gesell. zu St. Petersburg (2), 1896, p. 385.

Beyrichia GRABAU, Bull. Buffalo Soc. Nat. Sci., VI, 1899, p. 306.

Beyrichia ULRICH and BASSLER, Proc. U. S. Nat. Mus., XXX, 1906, p. 151.

Carapace comparatively large, 2 mm. to 5 mm. in length, semiovate or semicircular to oblong in outline, with sharp dorsal and rounded ventral angles. Valves only moderately convex, strongly impressed with two vertical furrows, extending from the straight dorsal edge to the ventral portion of the valve so as to divide the intramarginal part of the surface into three unequal and unsymmetrical lobes. These vary considerably in size with respect to each other and with respect to their separation; also in the development of their ventral ends. The furrows may be much narrower or they may equal the ridges in width. The ovate median lobe is the most constant in form and size, usually the smallest, and ordinarily begins some distance beneath the dorsal edge. The anterior lobe, though generally the largest, is the most variable in size and form, being also often broken up into subsidiary nodes. The posterior ridge is, as a rule, the narrowest, runs nearly parallel with the posterior border, is rounded and thickest above, sometimes constricted near its middle, and often tapers to the vanishing point near the middle of the ventral edge. In other species it joins the ventral prolongation of the anterior lobe, in which cases commonly all three lobes are joined. When only two of the lobes are connected, it is, perhaps invariably, the median and the anterior. Ventral pouch (presumably of female) egg-shaped or

subglobular, as large or larger than either of the ordinary lobes, arising from the ventral part of the posterior lobe, hence located wholly or mostly behind the middle of the valve. A flange-like border around the ends and the ventral side. This may be narrow or wide, simple or rimmed, and variously ornamented with granules or spines. The flange overhangs the real contact edges which are beveled inward, the opposite edges meeting either flush or that of the right valve very slightly overlaps the edge of the left. Surface of valves smooth, granulose, punctate, or reticulate, or granulo-reticulate.

The following species have the characters of the genus as here restricted:

ORDOVICIAN SPECIES.

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|---|--|
| <i>Beyrichia (Steusloffia) acuta</i> (<i>Beyrichia erratica</i> , var. <i>acuta</i> Krause). | <i>Beyrichia (Steusloffia) signata</i> (<i>Beyrichia signata</i> Krause). |
| <i>Beyrichia (Steusloffia) antiqua</i> (<i>Beyrichia antiqua</i> Steusloff). | <i>Beyrichia tumida</i> (<i>Ctenobolbina tumida</i> Ulrich). |
| <i>Beyrichia granulifera</i> , new name (<i>Bollia granulosa</i> Krause). | <i>Beyrichia r-scripta</i> (<i>Bollia r-scripta</i> Krause). |
| <i>Beyrichia (Steusloffia) linnarssoni</i> (<i>Streptula linnarssoni</i> Krause). | |

SILURIAN SPECIES.

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|--|--|
| <i>Beyrichia admixta</i> Jones and Holl. | <i>Beyrichia klædeni</i> McCoy. |
| <i>Beyrichia aequalatera</i> Hall. | <i>Beyrichia klædeni acadica</i> ^a Jones. |
| <i>Beyrichia baueri</i> Reuter. | <i>Beyrichia klædeni antiquata</i> Jones. |
| <i>Beyrichia baueri tripartita</i> Reuter. | <i>Beyrichia klædeni bicuspis</i> Kiesow. |
| <i>Beyrichia (Steusloffia) beyrichioides</i> (<i>Streptula beyrichioides</i> Jones and Holl). | <i>Beyrichia klædeni granulata</i> Jones. |
| <i>Beyrichia bolliana</i> Reuter. | <i>Beyrichia klædeni infecta</i> Jones. |
| <i>Beyrichia bronni</i> Reuter. | <i>Beyrichia klædeni intermedia</i> Jones. |
| <i>Beyrichia buchiana</i> Jones. | <i>Beyrichia klædeni intermedia</i> , subvar. <i>subspissa</i> Jones and Holl. |
| <i>Beyrichia buchiana angustata</i> Reuter. | <i>Beyrichia klædeni nuda</i> Jones. |
| <i>Beyrichia buchiana incisa</i> Reuter. | <i>Beyrichia klædeni protuberans</i> Boll. |
| <i>Beyrichia buchiana lata</i> Reuter. | <i>Beyrichia klædeni subtorosa</i> Jones. |
| <i>Beyrichia buchiana nutans</i> Kiesow. | <i>Beyrichia klædeni torosa</i> Jones. |
| <i>Beyrichia clarata</i> Kolmodin. | <i>Beyrichia klædeni verruculosa</i> Jones. |
| <i>Beyrichia damesi</i> Krause. | <i>Beyrichia kochii</i> Boll. |
| <i>Beyrichia diffusa</i> Jones. | <i>Beyrichia lata</i> ^a Hall. |
| <i>Beyrichia dubia</i> Reuter. | <i>Beyrichia laucensis</i> Kiesow. |
| <i>Beyrichia grandis</i> Kolmodin. | <i>Beyrichia lindstromi</i> Kiesow. |
| <i>Beyrichia granulosa</i> ^a Hall. | <i>Beyrichia maccoyiana</i> Jones. |
| <i>Beyrichia interrupta</i> (<i>Bollia interrupta</i> Jones). | <i>Beyrichia maccoyiana sulcata</i> Reuter. |
| <i>Beyrichia jonesii</i> Boll. | <i>Beyrichia moodeyi</i> , ^a new species. ^b |
| | <i>Beyrichia muldensis</i> Chapman. |
| | <i>Beyrichia nodulosa</i> Boll. |

^a American species.

^b This species is very similar to *B. maccoyiana* and is probably the American form referred to this latter species by Jones. It is distinguished by the greater isolation of the median lobe and the very finely punctated surface of the lobes. See Plate XXXVII, fig. 8.

Formation and locality.—Cayuga formation, near Cacapon, West Virginia.
Cotypes.—Cat. No. 53936, U.S.N.M.

- Beyrichia nodulosa expansa* (*B. lindstromi*, var *expansa* Kiesow).
Beyrichia noellingeri Reuter.
Beyrichia noellingeri conjuncta Reuter.
Beyrichia plagosa^a Jones.
Beyrichia plicata (*Entomis plicata* Krause).
Beyrichia pustulosa^a Hall.
Beyrichia reticulata (*Strepula reticulata* (limbata in text) Krause).
Beyrichia reuteri Krause.
Beyrichia salteriana Jones.
Beyrichia seaucensis Kolmodin.
Beyrichia (*Steusloffia*) *simplex* (*Strepula simplex* Krause).
Beyrichia spinulosa Boll.
Beyrichia steusloffii Krause.
Beyrichia trilobata (*Entomis trilobata* Krause).
Beyrichia tuberculata (*Battus tuberculatus* Kloeden).
Beyrichia tuberculata bigibbosa Reuter.
Beyrichia tuberculata foliosa Jones.
Beyrichia tuberculata spicata Jones.
Beyrichia tuberculato-koehiana Reuter.
Beyrichia umbonata (*Beyrichia bolliana umbonata* Reuter).
Beyrichia waldronensis,^a new species.^b

DEVONIAN SPECIES.

- Beyrichia aurita* Richter.
Beyrichia devonica Jones and Woodward.
Beyrichia, new species (*B. klødeni* var. Jones).

Approximately 225 named species and varieties, varying in time from the Cambrian to the Permian, have, in the past sixty years, been referred to *Beyrichia*. Of the total number, only the seventy-three species and varieties listed above may be accepted as conforming strictly to the genus as here characterized. Only a few of these are Ordovician, and only two or three Devonian. The Cambrian species are regarded as widely different and probably not Ostracoda at all, while none of the Carboniferous species is strictly referable to the genus. As restricted, then, *Beyrichia* is preeminently a Silurian genus.

It is interesting to note further that only four of these species are as yet known in American deposits, and of these but one, *Beyrichia granulosa* Hall, is found in the Ohioan province, the other three occurring in the Atlantic and Polar provinces. All the remaining true *Beyrichiæ* seem to be confined to Baltic and British deposits, none of the central and southern European species being, so far as known, strictly referable to the genus. The list will be increased by two or three as yet unpublished east American Silurian species, but even with these the American representation is so weak that it is justifiable

^a American species.

^b Related to *B. moodenii* and *B. maccoyiana*, but has a much broader marginal border, a rather longer median lobe, and a distinctly reticulate surface which is especially marked on the lobes. The species presents considerable resemblance to *Beyrichia reticulata* as figured by Krause, but differs in wanting the crest-like ridge. See Plate XXXVII, figs. 9, 10.

Formation and locality.—Niagaran (Waldron shale), Waldron, Indiana.
 Cotypes.—Cat. No. 41660, U.S.N.M.

to regard *Beyrichia* as essentially a north European genus. The direct opposite is true of the group of Beyrichiida typified by *B. wilkenskiana* Jones, for which Jones and Holl subsequently erected the genus *Klædenia*. That is to say, the latter genus is much more strongly developed in America than in Europe.

About ninety of the species originally described as *Beyrichia* remain to be distributed among their proper genera. A large part of this number will be accounted for in the following discussions of the other genera of the family. But a considerable number will remain even then that for one reason or another cannot yet be definitely placed. In most cases it is lack of knowledge that suggests delay in deciding their systematic positions. A few, however, require further study and comparison, being too peculiar to fall readily into place.

The species here definitely referred to *Beyrichia* fall into seven, in part genetic, in part perhaps artificial groups. The first three of these, the *B. klædeni*, the *B. tuberculata*, and the *B. buchiana* groups, are made up entirely of unequivocal species of the genus. The other four groups, however, are more or less synthetic, and, though including species that cannot be clearly distinguished from *Beyrichia*, they are yet closely connected with species that must be referred to other genera. In other words, they represent different lines of development that seem to have originated in diverse Ordovician types but ended through what might be called convergent evolution in much more uniform stages. It appears further that in the decline of the genus a partial reversion to ancestral stages took place. Suggestive observations bearing on these points will be found in the following notes.

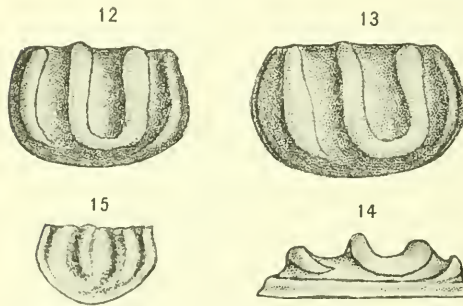
GROUP OF *B. KLÆDENI*.

This group embraces *B. klædeni*, *B. muccojiana*, *B. bolliana*, *B. kochii*, *B. tuberculato-kochiana*, *B. moodeyi*, new species, *B. lindstromi*, and most of the forms described by various authors as varieties of the first-named species. Its valves are usually short, semi-elliptical in outline, and sharply lobed. The lobes are of medium thickness, the anterior one tending to enlargement and dissection, while the middle lobe is nearly as large as the posterior and commonly exhibits a tendency to union with the incurved ventral extremity of the anterior lobe. The posterior lobe is more or less acuminate and incurved below, but does not extend forward beyond the base of the median lobe. The type usually is shorter and always has somewhat thicker and more bulbous lobes than the *buchiana* section, and it is commonly shorter, with less dissected anterior and posterior lobes, and a longer median lobe than the *tuberculata* group. It constitutes, therefore, an admirable central type for the genus, and its

least synthetic, hence most characteristic phase. None of the species belonging to the group suggests genetic relations to species not included in the genus as here defined.

GROUP OF *B. BUCHIANA*.

In *B. buchiana* and its nearest allies and varieties the anterior and median lobes are joined, as commonly happens in *Beyrichia*, but the anterior lobe is thinner and the ventral connection proportionally thicker than usual, the combination giving to the united lobes a striking similarity to the horse-shoe ridge in the *B. ungula* section of *Bollia*. Indeed, *Beyrichia buchiana* and the Cincinnati *Bollia regularis* (Emmons) and *B. persulcata* (Ulrich) are sufficiently alike in general aspect to have induced so thorough a student of Ostracoda as T. Rupert Jones to refer a partially covered specimen of the last



FIGS. 12-15.—12-14. LEFT VALVE AND SIDE AND EDGE VIEWS OF ANOTHER LEFT VALVE OF *BOLLIA REGULARIS* (EMMONS), $\times 30$. ARNHEIM BEDS OF RICHMOND GROUP, WAYNESVILLE, OHIO. 15. LEFT VALVE OF *BEYRICHIA BUCHIANA* JONES, $\times 8$ (AFTER JONES). THE FIGURES ARE INTENDED TO ILLUSTRATE THE POSSIBLE DERIVATION OF THE *B. BUCHIANA* GROUP OF *BEYRICHIA* FROM *BOLLIA*.

to the Silurian *Beyrichia*. The resemblance might be regarded as indicating genetic affinity between the two, the younger *B. buchiana* being evolved through the continued and finally total obsolescence of the anterior marginal ridge of the *Bollia*.

Though admitting the possibility of such a derivation, it has yet seemed to the writers an improbable relationship. The marginal ridge is one of the most stable characters of

Bollia, and though its ventral part is often low and sometimes quite obsolete, there is no evidence to show that the anterior part is even lost entirely. The arrangement of the ridges in *Bollia* is bilateral with respect to a median furrow, in *Beyrichia* with respect to a median lobe. In *Bollia regularis* the anterior marginal ridge is paired with a less well-developed posterior ridge, the pair of median ridges uniting below as usual. In testing the possible derivation of *Beyrichia buchiana* from *Bollia regularis*, it should be remembered that in the *Beyrichia* it is the anterior and median lobes that are united, and that if the suggested derivation were a fact, it must have been by anterior shrinkage of the *Bollia* and final loss of the part bearing the anterior marginal ridge. Instead of this it seems certain that the stronger of the terminal ridges on valves of *B. regularis* is the anterior one, proving that in this species at least the conditions are the opposite of what they should be.

The *B. buchiana* group is characterized by its comparatively long shells, but passes by easy gradation into the *B. klædeni* group, the mere proportionate shortening of the valves sufficing to bring about some of the differences between them. On the other side it grades by thickening and division of lobes into the *B. tuberculata* section. *B. laevis* Kiesow is regarded as an extreme member of the group, differing from the other species in the dissection of the anterior lobe and its separation from the median lobe.

GROUP OF *B. TUBERCULATA*.

This section of the genus comprises a number of species and varieties in which the anterior and posterior lobes are broken up by minor furrows, the posterior lobe into two, the anterior lobe into from two to six or seven node-like parts. Reuter's *B. buchiano-tuberculata* would represent about the simplest type and *B. pustulosa* Hall and *B. natlingi* Reuter the most complex. The anterior lobe is, as a rule, larger than in other groups, and when not too much dissected, retains the "leg-of-mutton shape" pertaining to this lobe in the majority of the species of the genus. In the most simple species of the group the posterior lobe is sharply constricted about its midlength, or somewhat above this point, the upper bulb being usually considerably smaller than the lower. The anterior lobe in these is crossed obliquely by a single curved furrow dividing the vertical upper part from the much larger ventral portion. In the next stage of dissection (as, for instance, *B. tuberculata* and *B. bronni*) the posterior lobe is usually completely divided, while the anterior lobe is crossed by two parallel furrows instead of one. In further stages the lower and largest of the three divisions of the anterior lobe is broken up into a series of three nodes and the middle division commonly into two, while the upper may also be divided into two much smaller tubercles.

Except in the most simple species, which of course are not far removed from *B. klædeni* and *B. buchiana*, none of the lobes are connected ventrally. This fact sets the group somewhat apart from the majority of the remaining species here referred to the genus, and allies it to the subgenus *Stenusloffia*. A coarsely granulose surface ornament of the lobes usually obtains except in the most highly dissected species. As a rule, the main lobes are well separated and the carapaces large, thus differing from the otherwise similar group of *B. salteriana*.

Respecting the derivation of this group of species, the problem seems at first sight very obscure. However, on closer analysis of the lobes and comparison with Ordovician genera, the possibility of its having sprung from *Drepanella* becomes more and more evident, so that finally the idea assumes the rank of high probability and needs but the discovery of one or two links to make it a certainty. To illus-

trate the supposed evolution, the lines of a *Drepanella* have been drawn in black over a figure of *B. tuberculata*. This shows that by merely dividing the sickle-shaped marginal ridge of *Drepanella* into a series of three or more node-like parts, the result is in essential accord with the structure characterizing the group of *B. tuberculata*. Above the submarginal ridge the valves of *Drepanella* have two persistent lobes corresponding to the median and anterior lobes of most *Beyrichia*. They may be dissected into subsidiary nodes (as, for instance, *D. crassinoda* and *D. nitida*) and are sometimes connected ventrally (*D. bigeneris*), as is commonly the case in the groups of *B. buchiana* and *B. klædeni*. The subsidiary nodes of the dissected anterior lobe in *Drepanella macra*, *D. crassinoda*, and *D. nitida* can be matched exactly in respectively *Beyrichia tuberculata*, *B. wællingi*, and *B. baueri*. But the tendency to dissection of the median lobe exhibited by the oldest species of *Drepanella* is never observed in species of *Beyrichia*. Indeed, this lobe soon became the most constant feature for the whole family. Aside from this occasional difference,

the greatest distinction between *Drepanella* and the *tuberculata* section of *Beyrichia* is that, whereas in the former the outer sickle-shaped ridge is the most constant feature, in the latter it became through dissection the least stable.

The youngest unquestionable *Drepanella* known is the *D. richardsoni* of the Richmond in Ohio. In this the anterior end of the sickle-shaped submarginal ridge is thick and tends to connect with

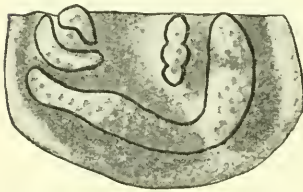
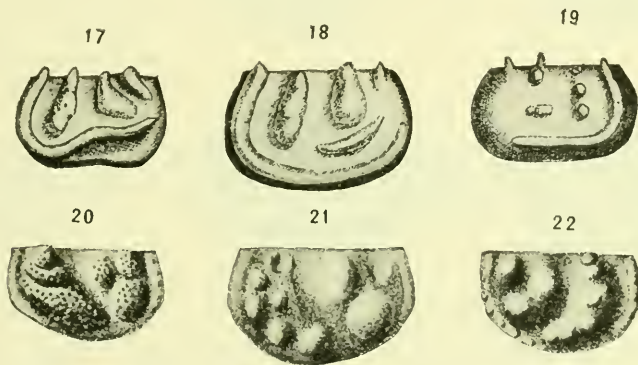


FIG. 16.—A LEFT VALVE OF BEYRICHIA TUBERCULATA (KLÆDEN), $\times 15$, WITH THE LINES OF A DREPANELLA DRAWN OVER IT.

the basal part of the expanded and prominent, though still partially dissected anterior lobe. Continuing this line of departure from the older, typical species of the genus, a stage might be expected in which the anterior lobe would be swollen to such a degree that the component nodes or tubercles of the earlier dissected stages would be entirely obscured. In fact, we have such a stage in a late Richmond species described by Ulrich as *Ctenobolbina tumida*. As stated in the discussion of that genus, the species is not a *Ctenobolbina*, the bulbous part of the carapace which was thought to correspond to the similarly bulbous posterior end of *C. ciliata* being, in fact, anterior. The original specimens of the species were not in condition to permit working out all its characters exactly, nor had any reason occurred at that time to lead the author to suspect that the swollen end of the carapace is anterior and not posterior. Such a suspicion, ending finally in conviction, arose only during the course of the present revision of the family. Recognizing the median lobe of *Beyrichia* in the small vertical node or ridge located well to one side of the middle

of the valve in *C. tumida*, and having learned that this is invariably situated *behind* the middle, no other course remained than to interpret the bulbous end as anterior.

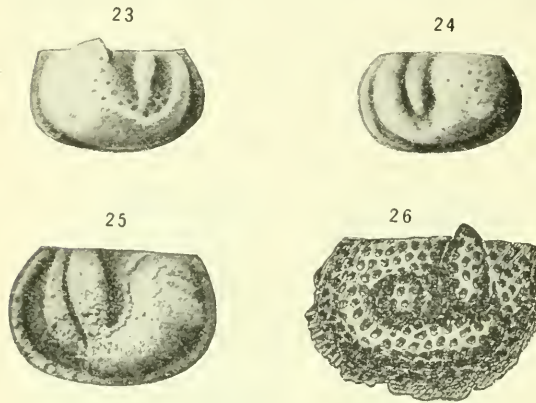
Having oriented the valves in this manner, the relations of *C. tumida* to *Drepanella richardsoni* became fairly clear; but even then it required a more perfect specimen than the original types to enforce conviction. This specimen, recently collected at Moreland, Kentucky, has a thick marginal ridge running from the post-dorsal angle to the middle of the ventral edge, where its further extent is lost in the ventral slope of the anterior bulb. But its anterior extremity reappears on the opposite side of the bulb as a distinct node. Taking essentials alone into account, the characters of *C. tumida* are not greatly different from those of *Beyrichia* like *B. protuberans*, *B.*



FIGS. 17-22.—17, RIGHT VALVE OF DREPANELLA MACRA ULRICH FOR COMPARISON WITH FIG. 20. LEFT VALVE OF BEYRICHIA TUBERCULATA (KLEDEN). 18, RIGHT VALVE OF DREPANELLA CRASSINODA ULRICH FOR COMPARISON WITH LEFT VALVE OF BEYRICHIA NOETLINGI REUTER (FIG. 21). 19, LEFT VALVE OF DREPANELLA NITIDA (ULRICH) FOR COMPARISON WITH THE CORRESPONDING VALVE OF BEYRICHIA BAUERI REUTER, SHOWN IN FIG. 22. (COPIED AFTER ULRICH AND REUTER.)

jonesi, or *B. clavata*, in which also the anterior lobe is the most prominent part of the valves and the posterior lobe extends forward beneath the middle and anterior lobes. Therefore, despite the rather strong dissimilarity in aspect, there seems really to be no very essential difference between *C. tumida* and *Beyrichia*. The posterior half is nearly the same in both, and only the great development of the anterior lobe gives the Ordovician species a strange look. However, as the writers are convinced that the latter is related genetically to unquestionable species of *Beyrichia*, and that the differences noted are not of greater importance than those obtaining between, for instance, the *B. tuberculata* and the *B. klodeni* groups, the species *tumida* is removed from *Ctenobolbina*, where it certainly does not belong, to *Beyrichia*.

The relations of *B. tumida* to the Clinton *B. lata*, suggested in 1894,^a have been confirmed in the present investigation. Though widely different in general aspect, the evolution of the latter from the former is regarded as not unlikely. In the rapid and sometimes extravagant mutation that is indicated, not only for the ostracoda but also in other classes of animals, at and immediately following the close of the Ordovician, it is readily conceivable that both the anterior and the posterior lobes of *B. tumida* might have been greatly reduced and thus to have brought about a temporary stage like *B. lata*.



FIGS. 23-26.—23. LEFT VALVE OF *DREPANELLA RICHARDSONI* (MILLER), $\times 10$, INTRODUCED FOR COMPARISON WITH *BEYRICHIA TUBERCULATA*. UPPER BEDS OF THE RICHMOND GROUP, NEAR WILMINGTON, OHIO. 24. RIGHT VALVE OF *BEYRICHIA TUMIDA* (ULRICH), $\times 10$, SHOWING ITS DERIVATION FROM *DREPANELLA*. TOP OF RICHMOND GROUP, MORELAND, KY. 25. RIGHT VALVE OF *BEYRICHIA LATA* HALL, $\times 10$, FOR COMPARISON WITH *BEYRICHIA TUMIDA* AND *DREPANELLA RICHARDSONI*. CLINTON GROUP, NEW HARTFORD, N. Y. 26. RIGHT VALVE OF *TREPOSELLA LYONI* (ULRICH), $\times 20$, A DERIVATION OF *BEYRICHIA* IN WHICH THE POSTERIOR LOBE HAS BECOME OBSOLETE. (AFTER ULRICH.) ONONDAGA LIMESTONE, FALLS OF THE OHIO.

the loop formed by the ventral union of the nodes, *B. lata* also suggests a *Bollia*.

GROUP OF *B. SALTERIANA*.

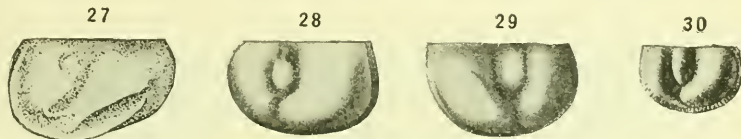
The species of this group do not, as a rule, attain the average size of those included in the *B. tuberculata*, *B. kladeni*, and *B. buchiana* groups. They differ rather obviously, too, from these other groups in the fullness of their lobes and the proportionate narrowness of the furrows. The departure from the more typical sections is toward *Kladenia*, in which the furrows are obscure or die out entirely in

The Clinton species is chiefly remarkable because of the slight development of its posterior lobe. In the Devonian decadence of typical *Beyrichia* a similar obsolescence of the posterior ridge is noted in the modified stage represented by *Treposella lyoni* (Ulrich). At this time the *Beyrichiidae* assumed various atavistic expressions, some suggesting *Ctenobollina*, others *Bollia*, while a third may recall *Tetradella*. In the partial obsolescence of the posterior lobe and the proportionate distinctness of the median and posterior

^a Ulrich, Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, p. 674.

the swollen ventral half of the valves. While clearly intermediate in character between typical *Beyrichia* and *Klædenia*, it yet seems unlikely that either was derived from the other through the *salteriana* group. On the contrary, a study of *B. salteriana* Jones, *B. reuteri* Krause, *B. plicata* (Krause), and *B. trilobata* (Krause) seems to indicate a closely knit line of development that diverged, like the *B. linnaeussoni* group, from some early stage of *Ctenobolbina*. The resemblance exhibited by *B. plicata* to *Ctenobolbina subcrassa*, for instance, is too close to be regarded as otherwise than genetic; and the agreement between *B. plicata* and *B. reuteri*, and between the latter and *B. salteriana*, is so intimate that a similar relationship seems undeniable.

Compared with the other sections of the genus, the *salteriana* group agrees best with the *B. tuberculata* group in the isolation of its median lobe. The dissection of the other two lobes occurring so generally in that group, however, is not even suggested.



FIGS. 27-30.—27. RIGHT VALVE OF CTENOBOLBINA SUBCRASSA ULRICH, $\times 20$. (AFTER ULRICH.) 28. RIGHT VALVE OF BEYRICHIA PLICATA (KRAUSE), $\times 20$. 29. LEFT VALVE OF BEYRICHIA REUTERI KRAUSE, $\times 15$. (FIGS. 28 AND 29 ARE COPIED FROM KRAUSE.) 30. RIGHT VALVE OF BEYRICHIA SALTERIANA JONES, $\times 10$. (AFTER REUTER.) THE FIGURES ILLUSTRATE THE RELATION AND PROBABLE DERIVATION OF THE BEYRICHIA SALTERIANA GROUP FROM A CTENOBOLBINA LIKE SUBCRASSA. TWO INTERMEDIATE STAGES ARE SHOWN IN FIGS. 39 AND 41.

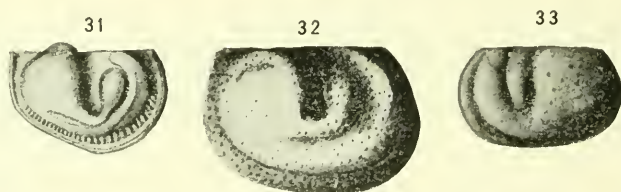
Beyrichia granulosa Hall, from the Waldron shale of Indiana, is a good American example of this section of the genus. This species is of exceptional interest because it is one of the few species of the genus that occur in Silurian deposits of the Ohioan Province.

GROUP OF *B. CLAVATA*.

Of the foregoing groups, those of *B. klædeni*, *B. buchiana*, and *B. tuberculata* represent the fully established and most typical stages of the genus. The group of *B. salteriana* evidently originated in some species of *Ctenobolbina* and probably is the stock from which *B. klædeni* was derived. It is also the only known group from which the genus *Klædenia* might have sprung. The small group of *B. clavata*, which includes *B. jonesii* Boll and possibly *B. umbonata* Reuter, likewise has a character suggesting an earlier genus, namely, the posterior ridge curves forward along the ventral margin, and, though attached to the slender isthmus connecting the anterior and median lobes, is often distinguishable as far as the antero-ventral angle where it merges into the great, pear-shaped anterior lobe. So

far as essentials go, the result is not unlike the Ordovician genus *Drepanella*, with its great, sickle-shaped marginal ridge.

Much similarity is traceable also between *B. clavata* and the synthetic *B. interrupta* group. The posterior ridge is not so well developed in that group, but in *B. v-scripta* and *B. granulifera* it is clearly suggested to where it is lost in the low anterior lobe; and just over its ventral part is the antero-median isthmus. Whether either of these resemblances are indicative of close genetic alliances can not be decided with the evidence now available. The youngest unquestionable *Drepanella*, *D. richardsoni* (Miller), of the Richmond group, analyzes more in accord with *Beyrichia tuberculata* than with *B. clavata*. As stated in another note, the union of the posterior lobe of *B. tuberculata* with the lower of the three parts of the anterior lobe (see figure) would give every essential of *Drepanella*. While the importance of the difference is recognized, and it is a fact that links establishing the relation are unknown, the writers, nevertheless,



FIGS. 31-33.—31. LEFT VALVE OF BEYRICHIA CLAVATA KOLMODIN. 32. LEFT VALVE OF BEYRICHIA GRANULIFERA, NEW NAME (BOLLIA GRANULOSA KRAUSE), $\times 15$. (AFTER KRAUSE.) 33. RIGHT VALVE OF BEYRICHIA TUMIDA (ULRICH), $\times 10$. THE FIGURES ILLUSTRATE THE RESEMBLANCE OF THE BEYRICHIA CLAVATA GROUP TO THE *B. INTERRUPTA* GROUP AND SHOW THE SIMILAR ANTERO-VENTRAL PROLONGATION OF THE POSTERIOR LOBE.

are convinced that the *B. tuberculata* section was evolved out of *Drepanella*.

Despite the unbroken antero-ventral continuation of the posterior ridge in *B. clavata*, the direct derivation of this species from *Drepanella* seems unlikely, except it be through *B. tumida* (*Ctenobolbina tumida* Ulrich)^a Derivation from something like *B. granulifera* and *B. v-scripta* is at least equally plausible. However, neither of these possible solutions is entirely satisfactory, so that for the present the origin of *B. clavata* must be left as undecided.

As for *B. umbonata*, which is somewhat doubtfully referred to this group, the alliance with *Drepanella* seems much more natural. Except that the valves are, on the whole, more convex, and the lobes thicker and less sharply defined, every other essential feature may be duplicated in typical *Drepanella* like *D. crassinoda* and *D. macra*.

Another drepanelloid Beyrichian and possible member or derivation of this group is the Devonian *B. kolmodini* Jones. This species has

^a See notes on *Drepanella richardsoni* and *Beyrichia tumida* on page 290.

a thick, yet sharply defined, sickle-shaped ridge with two separate rounded nodes above and a variable short ridge just within the anterior edge. Except the interiorly concave marginal border, smaller size, and proportionally narrow anterior end, the general aspect, especially in the matter of lobation, is highly suggestive of *Drepanella*. Here again, however, the writers doubt the reality of the suggested genetic relation. On the contrary, it is thought the true affinities of the species lie with other middle Devonian species that could not be suspected of alliance to *Drepanella* except in a very remote degree. These species, namely, constitute a peculiar group, described and mostly referred by Ulrich, as is now believed incorrectly, to *Ctenobolbina*. Conspicuous members of this group are *C. informis*, *C. antespinoza*, *C. spiculosa*, *C. cavimarginata*, and *C. insolens*. These species, it will be noted, vary greatly in general expression, and because of their spinosity, probably indicate decadence of the Silurian type of Beyrichiidae, and rapid evolution toward the establishment of the final, again comparatively long-lived type of the family. In the transition, various atavistic stages are indicated, some recalling *Ctenobolbina*, some *Bollia*, and others, like *B. kolmodini*, more nearly resembling *Drepanella*. Previously highly important and constant features have become most unstable, but through all the vagaries the steady evolution of the two rounded nodes which constitute the essential characteristic of the dominant and generically distinct later Paleozoic Beyrichian type is manifest. These two nodes, which represent the median and anterior lobes of typical Beyrichiæ, are well developed in *B. kolmodini*, but the general expression of the valves in this transitional stage in the development of the family is so at variance with that of the typical Silurian groups of *Beyrichia* that the writers have decided to recognize it by erecting the new genus *Hollina*.

Subgenus **STEUSLOFFIA**, new.

Beyrichia (part) of AUTHORS.

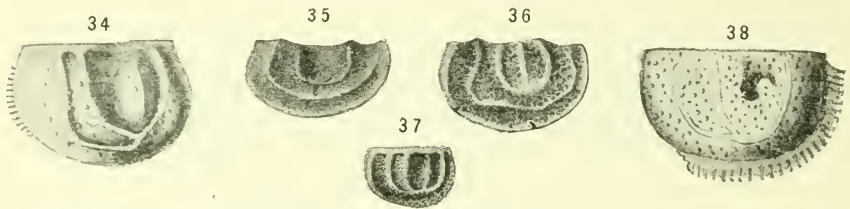
Strepula (part) of AUTHORS.

GROUP OF B. LINNARSSONI.

Beyrichia antiqua, *B. acuta*, *B. simplex*, *B. linnarssoni*, *B. signata*, *B. beyrichioides*, and probably *B. erratica* Krause, which is provisionally not included in the above list, constitute a peculiar group suggesting *Strepula* in having thin, elevated ribs or crests running over the surface of the valves. It is believed that these ribs served the purpose of strengthening the valves and that they are developed in genetically distinct groups of species. Depending primarily on the lobation of the valves and on their form in deciding questions of relationship, the group under consideration conforms in all essential respects with typical *Beyrichia*.

Beside the presumably dominating alliance of the *B. linnarssoni* group to *Beyrichia* s. s., and the suggested relation to *Strepula*, other in part apparently true alliances are indicated, in some by the arrangement of the superficial ribbing, in others by the form and disposition of the lobes. Thus the tetrameroid arrangement of the ribs in *B. erratica* and *B. signata* recalls *Tetradella*. The same may be said of certain more typical and possibly true strepulae like *S. lineata* Krause and the two varieties described by Steusloff as *granulosa* and *separata*. The more simple *B. antiqua* Steusloff and *B. acuta* Krause are like certain species of *Ctenobolbina*. In the opinion of the writers, this resemblance is of real genetic significance, the indicated relationship and probable derivation of at least some *Beyrichia* from *Ctenobolbina* seeming fairly easy to establish.

In tracing out this relationship we begin, not with the genotype, *C. ciliata*, and the four or five closely allied species found in the Cincinnati rocks, but with the older Stones River and Mohawkian



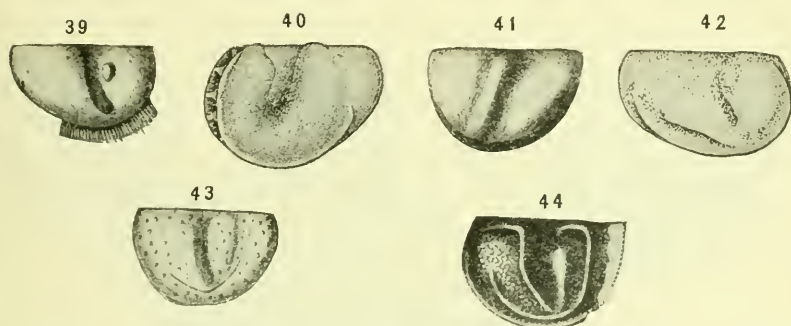
FIGS. 34-38.—34. LEFT VALVE OF BEYRICHIA (STEUSSLOFFIA) LINNARSSONI (KRAUSE), $\times 20$. (AFTER KRAUSE.) 35. RIGHT VALVE OF STREPULA CONCENTRICA JONES AND HOLL, $\times 15$. (AFTER JONES AND HOLL.) 36. LEFT VALVE OF STREPULA IRREGULARIS JONES AND HOLL, $\times 15$. (AFTER JONES AND HOLL.) 37. LEFT VALVE OF BEYRICHIA (TETRADELLA?) ERRATICA KRAUSE. (AFTER KRAUSE.) 38. LEFT VALVE OF STREPULA? LINEATA GRANULOSA STEUSLOFF, $\times 20$. (AFTER STEUSLOFF.) SHOWS SIMILAR DEVELOPMENT OF SUPERFICIAL LINEAR CRESTS IN STEUSLOFFIA AND STREPULA. IN TRUE STREPULA THE BEYRICHIAN LOBES ARE NOT CLEARLY DETERMINABLE.

forms. In the *ciliata* section of *Ctenobolbina* the median lobe is undistinguishably merged in the larger posterior bulb which characterizes this section. It began in species like the early Trenton *C. obliqua* Ulrich and the foreign Ordovician *C. oblonga* (*Entomis oblonga* Steusloff), in which this median lobe is merely indicated by the abruptness of the inner slope of the main lobe; and these species seem to have been derived from the previously established *C. subcrassa* section.

In the *subcrassa* section the median lobe is generally distinguishable, appearing as a small or larger node or ridge situated immediately behind the main, median sulcus. Usually the posterior side of the lobe is not sharply defined from the more or less swollen surface behind it. Sometimes, as in *C. umbonata* (*Entomis umbonata* Steusloff) and *C. subcrassa* Ulrich, it forms a small, rounded node on the inner slope of the main posterior bulb. In others (as, for instance, *C. crassa* and *C. fulvata* Ulrich) it makes a low ridge rising

slightly above the rest of the swollen posterior lobe, and of which it forms the greater part, while in some of the later Silurian species, namely *C. auricularis* (*Bollia auricularis* Jones and Holl), and *C. minor* (*Bollia minor* Krause), it is rendered even more prominent by the almost total obsolescence of the posterior part of the *Ctenobolbina* bulb (the obsolete part corresponds to the posterior lobe of a *Beyrichia*).

Having reached the stages of *C. subcrassa* and *C. fulcrata*, a further discrimination of the median lobe might result in a species like *C. impressa* (*Eutomis impressa* Steusloff) and finally in one like *Beyrichia antiqua* of the same author. In this last the median lobe is at least as large as in the average *Beyrichia*, and the species differs from the more usual types of this genus only in the less sharp defini-



FIGS. 39-44.—39. LEFT VALVE OF CTENOBOLBINA UMBONATA (STEUSSLOFF). 40. RIGHT VALVE OF CTENOBOLBINA FULCRATA (ULRICH). 41. RIGHT VALVE OF CTENOBOLBINA IMPRESSA (STEUSSLOFF). 42. LEFT VALVE OF CTENOBOLBINA SUBCRASSA ULRICH. 43. LEFT VALVE OF BEYRICHIA (STEUSSLOFFIA) ANTIQUA (STEUSSLOFF), $\times 20$. 44. LEFT VALVE OF BEYRICHIA (STEUSSLOFFIA) ACUTA (KRAUSE). (FIGS. 40 AND 42 ARE AFTER ULRICH, 39, 41, AND 43 AFTER STEUSSLOFF, AND 44 AFTER KRAUSE. ALL $\times 20$.)

tion of the post-median furrow and in the slight elevation and general lack of definition that pertains to both the anterior and posterior lobes.

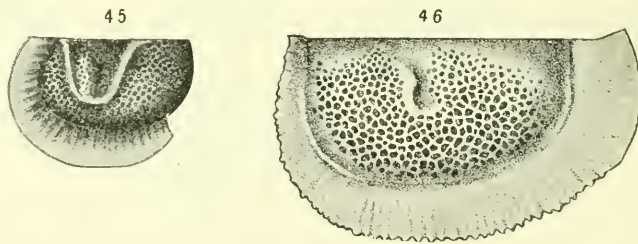
It is probably significant that most of these ribbed or crested species comprising the *B. linmarssoni* group are of Ordovician age, in which rocks *Ctenobolbina* and *Tetradella* are the prevailing genera, and unribbed, true *Beyrichias* almost unknown. The group, therefore, may be viewed as an intermediate stage in the development of at least one of the groups of *Beyrichia* from *Ctenobolbina*.

If accurately figured, Krause's *Strepula reticulata* should perhaps be referred to this group. On account of the proportionately elongate form of its valves and the great width of its marginal frill, the species would stand somewhat apart from the more typical representatives of the group. Because of a similarly fringed and reticulated *Beyrichia* in the Waldron shale of Indiana, it seems just pos-

sible that the figure given by Krause is a little defective at the base of the median and posterior lobes. The Waldron species sometimes even exhibits a suggestion of the V-shaped crest, but, as is shown on Plate XXXVII, the ventral part of the posterior lobe is distinctly contracted, giving an appearance quite different from the same part in Krause's figure of *B. reticulata*, but closely simulating the fringed species of the *B. maccoyi* group.

As figured, *B. reticulata* appears to be somewhat obscurely lobed, which, with the broad frill, is somewhat suggestive of *Eurychilina*. But it has no sharply defined median pit, and it is thought unlikely that the marginal frill is hollowed out on its inner surface. The median lobe also is too long. It seems probable, therefore, that the general resemblance to *Eurychilina* does not indicate close genetic relations.

The *B. linnarssoni* group has a sufficiently uniform expression to suggest the advisability of its separation as an independent though decidedly synthetic genus. The crested valves recall *Strepsula*, the



FIGS. 45-46.—RIGHT VALVE OF BEYRICHIA RETICULATA (KRAUSE), $\times 20$, AND THE SAME VALVE OF EURYCHILINA RETICULATA ULRICH, $\times 20$ (AFTER ULRICH), SHOWING THE SIMILARITY OF THE TWO FORMS REFERRED TO IN THE TEXT.

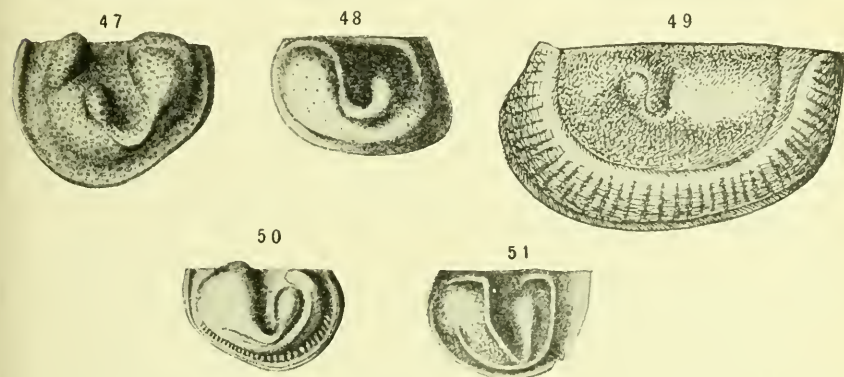
mode of lobation is very much as in the *Beyrichia salteriana* group, and through this resembles on the one hand the typical Beyrichian section of *B. tuberculata* and on the other *Kladdenia*. In still another direction, close alliance with *Utenobolbina*, as above outlined, is established. If *Utenobolbina* were expanded to take in a part of the group, consistency would demand that species of the *B. salteriana* group be also included. But this would render the boundary between *Utenobolbina* and *Beyrichia* more artificial than it is desired to make it. Besides, it would split up an apparently very natural association of species.

The group as a whole is undoubtedly more in accord with *Beyrichia* than *Utenobolbina*, and in the first suggestion of the heterogeneous mass of Beyrichiidae, its species were left with or referred to the restricted genus without much hesitation. However, in the still considerable and variable mass of species having the essential characters of *Beyrichia*, the comparative entity of the *B. linnarssoni* group is lost sight of. In order to secure its deserved recognition without

at the same time completely disassociating it from its most obvious alliance, it is provisionally suggested that the group be distinguished merely subgenerically from *Beyrichia*, and that it be known by the proposed name *Steusloffia*, with *Beyrichia linnarssoni* as the type.

GROUP OF *B. INTERRUPTA*.

Another resemblance that has led to unnatural associations is that borne to *Bollia* by a small group comprising *Beyrichia granulifera*, new name (*Bollia granulosa* Krause, specific name preoccupied under *Beyrichia*), and *B. v-scripta* (Krause), two Ordovician species, *B. damesi* Krause, and *B. interrupta* (Jones and Holl), two Silurian species. In fact, with the exception of *B. damesi*, all of these species were originally referred to *Bollia*, but, as will be clear enough when



FIGS. 47-51.—47, RIGHT VALVE OF BEYRICHIA INTERRUPTA (JONES), $\times 20$. 48, LEFT VALVE OF BEYRICHIA V-SCRIPTA (KRAUSE), $\times 15$. 49, RIGHT VALVE OF EURYCHILINA SUBRADIATA ULRICH, $\times 20$. 50, LEFT VALVE OF BEYRICHIA CLAVATA KOLMODIN. 51, LEFT VALVE OF BEYRICHIA (STEUSSLOFFIA) ACUTA (KRAUSE). (FIG 47 IS AFTER JONES, 48 AFTER KRAUSE, 49 AFTER ULRICH, 50 AFTER KIESOW, AND 51 AFTER KRAUSE.) THE ILLUSTRATIONS SHOW POSSIBLE DERIVATION OF THE BEYRICHIA INTERRUPTA GROUP FROM EURYCHILINA AND ITS RELATIONS TO THE BEYRICHIA CLAVATA GROUP AND TO STEUSLOFFIA.

that genus is considered, they do not belong there. The curved ridge in these species seems really to have no greater taxonomic significance than the similar node and ridge often seen in typical *Eurychilina*. On the other hand, the lobation of their valves, though in part obscure, is essentially that of *Beyrichia*, the connection with species of this genus like *B. jonesi* and *B. clavata* being, apparently at least, very clear.

The group suggests passage from Primitiidae to *Beyrichia*, but whether this suggestion is based on fact or is merely apparent and thus misleading, can not be decided with the evidence at hand. However, the possibility of species conforming to the generic diagnosis of

Beyrichia having been developed from diverse stocks by convergence in evolution, is worth bearing in mind. In general aspect, and especially in having a well-defined median pit, *B. granulifera* and *B. r-scripta* certainly indicate Primitian ancestry, close affiliations being suggested to both *Primitia* and *Eurychilina* (as, for instance, *E. schmidti*). However, an analysis of their lobes seems to show more positive alliances on the one hand to the *B. clavata* group of *Beyrichia*, and on the other to the proposed subgenus *Steusloffia*. Perhaps it would be well to institute another subgenus for this group.

Genus KLÆDENIA Jones and Holl.

Klædenia JONES and HOLL, Ann. and Mag. Nat. Hist. (5), XVII, 1886, p. 362.

Klædenia (part) KRAUSE, Zeits. d. d. geol. Gessell., XLI, 1889, p. 21.

Klædenia (part) MILLER, North Amer. Geol. and Pal., First App., 1892, p. 708.

Klædenia (part) KOKEN, Die Leitfossilien, 1896, p. 39, text fig. 26A.

Beyrichia (part) of AUTHORS.

Carapace of moderate size, 1 mm. to 4 or 5 mm. in depth. Valves very nearly equal, the ventral edge of the right valve sometimes very slightly overlapping the edge of the left. Outline oblong, subquadrate to subovate, rarely subtriangular, the hinge line long and straight, the remaining sides more or less curved. Surface of valves strongly convex, especially in the unlobed ventral half; dorsal half with two furrows deep above but growing obsolete before or shortly after crossing half the valve. Anterior furrow deeper and broader than the posterior one and located near the mid-length. Of the three lobes the median is the most constant in size and form. It is generally rounded and somewhat bulbous, more rarely obtusely pointed above, and its diameter usually about one-fifth of the length of the valve. Posterior and anterior lobes sharply defined only along the furrows, the outer parts usually sloping more or less gently to the end rims and below merging into the swollen ventral surface, their dorsal extremities occasionally projecting beyond the horizon line. Posterior lobe varying in width from rather less than to nearly twice the diameter of the median lobe. Anterior lobe constituting the greater part of this half of the valve, sometimes divided so as to form a broad inner lobe and one or two narrower ridges in front. When the anterior lobe is thus prolonged and divided (as, for instance, *K. plicatu* Jones), the separating furrows extend entirely across the valve. Ventral pouch (as in *Beyrichia* presumably of female) mostly posterior, merely an extra, obscurely outlined swelling, not globular as in *Beyrichia*. A simple, narrow, flange-like border commonly present but may be wanting. Surface of valves granulose, punctate, reticulate, or without ornament.

Genotype.—*Kladenia wilkensis* (*Beyrichia wilkensis* Jones).

LIST OF SPECIES HAVING THE CHARACTERS OF KLADENIA AS ABOVE DEFINED.

Kladenia apiculata Jones.

Kladenia barretti^a (*Beyrichia barretti* Weller).

Kladenia centricornis,^a new species.^b

Kladenia concinna (*Beyrichia concinna* Jones and Holl).

Kladenia fimbriata,^a new species.^c

Kladenia granulata^a (*Beyrichia granulata* Hall).

Kladenia initialis^a (*Beyrichia initialis* Ulrich).

Kladenia intermedia (*Beyrichia intermedia* Jones and Holl).

Kladenia intermedia marginata Jones and Holl.

Kladenia jerseyensis^a (*Beyrichia jerseyensis* Weller).

Kladenia kummeli^a (*Beyrichia kummeli* Weller).

Kladenia manliensis^a (*Beyrichia manliensis* Weller).

Kladenia manliensis deckercensis^a (*Beyrichia deckercensis* Weller).

Kladenia marginalis,^a new species.^d

Kladenia montaguensis^a (*Beyrichia montaguensis* Weller).

Kladenia nearpassi^a (*Beyrichia nearpassi* Weller).

Kladenia oculina^a (*Beyrichia oculina* Hall).

Kladenia parasitica^a (*Beyrichia parasitica* Hall).

Kladenia prænuntia,^a new species.^e

Kladenia punctillosa,^a new species.^f

^a American species.

^b The unusual length of the valve, spine-like central node, and coarse pitting are features which will cause the easy identification and differentiation of this species from others of the genus. See Plate XXXVIII, fig. 23.

Formation and locality.—Coeymans limestone, Cumberland, Maryland.

Holotype.—Cat. No. 53305, U.S.N.M.

^c This fine species will be recognized at once by its spinous margin. This spiny frill, together with the reticular surface ornament and general neatness of form, impart a striking elegance to the shell. See Plate XXXVIII, fig. 22.

Formation and locality.—Coeymans limestone, Herkimer County, New York.

Holotype.—Cat. No. 53306, U.S.N.M.

^d This species is similar to *Kladenia manliensis* (Weller), but has a wider margin, is more elongate, and its sulci are much shallower. The surface is smooth, without ornament. See Plate XXXVIII, fig. 16.

Formation and locality.—Helderbergian, Dalhousie, New Brunswick.

Holotype.—Cat. No. 53307, U.S.N.M.

^e The distinctive features of this species are the unusual narrowness of the posterior lobe and the sharp impression yet unusual brevity of the sulci. The smooth surface and obscurely defined marginal rim will likewise assist in the discrimination of the species. See Plate XXXVIII, fig. 15.

Formation and locality.—Ordovician (local bed in upper part of Hermitage formation). Four miles south of Carthage, Tennessee.

Holotype.—Cat. No. 41643, U.S.N.M.

^f This new species is similar to *Kladenia nearpassi* (Weller) and *K. barretti* (Weller) in outline, but its dorsal angle is more nearly rectangular and the marginal rim narrower. The surface is finely punctate. See Plate XXXVIII, fig. 17.

Formation and locality.—Helderbergian, Dalhousie, New Brunswick.

Holotype.—Cat. No. 53308, U.S.N.M.

Klædenia retifera,^a new species,^b

Klædenia scotica (*Beyrichia klædeni*, var. *scotica* Jones and Holl.)

Klædenia simplex^a Jones.

Klædenia smacki^a (*Beyrichia smacki* Weller).

Klædenia susserensis^a (*Beyrichia susserensis* Weller).

Klædenia tuberculata (*Beyrichia tuberculata* Salter).

Klædenia wallpackensis^a (*Beyrichia wallpackensis* Weller).

Klædenia wilckensiana (*Beyrichia wilckensiana* Jones).

Klædenia wilckensiana plicata (*Beyrichia wilckensiana plicata* Jones).

Of the above species, *K. initialis* and *K. prænuntia* are middle Ordovician and *K. simplex* late Devonian. All the others are of Silurian, mainly late Silurian, age.

It will be seen from this list of species that *Klædenia*, as here defined, includes only six of the twelve species and varieties which have been referred to it. Most of the others constitute a distinguishable group of which *K. pennsylvanica* Jones is a good example, and which it is proposed to separate as a new genus under the name *Klædenella*. The new genus, as will be more fully set forth on a following page, differs from true *Klædenia*, as understood by the writers, chiefly in the more cylindrical form of its shells and the greater inequality of its valves. In both of these respects, typical *Klædenia* is essentially the same as *Beyrichia*, the differences between the two lying in the relative convexity and lobation of the valves.

In *Beyrichia* the valves are depressed convex, the three lobes are represented by sharply defined ridges or elevations which rise abruptly above the flattened floor of the valves. The ridges are separated by deep, vertical furrows, which, though varying in width, are yet very constant in their length. As a rule, the posterior furrow extends across the valve to the ventral rim. The anterior furrow commonly is limited below by the ventral junction of the anterior and median lobes, but when the latter is isolated it passes around the lower side of the median lobe and merges with the posterior furrow.

In *Klædenia* the main furrows never extend across the valves, but are confined to its dorsal half. They mark off a rather large submedian node and often converge beneath so as to isolate it. The anterior and posterior lobes are broad and never ridge-like, but, as a rule, form part of the general convexity of the valve. In fact, the majority of the species might be described as approximately uniformly convex save for the short furrows inclosing the median node.

^a American species.

^b The surface ornament, practically obsolete marginal rim, the small spine at posterior extremity of hinge, and the unusually slight depth of the sulci are characters which will distinguish this species. See Plate XXXVIII, fig. 18.

Formation and locality.—Helderbergian, Dalhousie, New Brunswick.

Holotype.—Cat. No. 53939, U.S.N.M.

The relations of the genus to the group of *Beyrichia salteriana*, which section of *Beyrichia* includes the species most like *Klædenia*, have been discussed on a preceding page.

Klædenia may have been evolved through several rather widely different ways. First, it may have been derived from the *salteriana* group of *Beyrichia* by the ventral coalescence of the three lobes. Though possible, even reasonable, the known species afford no satisfactory evidence of such an alliance. In the absence of intermediate stages, the evidence must be admitted as wholly negative, if not positively opposed to this view. Considering that the *salteriana* group of *Beyrichia* is Silurian, and that *Klædenia*-like ostracoda began already in middle Ordovician time, it is clear that only a part of the genus could have been descended from *Beyrichia*.

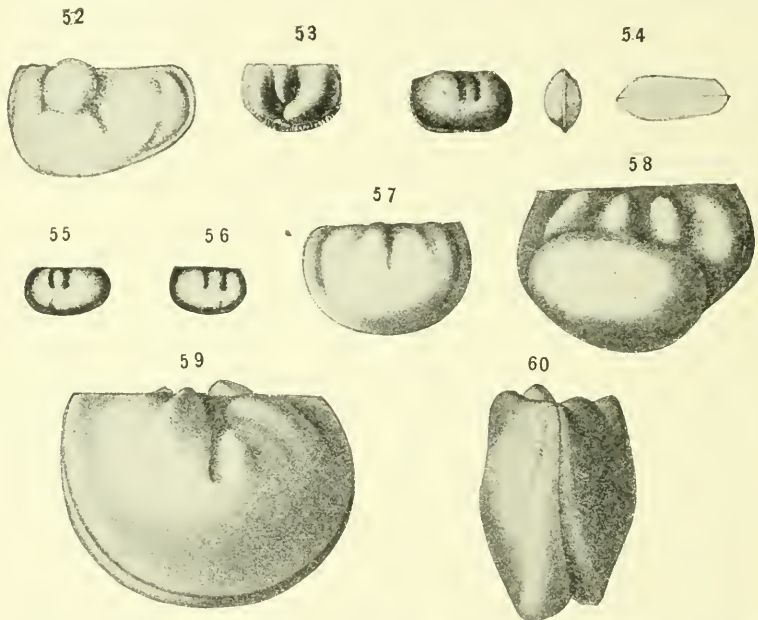
According to the second view, *Klædenia* was derived from some unsulcate Primitian stock by the segregation and enlargement of the post-median node. Suggestive resemblances may be noted on comparison with the Ordovician *Primitia tumidula*, *P. cincinnatiensis*, *Eurychilina reticulata*, and *E.? subaquata*. Regarding the two valves of *P. tumidula* figured by Ulrich^a as right valves, and comparing them with the right valve of *Klædenia initialis* (*Beyrichia initialis* Ulrich) figured on the same plate, the possible derivation from *Primitia* is clearly indicated by correlation of the nodes and furrows. It should be borne in mind, however, that this comparison merely indicates the *kind* of steps by which passage from *Primitia* to *Klædenia* may have been effected, and not the links themselves, because *K. initialis* is older than either of the two *Primitias* mentioned.

Still other derivations are suggested by the new Ordovician species, *K. prænuntia*. This is a larger shell than any *Primitia* and has the median lobe too well separated to recall that genus. Except for the much sharper definition of the *Klædenia* characteristics, this species resembles leperditellæ like *L. germana* and *L.? dorsicornis*. But it recalls even more *Drepanella elongata*, which differs in little that may be called essential except that it has the sickle-shaped ridge of *Drepanella*. This ridge is weaker in *D. elongata* than usual, and it is really conceivable that it might have become obsolete early in the descendants of this species, and thus give origin to a stage that, with our present limited knowledge, must be referred to *Klædenia*.

These diverse, yet all reasonably possible, derivations of *Klædenia* illustrate the extreme difficulties encountered in determining the genetic relations of the major groups of the family Beyrichiidae. Though inclined to favor the view that the majority of the species referred to *Klædenia* were evolved out of *Primitia*, it must be admitted that the evidence is far from conclusive.

^a Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, pl. XLIII, figs. 62-65.

The genus *Kyammodes* Jones, founded on a British Devonian species, but thought to include also a few Silurian forms (as, for instance, *Klædenia kiesowi* Krause), doubtless is closely allied to and probably evolved out of typical *Klædenia*. Though distinguished chiefly by the much greater inequality of its valves, the thick ventral edge of the right overlapping the smaller left valve, there are some peculiar differences in lobation also. In all the species there is a deep median furrow that, however, dies out before reaching the middle of the valve. In *Kyammodes kiesowi* (*Klædenia kiesowi* Krause) the parts



FIGS. 52-60. — 52, 53, RIGHT VALVE OF *KLÆDENIA WILCKENSIANA* (JONES), $\times 8$ (FEMALE INDIVIDUAL), AND *BEYRICHTIA SALTERIANA* JONES, $\times 10$, RESPECTIVELY, SHOWING THE RELATION OF *KLÆDENIA* TO THE *B. SALTERIANA* GROUP. (AFTER JONES AND REUTER.) 54, LEFT SIDE, END, AND VENTRAL VIEWS OF COMPLETE CARAPACE OF *KLÆDENELLA PENNSYLVANICA* (JONES), $\times 15$. (COPIED FROM JONES.) 55, 56, RIGHT AND LEFT VALVES OF *KLÆDENIA NEARPASSI* (WELLER), $\times 6$. (AFTER WELLER.) 57, 58, LEFT AND RIGHT VALVES, THE LATTER A FEMALE FORM, OF *KYAMMODES KIESOWI* (KRAUSE), $\times 10$. (AFTER KRAUSE.) 59, 60, LEFT VALVE AND ANTERIOR VIEW OF COMPLETE CARAPACE OF *KYAMMODES WHIDBORNEI* JONES, $\times 20$. (AFTER JONES.) THE SIMILARITY OF *KLÆDENIA*, *KLÆDENELLA*, *KYAMMODES*, AND THE *BEYRICHTIA SALTERIANA* GROUP ARE SHOWN IN THE ABOVE FIGURES.

of the valve are arranged almost regularly bilaterally with respect to this furrow, which separates two subequal, low nodes, each taking up about one-fifth the total length of the valve. The outer limits of these nodes are defined by shallower converging furrows, which in turn set off another matching pair of similarly curving low ridges. In *K. whidbornei*, the type of the genus, the lobes are both less regular and less constant in their development, the posterior median lobe, which corresponds to the median lobe of *Klædenia*, being especially variable. As a rule it is smaller and set farther down than the antero-

median one, and, furthermore, tends to merge with the post-dorsal node.

The type of the genus *Klædenia*, *K. wilckensiana*, occupies an intermediate position between two sections into which the genus is divisible. One of these sections, the smaller, includes, with the genotype, most of the European species, while all the known American forms fall into the second. The first section is characterized by a tendency to produce and to attenuate the anterior extremity and to develop on this part one or two accessory furrows. In consequence the outline of the valves is more or less triangular and comparatively elongate. In the American section of the genus the valves are usually shorter, the ends approximately equal and the anterior one without distinct furrows.

Of American species, *K. oculina* (Hall) and *K. notata* (Hall) probably are to be regarded as nearest to *K. wilckensiana*. It is certain at least that they are congeneric, and it seems no less a fact that these species belong to the same genus as those constituting the prevailing American type of Beyrichiidae found in the late Silurian Manlius and Coeymans, members of Hall's Lower Helderberg group. The writers therefore feel little hesitancy in revising and restricting the genus as indicated above. The elimination of the *K. pennsylvanica* group is the most important departure from Jones's later conception of *Klædenia*. Another is the inclusion of certain species, like *K. tuberculata* (Salter), which he had left with *Beyrichia*, indeed, in the case mentioned, as a variety of *B. klædeni*. Speaking of *K. tuberculata*, it is worth noting that this is one of the very few European Beyrichiidae that is represented in America by a form so nearly like Scandinavian specimens that a specific distinction is scarcely justified. Hall called the American variety *Beyrichia granulata*.

Except the two Ordovician species, *K. prununtia*, new species, and *K. initialis*, and the Chemung species, *K. simplex*, all of which, though doubtless possessing the essential features of the genus, are yet referred here with some misgivings, the genus *Klædenia* is confined to Silurian rocks. In its typical expression, indeed, the genus might be regarded as one of the most characteristic fossils of this system. In America there are numerous, in part undescribed species. By far the greater number of these are found in the upper parts of the Silurian and principally in the Manlius and Coeymans limestones. So far none has been seen in the overlying New Scotland formation. It is interesting and important to note further that all the known species are confined to Appalachian and more eastern Atlantic provinces, the genus apparently having failed to gain a foothold in the interior Ohioan Province.

The new species figured on Plate XXXVIII are only a part of those determined during the course of the present studies.

Genus TETRADELLA Ulrich.

Tetradella ULRICH, Jour. Cincinnati Soc. Nat. Hist., XIII, 1890, pp. 112-114.

Tetradella MILLER, North Amer. Geol. and Pal., First App., 1892, p. 711.

Tetradella ULRICH, Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, p. 677.

Beyrichia (part) of AUTHORS.

Based on *Tetradella quadrilivata*, the genotype, and drawn up so as to include the subjoined list of unquestioned species, this genus may be characterized as follows:

Carapace small, 1 mm. to 2 mm. long, equivalved, never tumid, somewhat oblong, varying from subquadrate to subovate, with the hinge line straight. Valves depressed-convex, deeply trisulcate, the furrows separating four more or less sharply elevated ridges. As a rule the ridges connect ventrally, but are quite distinct at their dorsal extremities, the result being a semielliptical submarginal ridge with two simple or double, equal or unequal, and less curved ridges within the inclosed space. These inner ridges commonly unite with the ventral part of the marginal ridge and extend upward from it toward the dorsal edge, the posterior one often failing to reach it. Free margins usually with a simple flattened border, which in certain cases extends beyond and conceals thickened contact edges. Surface of valves usually smooth, occasionally minutely granose.

All of the species of *Tetradella* and of the new subgenus *Kiesowia*, a list of which follows, are derived from Ordovician strata.

LIST OF SPECIES OF TETRADELLA.

Tetradella ? *affinis* (*Beyrichia affinis* Jones).

Tetradella bohémica (*Beyrichia bohémica* Barrande MSS. Jones).

Tetradella bussacensis (*Beyrichia bussacensis* Jones).

Tetradella carinata (*Beyrichia carinata* Krause).

Tetradella complicata (*Beyrichia complicata* Salter).

Tetradella complicata decorata (*Beyrichia complicata*, var. *decorata* Jones).

Tetradella ? *digitata* Krause (*Beyrichia digitata* Krause).

Tetradella ? *digitata separata* (*Beyrichia digitata*, var. *separata* Steusloff).

Tetradella (*Kiesowia*) *dissceta* (*Beyrichia dissceta* Krause).

Tetradella ? *erratica* (*Beyrichia erratica* Krause).

Tetradella harpa (*Beyrichia harpa* Krause).

Tetradella ? *lacunata* (*Beyrichia lacunata* Jones and Holl).

Tetradella lunatifer^a (*Strepula lunatifer* Ulrich).

Tetradella (*Kiesowia*) *mamillosa* (*Beyrichia mamillosa* Krause).

Tetradella marchica (*Beyrichia marchica* Krause).

Tetradella marchica angustata (*Beyrichia marchica*, var. *angustata* Krause).

Tetradella marchica lata (*Beyrichia marchica*, var. *lata* Krause).

Tetradella palmata (*Beyrichia palmata* Krause).

^a American species.

Tetradella quadrilirata^a (*Beyrichia quadrilirata* Hall and Whittfield).

Tetradella (*Kiesowia*) *radians* (*Beyrichia radians* Krause).

Tetradella ribciviana (*Beyrichia ribciviana* Jones).

Tetradella simplex^a (*Tetradella quadrilirata* var. *simplex* Ulrich).

Tetradella subquadrans^a Ulrich.

In the original description of the genus^b the species subsequently distinguished as *Ceratopsis*^c were included. In 1889^d the typical species was erroneously referred to *Strepula* Jones and Holl. In 1894,^e when the revised description of *Tetradella* was published, certain European species were referred to the genus, which it is now thought advisable to view as doubtful or to place elsewhere. Thus, *T. signata* Krause, as mentioned on page 295, is now referred to *Steusloffia*, a proposed subgenus of *Beyrichia*. *T. (Beyrichia) eratica* Krause may belong to the same subgenus, but it is preferred to regard it provisionally as questionable, because, with the evidence available to the writers, it is impossible to decide that it is not a *Strepula* rather than a *Tetradella* or a *Steusloffia*. *T. (Beyrichia) lacunata* Jones may be a degenerated species of the genus, but in the absence of satisfactory specimens it should be placed as doubtful. *T. (Beyrichia) affinis* Jones also is doubtful, and the same is true of *T. (Beyrichia) digitata* Krause. Of the species there designated as "somewhat doubtful upper Silurian representatives," *B. nodulosa* is returned to *Beyrichia*, but *B. dissecta* Krause, *B. radians* Kiesow, and *B. mamillosa* Krause must be removed or continue to be regarded as questionable. The dissection of the lobes in the latter two is somewhat similar to what occurs in *Beyrichia* of the group of *B. tuberculata* (see page 289). Critically compared, however, the breaking up of the lobes is not exactly the same. No *Tetradella* could be dissected so as to look like *B. tuberculata* or any of its immediate allies; but if the vertical part of the ridges of, say, *Tetradella subquadrata*, were divided transversely and the furrows were extended ventrally through the marginal ridge, the result would be, in every essential respect, precisely as in *B. dissecta*. The size of the valves also accords much better with the average for *Tetradella* than for *Beyrichia*. Under the circumstances, a separation from both *Beyrichia* and *Tetradella* is suggested, but should it be decided, as the writers believe, that the two species were derived from *Tetradella*, the demands of classification might very well be satisfied by subgeneric discrimination. The name *Kiesowia* is proposed, with *Beyrichia dissecta* Krause as the type of the new genus or subgenus.

^a American species.

^b Jour. Cincinnati Soc. Nat. Hist., XIII, 1890, p. 112.

^c Ulrich, Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, p. 675.

^d Ulrich, Geol. Surv. Canada, Cont. Micro-Pal., Pt. 2, 1889, p. 54.

^e Ulrich, Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, p. 677.

Genus CERATOPSIS Ulrich.

Ceratella ULRICH, Jour. Cincinnati Soc. Nat. Hist., XIII, 1890, p. 113 (not established).

Ceratopsis ULRICH, Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, p. 675.

Beyrichia (part) of AUTHORS.

Carapace essentially as in *Tetradella* except that the post-dorsal end of the marginal ridge is raised into a strong, spine-like, or a mushroom-shaped process, which is commonly beaded or fimbriated along one edge or around the flattened top. Free edges of carapace blunt, the contact line between the two valves concealed by well-developed false borders.

Genotype.—*Ceratopsis chambersi* (*Beyrichia chambersi* Miller).

This genus stands to-day in essentially the same position given it in the original definition. The species referred to it then are still retained, and few new species or varieties of the genus have been discovered in the past fourteen years. Among the specimens then referred to the genotype several minor varieties might have been distinguished, but the propriety of doing so was not appreciated at the time. At least one, and probably two, of these varieties seem to be confined to different stratigraphic horizons. Their discrimination, therefore, in a subordinate degree might be desirable on this account alone. However, as the prime object of this paper is to discuss generic rather than specific and minor variations, it is thought advisable to defer such matters to a time when it will be possible to treat the subject monographically.

In addition to *C. chambersi*, the genus includes *C. robusta* Ulrich, *C. intermedia* Ulrich, *C. oculifera* Hall, all American upper Ordovician species, and *C. hastata* (*Beyrichia hastata* Barrande), a Bohemian species of similar age. *Beyrichia rostrata* Krause, from Ordovician drift in northern Germany, seems referable to *Ceratopsis* rather than *Tetradella*. The same is to be said of *Beyrichia quadrifida*, described by Jones as from the "Trenton" at Lorette Falls, Canada. In the figured specimen of the latter the horn is evidently broken away. In the former, providing Krause's figures represent the species fully and accurately, the horn is not so well developed as in the Cincinnati species. Assuming that the last two are correctly understood, then the genus, as at present known, comprises seven species, ranging in time from about Black River to the close of the Ordovician. Apparently the stock became extinct with the close of this period.

Genus CTENOBOLBINA Ulrich.

- Ctenobolbina* ULRICH, Jour. Cincinnati Soc. Nat. Hist., XIII, 1890, p. 108.
Ctenobolbina MILLER, North Amer. Geol. and Pal., First App., 1892, p. 706.
Bollia (part) KRAUSE, Zeits. d. d. geol. Gesell., XLIV, 1892, p. 392.
Entomis (part) STEUSLOFF, Zeits. d. d. geol. Gesell., XLVI, 1894, p. 780.
Ctenobolbina ULRICH, Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III,
 Pt. 2, 1894, p. 673.
Ctenobolbina GRABAU, Bull. Buffalo Soc. Nat. Sci., VI, 1899, p. 309.
Ctenobolbina ULRICH, Jour. Cincinnati Soc. Nat. Hist., XIX, 1900, p. 180.
Beyrichia (part) of AUTHORS.

Carapace small, usually less than 2 mm. in length, subquadrate or subovate in outline, the hinge line long and straight; posterior two-fifths more or less decidedly bulbous or subglobular in the typical section of the genus, but in the *C. subcrassa* section the corresponding parts of the carapace are smaller and usually of lesser thickness than certain portions in front of it. In the latter section a small node (the homologue of the median lobe of *Beyrichia*) is sometimes distinguishable on the inner slope of the posterior lobe. One deep, long, narrow, generally curved and more or less oblique sulcus extends from the middle of the dorsal edge toward the post-ventral angle, occasionally reaching the border. Area in front of median sulcus either simply convex or divided by a shallower furrow usually paralleling the main sulcus. Valves equal, the free edges thick, the contact margins generally concealed, partly or wholly, in a lateral view, by a variously modified overhanging border. Surface granulose, smooth, or punctate.

Genotype.—*Ctenobolbina ciliata* (*Beyrichia ciliata* Emmons).

Since 1890, when this genus was first described, Ulrich has on two occasions (both cited above) added to the list of species originally referred to the genus. Recent studies of the family have convinced the writers that a good part of these later additions represents, as indicated on page 295, atavistic Devonian stages in the development and decadence of the predominating Silurian phase of the family. Admitting this as probably true, it is thought desirable and of distinct advantage in classification to remove these species from *Ctenobolbina* and to refer them, together with a few species hitherto placed with *Beyrichia* and *Bollia*, to a new genus for which the name *Hollina* is proposed on a following page.

Even after the elimination of this peculiar Devonian group, the remaining species fall into two easily distinguishable subgenera or sections of the genus. The first of these two groups includes *C. ciliata* and its immediate Ordovician allies—all of them with a granulose surface ornament—one early Trenton, one Silurian species with finely reticulate surface, one Helderbergian, and one middle Devonian papillose species. This section is characterized by the

thick, bulb-like form of the posterior lobe, which single swelling comprises both the median and the posterior lobe of a true *Beyrichia*, and by its surface ornament. The second group consists of species without surface ornamentation and whose average size is inferior to that of the first group. The posterior lobe is smaller and commonly exhibits a tendency to segregate a small node or undefined swelling on its inner slope that doubtless represents the larger and more definitely separated median lobe of *Beyrichia*. So far this section is known by seven Ordovician species, one Silurian, one Devonian, and one early Mississippian species. It seems probable that the two Ordovician forms described by Krause as *Bollia minor* and *Bollia major*^a are also referable to this section. They are most certainly not true *Bollias*.

As now restricted and defined, *Ctenobolbina* includes the following species:

GROUP OF CTENOBOLBINA CILIATA.

ORDOVICIAN SPECIES.

- Ctenobolbina alata*^b Ulrich.
Ctenobolbina bispinosa^b Ulrich.
Ctenobolbina ciliata^b (*Beyrichia ciliata* Emmons).
Ctenobolbina curta^b (*Ctenobolbina ciliata*, var. *curta* Ulrich).
Ctenobolbina duryi^b (*Beyrichia duryi* Miller).
Ctenobolbina emaciata^b (*Ctenobolbina ciliata*, var. *emaciata* Ulrich).
Ctenobolbina guillieri (*Beyrichia guillieri* Tromelin).
Ctenobolbina hammelli^b (*Beyrichia hammelli* Miller and Faber).
Ctenobolbina obliqua^b Ulrich.
Ctenobolbina oblonga (*Entomis oblonga* Stensloff).

SILURIAN SPECIES.

- Ctenobolbina granosa*^b Ulrich.
Ctenobolbina punctata^b Ulrich.

DEVONIAN SPECIES.

- Ctenobolbina papillosa*^b Ulrich.

GROUP OF CTENOBOLBINA SUBCRASSA.

ORDOVICIAN SPECIES.

- Ctenobolbina crassa*^b Ulrich.
Ctenobolbina fulcrata^b Ulrich.
Ctenobolbina impressa (*Entomis impressa* Stensloff).
Ctenobolbina major (*Bollia major* Krause).
Ctenobolbina minor (*Bollia minor* Krause).
Ctenobolbina subcrassa^b Ulrich.
Ctenobolbina umbonata^b (*Entomis umbonata* Stensloff).

^a Zeits. d. d. geol. Gesell., XLIV, 1892, pp. 391, 392, pl. XXI, figs. 15, 18.

^b American species.

SILURIAN SPECIES.

Ctenobolbina auricularis (*Bollia auricularis* Jones).

DEVONIAN SPECIES.

Ctenobolbina minima^a Ulrich.

MISSISSIPPIAN SPECIES.

Ctenobolbina loculata^a Ulrich.

Krause^b and Stensloff^c have described and referred a number of unisulcate Ordovician species to *Entomis*. This arrangement of the species is probably incorrect, the present writers doubting even that the typical Entomidæ are Ostracoda at all. Krause's and Stensloff's entomids, on the contrary, seem to be closely allied to *Ctenobolbina*, and, in part at least, congeneric with species referred to this genus. Others like Krause's *E. sigma* and *E. obliqua* are so completely bilobed as to suggest *Dilobella*. Pending an opportunity to study specimens of all these species, those not elsewhere referred in this work may be provisionally left where their authors placed them.

As stated on page 290, *Ctenobolbina tumida* Ulrich^d (see fig. 24, p. 292) is now thought to be a peculiar *Beyrichia* and to have no very intimate relations to the typical species of *Ctenobolbina*. Indeed, the bulbous end of the carapace in *B. tumida* is regarded as anterior, whereas in *C. ciliata* the thicker end is posterior. Hence, if the species is allied to *Ctenobolbina* at all, it must be to the *C. subcrassa* section and not to the typical section of the genus.

The genetic alliance of *Ctenobolbina* to *Beyrichia* (more especially to the subgenus *Stensloffia*) has been discussed on pages 296 to 299.

Genus DREPANELLA Ulrich.

Depranella ULRICH, Jour. Cincinnati Soc. Nat. Hist., XIII, 1890, pp. 117, 118.

Depranella MILLER, North Amer. Geol. and Pal. First App., 1892, p. 707.

Drepanella (part) ULRICH, Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, p. 670.

Carapace equivalves, usually about 2.5 mm. long, compressed convex, somewhat oblong, subquadrate to subelliptical in outline; dorsal edge straight, ventral side gently convex, ends subequal, the post-dorsal angle sharper than the anterior. A constant sickle-shaped, sharply defined ridge runs nearly parallel with and generally not far within the posterior and ventral edges of the valves. Central and

^a American species.

^b Zeits. d. d. geol. Gesell., XLIV, 1892, pp. 383-399; XLVIII, 1896, p. 935.

^c Idem, XLVI, 1894, p. 777.

^d Jour. Cincinnati Soc. Nat. Hist., XIII, 1890, p. 111, pl. vn, figs. 5a, 5b.

dorsal regions with two to seven nodes, the larger numbers resulting through dissection of the primary two. When only two, they may form a loop by union of their ventral parts. Surface smooth or coarsely reticulated.

Genotype.—*Drepanella crassinoda* Ulrich. Other species referred here, all of Ordovician age, are: *D. ampla* Ulrich, *D. bigeneris* Ulrich, *D. crassinoda nitida* Ulrich, *D. elongata* Ulrich, *D. macra* Ulrich, *D. richardsoni* (*Beyrichia richardsoni* Miller) and *D. richardsoni canadensis* Ulrich.

This apparently wholly American genus is remarkable for the extreme variability of the nodes within the central area of the valves. The binodose *D. ampla* probably represents the most simple type. From this we pass to *D. elongata*, with its ventrally fuller valves and Klødenia-like reduction and disposition of the nodes. There is a depression or sulcus between the nodes in this species. A similar depression of the surface outside of the nodes, without a reduction in altitude of the nodes and the lower boundary of the median sulcus, would result in a form essentially like *D. bigeneris*, which is strikingly like a *Bollia*. In *D. macra*, *D. crassinoda*, and *D. nitida* the nodes range in number from three in the first to seven in the last. A comparison of the nodes of these three species established beyond question that the larger numbers are produced by dissection. Indeed, the seven nodes of *D. nitida* are all indicated by corresponding wholly or partially separated nodes in *D. crassinoda*, and the corresponding parts are no less easily recognized in *D. macra*.

The only constant features of *Drepanella* are the sickle-shaped submarginal ridge, and, within reasonable bounds, the size of the carapace. In other respects the species are sometimes highly suggestive of in part probably very distinct contemporary and later genera. Thus, as stated on page 303, *D. elongata* might be classed as a *Klødenia* if it had not the characteristic, submarginal ridge, while it is really difficult to point out sufficient reasons for excluding *D. bigeneris* from *Bollia*. But *Drepanella* is an old genus—probably the oldest of the true rigid Beyrichiida—having been already well established in the Stones River epoch. These diverse resemblances may, therefore, be explained as synthetic vacillations of an ancient type prior to the fixation of generic characters marking later developmental stages within the family. The sickle-shaped ridge, however, was a fixed character and doubtless left its imprint in the history of the family. It is, therefore, not surprising that in the decadence of the main Silurian genus *Beyrichia* this ridge is again occasionally recognized. It is well shown, for instance, in the peculiar Devonian descendant of *Beyrichia*, *Hollina kolmodini* (Jones).

The probable relations of *Drepanella* to *Beyrichia*, especially to the *tuberculata* and the *clarata* sections, have been sufficiently dis-

cussed on pages 289 and 294. It is a remarkable fact that these two alliances are more obvious and apparently more intimate than are those between *Drepanella* and such nearly equally old genera as *Ctenobolbina* and *Tetradella*. There is so little evidence of transition between them that derivation of either of the latter from the first, or of the first from either of the latter, seems out of the question. Though it is highly probable that all three were derived out of the same stock—presumably *Primitia*—it seems certain that the departures from that primitive line were entirely independent and in all cases rapid. Indeed, *Primitia* itself, which contains the oldest of the distinctly furrowed Ostracoda, does not, geologically speaking, greatly antedate *Drepanella*. The Cambrian seems to contain no Ostracoda at all,^a the oldest known representatives of the class being Leperditiidæ, found in rocks of Beekmantown age. The Primitiidæ and Beyrichiidæ did not appear till post-Beekmantown.

The species described in 1894 by Ulrich as *Drepanella bilateralis*^b is so peculiar that it seems unwise to continue listing it as a species of this genus. Though exhibiting a general resemblance to *D. crassinoda*, it seems on closer comparison that the surface lobation is really very different. In the first place, the marginal ridge is developed only along the ventral border, terminating abruptly on both sides, when it begins to turn up on the ends. Next the nodes above the ridge do not correlate satisfactorily with those of any of the other species. There is a bilateral symmetry in their form and arrangement with respect to the small mid-dorsal node that can not be duplicated in typical *Drepanella*, nor readily explained. The explanations occurring to the writers entail departures from that generic type of such importance that the removal of the species from *Drepanella* seems imperative. If the posterior node is assumed to be in part made up of the post-dorsal portion of the marginal ridge, then its inner part must represent the lower two-thirds of the trinodate post-median ridge of *D. crassinoda* and the mid-dorsal node the upper third of that ridge. According to another interpretation the mid-dorsal node of *D. bilateralis* would correspond to the dorsal part of the antero-median node of *D. crassinoda* and the main but antero-median node, together with the crescentic ridge beneath it and the small antero-dorsal node in the latter. In either case it would mean that the mid-dorsal node occupies a different position from the corresponding part of typical *Drepanella*; also modification of the posterior lobes scarcely compatible with a strict conception of

^a A comprehensive study of the supposed Cambrian Ostracoda recently completed has led to the conviction that these are Phyllocarida and not Ostracoda.

^b Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, p. 671, pl. XLVI, figs. 35-38.

Drepanella. Under the circumstances the writers feel justified in proposing a new genus, with the following brief diagnosis.

Genus SCOFIELDIA, new.

Drepanella (part) ULRICH, Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, p. 670.

Carapace 2 mm. to 3 mm. in length, oblong, subquadrate, compressed; surface of valves broken up into ridges and nodes arranged bilaterally with respect to a small node situated close to the middle of the straight hinge line; on either side a large, irregularly triangular, ridged node, and along the ventral edge a thick, sharply elevated, bar-like ridge.

Genotype.—*Scofieldia bilateralis* (*Drepanella bilateralis* Ulrich).

The generic name is given in remembrance of Mr. Wilbur H. Scofield, with whom the senior author was pleasantly associated in the study of the Ordovician Gastropoda of Minnesota.

Genus TREPOSELLA, new.

Beyrichia (part) ULRICH, Journ. Cincinnati Soc. Nat. Hist., XIII, 1891, p. 190.

Carapace small, about 1 mm. in length, semiovate or subquadrate, the hinge long and straight, the other margins curved and supplied with a radially striated frill. Ventral part of valves swollen, the fullness forming a low, not sharply defined longitudinal ridge. Just above this, two unequal nodes, the smaller being of hemispheric form and located just behind the center of the valve. The larger node is somewhat balloon-shaped, situated in front of the middle, connected to the ventral ridge by a narrow neck, from which it extends upward to or slightly beyond the dorsal edge. Between the two nodes, a narrow, sharply excavated sulcus, terminating below in a pit. Female (?) provided with a sharply defined, egg-shaped, ventral pouch, located practically midway between the ends.

Genotype.—*Treposella lyoni* (*Beyrichia lyoni* Ulrich).

This genus is proposed for the reception of what is supposed to be an important link in the evolution of *Hollina* from *Beyrichia*. The female is still provided with a ventral pouch, but it is essentially median in position, while in all true *Beyrichiæ* it is placed well behind the mid-length. The anterior lobe also is essentially as in *Beyrichia*, but the indefinite ventral swelling is suggestive of *Kladenia* rather than *Beyrichia*. Compared further with *Beyrichia*, the entire obsolescence of the posterior ridge of that genus in *Treposella* is perhaps the most striking difference. The presence of a sharply defined median pit, as in *Eurychilina* and other Primitiidae, is probably a reversion to ancestral characteristics.

Except the ventral pouch, all the above-mentioned departures from the typical Silurian *Beyrichia* are toward the new Devonian and Carboniferous genus *Hollina*. Indeed, were it not that *T. lyoni* still possesses the Beyrichian ventral pouch, the writers would undoubtedly have referred the species to *Hollina*. But, having a pouch, and being also in other features nearer *Beyrichia* than is any one of the species of *Hollina*, the intermediate position of *T. lyoni* seems assured. As its inclusion in either of these genera would introduce undesirable elements of uncertainty in their respective diagnoses, it has been thought advisable to give it and any other similar species that may be discovered an independent position.

Genus HOLLINA, new.

Ctenobolbina (part) ULRICH, Jour. Cincinnati Soc. Nat. Hist., XIII, 1891, p. 187; XIX, 1900, p. 182.

Beyrichia (part) JONES, Quart. Jour. Geol. Soc. London, XLVI, 1890, p. 538.—ULRICH, Jour. Cincinnati Soc. Nat. Hist., XIII, 1891, p. 189.

Bollia (part) ULRICH, Jour. Cincinnati Soc. Nat. Hist., XIII, 1891, p. 205.

Carapace elongate, produced and tapering somewhat anteriorly, essentially equivalved. Valves provided with a marginal frill, concave on the inner side, overhanging the contact edge, often wanting at the anterior end. Except for two constant rounded nodes, the lobation of the surface varies greatly. One of the constant nodes is situated close to and partly in front of the middle of the hinge line; the other, usually the smaller, is placed lower and more or less behind the center of the valve. Occasionally the hollow between these two nodes is excavated. In most species there is a continuous or broken ridge in the ventral part; in one (*H. kolmodini*) this ridge continues up the hinder end to the dorsal angle, in others (*H. insolens* and *H. tricollina*) the post-dorsal extremity remains prominent and forms a rounded node, the remainder of the ridge being dissected and tending to obsolescence; in two other species (*H. granifera* and *H. antespinoza*) the ventral ridge joins the two constant nodes, the result being a loop as in *Bollia*. Finally, in a later stage (as, for instance, *H. radiata*) the ventral ridge is obsolete and only two rounded nodes remain. Occasionally an extra node is developed near the anterior margin. A ventral pouch, as in *Beyrichia*, has not been observed.

Genotype.—*Hollina insolens* (*Ctenobolbina insolens* Ulrich). Seven other middle Devonian species and four Carboniferous species are referred here as follows: *H. antespinoza*, *H. armata*, *H. carimarginata*, *H. informis*, *H. spiculosa*, all described by Ulrich as species of *Ctenobolbina*, and *H. kolmodini* and *H. tricollina*, originally referred to *Beyrichia*, the first by Jones, the second by Ulrich. The Carboniferous species are *H. granifera*, a Spergen species described

as a *Bollia* by Ulrich, *H. radiata* (*Beyrichia radiata* Jones and Kirkby), variety *cestriensis* Ulrich, *H. longispina* (*Beyrichia longispina* Jones and Kirkby), and *H. emaciata* (*Beyrichia* ? *emaciata* Ulrich and Bassler).

Comparison of the figures on Plate XLII gives a good idea of the unusual range of variability of the species associated in this new genus. On closer study, however, strong elements of similarity will be noted running through the whole assemblage, the observer being finally convinced of the essential naturalness of the association. It is not contended that the group is natural in the sense of being composed of species descended from a single ancestor. On the contrary, it is believed they were derived from perhaps several preceding species of *Beyrichia* and possibly *Ctenobolbina*, and that the singularities resulted through atavistic tendencies developed in the Devonian decadence of the Silurian *Beyrichiidae*.

The Devonian species of the genus may be regarded as vacillating intermediate stages between the trilobate Silurian *Beyrichia* and the final, again long-lived, simply binodate Carboniferous phase of the new genus, namely, the small group of species of which *H. radiata* (Jones and Kirkby) is a typical example. Whereas most of the Devonian species occur at the Falls of the Ohio in a thin bed thought to be of Onondaga age, indicating rapid evolution, *H. radiata* ranges with very slight change from the Chester to near the close of the Pennsylvanian.

Compared with true *Beyrichia*, which has constantly three vertically elongated lobes, the new genus *Hollina* is distinguished (1) by the progressive obsolescence of the posterior lobe, (2) by the rounded form of the median and anterior nodes or lobes, (3) by the restriction of these nodes to the dorsal half of the valve, (4) by the relative fullness of the ventral parts (agreeing in this respect with *Klodenia*), and (5) by the constant development of an anteriorly incomplete marginal frill. A probable sixth difference is indicated by the apparent absence of a ventral pouch.

The fullness of the ventral region, also the rounded form of the median (posterior) node suggests even closer alliances with *Klodenia*, but the rather obvious relations of *Hollina* to *Trepostella lyoni* and the probable derivation of that species from *Beyrichia* tends to negative this suggestion. The Devonian species would never cause one to think of *Klodenia*. It is only the more simple *H. radiata* group that might recall that Silurian genus. But these even will be distinguished at once by the anterior node, the like of which never occurs in *Klodenia*.

In a former paper,^a the writers mention the possible desirability of including *B. radiata* and its immediate allies in *Ulrichia*. It is

^a Proc. U. S. Nat. Mus., XXX, 1906, p. 152.

now quite clear that such a course would be unwarrantable. Taking into account only this, that both have two constant and similarly placed nodes, the logical course would be to unite them. But if the apparently unquestionable derivation of *H. radiata* from the Devonian species of *Hollina* is considered, the impropriety of the suggested reference cannot be ignored. *Ulrichia* is one of the Primitiida; *Hollina* is a derivative—presumably somewhat atavistic—of Beyrichiida.

As is evident from several preceding references in the paper to *Hollina*, the writers now regard the resemblance of certain species to *Ctenobolbina*, and of others to *Bollia*, as atavistic stages in the Devonian and Mississippian evolution of the typical Beyrichian stock, and not as survivals of the generic types to which they were originally referred. Ulrich placed most of the Devonian species under *Ctenobolbina* because of their general similarity in form, location, and range of variation to the *C. subcrassa* group of that genus, while the later *H. granifera* was referred to *Bollia* solely because the ventral union of its two nodes forms a loop precisely like the inner loop of typical species of that genus. In neither case were the characters now relied on, such as the two constant rounded nodes and the broad frill on the posterior and ventral margins, taken into account, and the genetic relations to *Beyrichia*, though suspected, were not appreciated as they should have been. "Loops" strikingly like that in *Bollia* occur in other types. This was recognized by Ulrich in 1894^a in discussing *Drepanella bigeneris*, a notable instance of this kind.

Subfamily KLCEDENELLINÆ.

Genus KLCEDENELLA, new.

Beyrichia (part) JONES and AUTHORS.

Klædenia (part) JONES, ULRICH, and most AUTHORS.

Bollia? (part) ULRICH, Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, p. 669.

Carapace small, strongly convex, elongate, somewhat barrel-shaped, the length usually less than 1.5 mm.; dorsal edge nearly straight, ventral edge usually somewhat concave, ends approximately equal in height but differing in outline, the antero-dorsal angle often rectangular and always more distinct than the post-dorsal. Valves unequal, the right overlapping the left around the ends and the ventral side. Of the lobation, the constant features are two sharply impressed vertical or slightly oblique furrows, separated by a narrow lobe, in the posterior half. In the more simple forms, these furrows extend only about half across the valve. Anterior half may be uniformly convex, but, as a rule, is more or less clearly bisected vertically by a straight or curved furrow. When present, this anterior furrow

^a Geol. and Nat. Hist. Surv. Minnesota, Final Rept., III, Pt. 2, 1894, p. 671.

often produces an appearance suggesting the "loop" of a *Bollia*. Surface generally smooth and polished, and without ornamental markings.

Genotype.—*Klædenella pennsylvanica* (*Klædenia pennsylvanica* Jones).

Of unquestioned species of this genus, some eight or ten, two of them perhaps being merely varieties, are contained in the collections of the U. S. National Museum. These range in time from the Clinton to middle Devonian. A British Carboniferous species, published by Jones and Kirkby under the name *Beyrichia? bicassa*, probably belongs to this genus. Except this and the two Devonian species, all the others are confined to the Silurian rocks of the Appalachian province. As a rule, the species are exceedingly prolific in the way of individuals, the layers of limestone in which they occur being almost literally made up of their remains. In most cases they occur as entire shells, which, being easily freed from the matrix, are admirably suited for detailed study.

Only about half of the known forms have been described, and one of these (described as *Beyrichia trisulcata* by Hall) has never been adequately figured. *Klædenia pennsylvanica*, as figured by Jones in 1889^a, includes two distinct species and a variety, which are represented by thousands of specimens in the material available to the writers. The form represented by Jones's figures 5*a*, *b*, *c*, *d*, and 6 is accepted as the *Klædenella pennsylvanica*. His figures 8 and 9 are regarded as based on examples of our *K. turgida*, new species,^b while 7*a* and 7*b* probably represent a variety of the latter, here distinguished by the subordinate name *ventrosa*.^c

^a Amer. Geol., IV, p. 341, figs. 5-9.

^b *Klædenella turgida* is distinguished from *K. pennsylvanica*, as here restricted, by the strong development of the anterior sulcus. This sulcus delimits a well-marked anterior lobe and produces a somewhat concentric arrangement of the lobes behind it, the effect being quite different from the usual appearance of *K. pennsylvanica*.

Length of a normal right valve, 1.10 mm.; height, 0.64 mm.; length of a short left valve, 0.97 mm.; height, 0.60 mm. See Plate XLIII, figs. 6, 7.

Formation and locality.—Coeymans limestone, Cumberland, Maryland.

Types.—Cat. No. 53278, U.S.N.M.

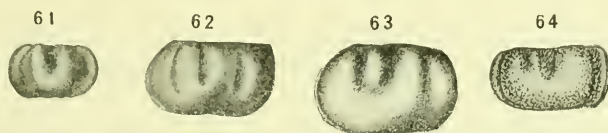
^c This form is more like *K. pennsylvanica* than *K. turgida* in lobation of the valves, being without a well-marked anterior sulcus, but in the less elongate form and general aspect it is so like *K. turgida* that it has been placed as a variety of this species. Its main peculiarity lies in a ventral swelling which causes an apparent break in the antero-medial lobe. The ventral flange is unusually well developed and the series of granules along the antero-ventral edge has not been observed in any other species of the genus. See Plate XLIII, fig. 8.

Formation and locality.—Coeymans limestone, Cumberland, Maryland.

Holotype.—Cat. No. 53279, U.S.N.M.

The genus is divisible into two sections, the first comprising the greater part of the known species, among them the genotype. In this group the posterior and median furrows are shorter than in the second, and the anterior furrow either wanting or more or less well developed. In the second group, of which *Beyrichia halli* Jones (*Bollia halli* Ulrich) is a good example, the posterior and anterior furrows are long, subequal, and extending nearly or quite across the valve. The general expression is rather strikingly dissimilar in the two groups, but on close comparison it is found that the differences are not essential and, moreover, that the extremes are bridged by connecting links.

The *Klædenella halli*, as it should now be called, simulates *Bollia symmetrica* (Hall) to such a degree as to suggest its derivation from that earlier Silurian (Rochester shale) species. The *Bollia*, however, has not overlapping valves as has the *Klædenella*. Besides, the latter type appears to have been established already in Clinton time, indicating that its ancestors are to be looked for among Ordovician



FIGS. 61-64.—61. LEFT VALVE OF *BOLLIA SYMMETRICA* (HALL). 62. RIGHT VALVE OF *KLÆDENELLA HALLI* (JONES). COPIED FROM JONES. 63. RIGHT VALVE OF *KLÆDENELLA TURGIDA*, NEW SPECIES. 64. RIGHT VALVE OF *BEYRICHIA? PARALLELA* ULRICH, $\times 20$. (AFTER ULRICH.) THESE FIGURES ILLUSTRATE (1) THE SIMILARITY OF EXPRESSION OF *BOLLIA* TO *KLÆDENELLA*, AND (2) THE POSSIBLE DERIVATION OF *KLÆDENELLA* FROM THE RICHMOND SPECIES *BEYRICHIA? PARALLELA*.

species. Such a possible ancestor is found in the peculiar Richmond species described by Ulrich as *Primitia* or *Beyrichia parallela*. The general form of the valves and the lobes are sufficiently like *Klædenella* to encourage the belief that it fulfills the requirements of the case. It is to be regretted, however, that only separated valves of this Richmond species are known, so that it is difficult, if not impossible, to decide the question by showing agreement also in the matter of inequality of its valves.

Because of the mentioned resemblance to *Bollia*, Ulrich in 1894 tentatively referred species of the *K. halli* section, including *K. clarkei* (*Beyrichia clarkei* Jones) and two new species, to *Bollia*. Although this reference is now thought to have been in error, it must be admitted that it is not easy to show just why the group was not descended from *Bollia regularis* and *B. symmetrica*. At that time the senior author had very few specimens of the type now discriminated under the name *Klædenella*, and *K. halli* and *K. clarkei* were known to him only from the rather indefinite figures and descriptions published by Jones, which neither showed nor mentioned the unequal-

ity of their valves. Hence, he had had no opportunity to observe the principal evidence in the case, namely, the transition from *K. pennsylvanica* to *K. clarkei*,^a and the fact that while the valves of *Bollia* are equal, those of *Klædenella* are unequal. In passing, it may be said that *Bollia* is regarded as an early derivative of *Primitia*, that it established an independent line having no subsequent connection with the true Beyrichiidae and that it represents the most complex stage of lobation attained by the Primitiidae.

The Klædenellinae are Beyrichiidae with valves more or less distinctly overlapping. As a rule, the overlap is confined to the ventral side and ends. *Beyrichiopsis* Jones and Kirkby, *Beyrichiella* Jones and Kirkby, *Jousina*, and *Kirkbyina*, new genera, are referred to the subfamily. Technically *Kyammodes* Jones fulfills the requirements, but, being convinced of the genetic alliance of that genus to *Klædenia*, the writers hesitate to remove it from the Beyrichiidae.

CARBONIFEROUS BEYRICHIIDÆ.

Two years ago,^b the writers had occasion to discuss the Carboniferous Beyrichiidae. Among the conclusions were (1) that the group of *Beyrichia radiata* is worthy of generic separation, a view carried out in the present communication by the erection of the new genus *Hollina*; (2) that the remaining, inequivalved Beyrichiidae, including *Beyrichiopsis*, *Beyrichiella*, and *Synaphe*, of Jones and Kirkby, besides a number of species referred by these authors to *Beyrichia*, probably constituted a single comprehensive genus; (3) that *Synaphe* should be relegated to synonymy under *Beyrichiella*; and (4) that two subgenera might be recognized, of which *Beyrichiopsis* would be one. Similar conclusions were reached in the present more comprehensive study of the family, the principal difference being that *Beyrichiopsis* and *Beyrichiella* are recognized as genera, and a new genus, *Jonesina*, is proposed instead of "a second subgenus." Finally, a fourth genus, *Kirkbyina*, is proposed for two species doubtfully referred to *Beyrichiella* by Jones and Kirkby, and which were not considered in 1906.

^aA new variety of *K. clarkei* is here instituted under the name of *paupera* of which the following are the characteristics: The valves and the ridges especially are thinner than in the species itself, giving the whole a somewhat emaciated appearance. Furthermore, the furrows present somewhat irregularly distributed but numerous papille which have not been observed in the typical form of the species. See Plate XLIII, fig. 5.

Formation and locality.—Coeymans limestone, Cumberland, Maryland.

Holotype.—Cat. No. 53280, U.S.N.M.

^bProc. U. S. Nat. Mus., XXX, 1906, pp. 151-155.

Considerable instability of character in these inequivalved Beyrichiidae was recognized in the preceding publication: also the fact that many of them exhibited more or less obvious resemblances to Ordovician and Silurian types. These facts were explained as resulting from reversion and arrested development incident to the degeneration and extinction of the family in Carboniferous time.

In now recognizing four genera instead of a single broad genus, it is not intended to convey the impression that the writers have materially changed their opinions respecting the close alliance of the several groups. Neither are the groups of species thought to be more natural genetic associations than they were believed to be in 1906. It is only in deference to the matter of convenience in classification, and to insure greater clearness and brevity in definition, that the change from one to four is made. Considering them as one genus, it seemed impossible to draw up a reasonably brief diagnosis that would not cover a variety of really very distinct pre-Carboniferous types. Though it can not be denied that the whole group is bound together by intimate alliances, it is yet a fact that but a single feature of generic or family rank pertains to all its members, namely, slight inequality of the valves. But this feature, of course, is not peculiar to this group, since it occurs in many otherwise very different Ostracoda. By dividing the group into four genera and using the feature common to them all as characterizing a subfamily of Beyrichiidae, the resulting classification is at least convenient and probably as natural as it can be made so long as established characters are consulted as not less important than genesis in the forming of zoological classifications.

In the present arrangement of the Carboniferous Klædeniellinae, all of the British species described by Jones and Kirkby are accounted for save *Beyrichia tuberculospinosa*, *B. multiloba*, and *B. varicosa*. The published figures of these three species^a indicate peculiarities, the value of which it would be unwise to decide without first verifying them by study of good specimens. Until that is done, it is advisable to leave them in the still large residuum of undetermined and doubtful species of *Beyrichia*. In the meantime it may be said that *B. multiloba* and *B. varicosa* would have been placed with *Lonesina* were it not that in both cases, as figured by Jones and Kirkby, the left instead of the right valve is the smaller. In this respect the two species agree with *Klædenella*. The figures of *B. tuberculospina* are indecisive on this point, and the most that may be said of this species at the present time is to suggest that it may be an aberrant *Hollina* and as probably related to *H. longispina*.

^a Jones and Kirkby, Ann. and Mag. Nat. Hist. (5), XVIII, 1886, pl. VIII.

Beginning with the most simple type, the genera may be defined briefly as follows:

Genus KIRKBYINA, new.

Beyrichiella ? JONES and KIRKBY, Ann. and Mag. Nat. Hist. (5), XVIII, 1886, p. 260.

Carapace small, less than 1 mm. in length, rather short, subovate to subquadrate, ventricose, thickest anteriorly, with a simple primitian sulcus about the middle of the dorsal half. Valves unequal, the right slightly larger and overlapping the edges of the left.

Genotype.—*Kirkbyina reticosa* (*Beyrichiella* ? *reticosa* Jones and Kirkby).

In the same paper ^a Jones and Kirkby describe a second more tumid species, likewise referring it doubtfully to *Beyrichiella* under the name *B. ? ventricornis*. At present only these two British species may be safely placed in the genus *Kirkbyina*. There are a few as yet unstudied, Primitia-like Ostracoda in American deposits of Carboniferous age that may turn out to belong here.

Kirkbyina resembles *Primitia*, but is readily distinguished by its overlapping valves and thicker anterior end. In *Primitia* it is the posterior half that is usually the thicker. *Beyrichiella* has a more elongate shell and broader sulcus, while its left valve and not the right is the larger.

Genus BEYRICHIELLA Jones and Kirkby.

Beyrichiella JONES and KIRKBY, Geol. Mag., Dec. 3, III, 1886, p. 438; Proc. Geol. Assoc., IX, 1886, p. 506.

Beyrichiella (part) ULRICH and BASSLER, Proc. U. S. Nat. Mus., XXX, 1906, pp. 151-155.

Synaphe JONES and KIRKBY, Trans. Royal Dublin Soc. (2), VI, 1896, p. 190.—ULRICH and BASSLER, Proc. U. S. Nat. Mus., XXX, 1906, p. 152.

Kirkbyia COSSMANN, Revue Critique de Paleozoologie, III, 1899, p. 45 (proposed for *Synaphe*, preoccupied).

Carapace small, 1 mm. or less in length, elongate subquadrate, thickest anteriorly, with a rather broad median sulcus giving the shell a bilobed aspect: a low, transverse ridge in the ventral part cuts off the sulcus and unites the lower parts of the two lobes. Valves unequal, the edge of the smaller right valve being set into the overlapping ventral and end parts of the larger left valve.

Genotype.—*Beyrichiella cristata* Jones and Kirkby.

The writers fail to see more than specific differences between *B. cristata* and *Kirkbyia annectens*, the type of *Synaphe* Jones and Kirkby (not *Synaphe* Huebner). It is, therefore, placed here as a

^a Ann. and Mag. Nat. Hist. (5), XVIII, 1886, p. 260.

second species of *Beyrichiella*. A third, the only known species from American strata, was described by Ulrich as *Ulrichia confluens*. Viewed in the narrow sense in which this genus was proposed and in which it is now thought desirable to recognize it, *Beyrichiella* is clearly distinguished from other members of the subfamily. The shell is relatively longer than that of *Kirkbyina* and its larger valve is not the right as in that genus, but the left. The lobation of the valves is also less simple, the low ventral ridge, connecting the two larger lobes, being a character not observed in *Kirkbyina*. The general shape of the carapace is decidedly like that of *Beyrichiopsis*, but the characteristic rounded, median—or rather post-median—node of that genus is wanting in *Beyrichiella*.

Genus BEYRICHIOPSIS Jones and Kirkby.

Beyrichiopsis JONES and KIRKBY, Geol. Mag., Dec. 3, III, 1886, p. 434; Proc. Geol. Assoc., IX, 1886, p. 506; Quart. Journ. Geol. Soc. London, XLII, 1886, p. 506.

Beyrichiopsis ULRICH and BASSLER, Proc. U. S. Nat. Mus., XXX, 1906, p. 152.

Carapace small, about 1 mm. in length, oblong, subquadrate to sub-elliptical, straight on the dorsal side, tapering slightly and thickest anteriorly; on the whole, rather strongly convex. A broad based, rounded swelling or lobe occupies the greater part of the anterior half. A second, smaller rounded eminence occurs behind the middle and usually above the mid-height of the valve. It is often surrounded by a slight depression usually deepest on the anterior side. Free edges of valves usually with a broad, spiny frill; in other cases merely denticulate. Two or three thin, crest-like ribs commonly cross the surface in a longitudinal direction.

Genotype.—*Beyrichiopsis fimbriata* Jones and Kirkby. Other typical species are *B. cornuta*, *B. subdentata*, *B. fortis*, *B. granulata*, and *B. simplex*, all described by Jones and Kirkby from British Carboniferous specimens.^a Two new species in the Ulrich collection in the U. S. National Museum were collected from the basal shales of the Tullahoma formation in central Tennessee. One of these has a frill like *B. fimbriata*, the other is more like *B. cornuta*.

Compared with the other genera of the subfamily Klædenellinæ, *Beyrichiopsis* is distinguished at once by the small, rounded post-median node. Otherwise the genus is not greatly different from *Beyrichiella*, its nearest ally, the usual presence of a spiny marginal frill being of subordinate importance. Another difference, however, is found in the transverse ventral ridge seen in *Beyrichiella* but which is absent in *Beyrichiopsis*.

^a Geol. Mag., Dec. 3, III, 1886, pp. 434-437.

B. simplex and *B. granulata*^a depart somewhat from the other species in the more subdued development of both the anterior and the median lobes. These two species strongly resemble *Klwardenia*. Indeed, it is difficult to point out satisfactory differences. However, as that genus became almost extinct with the close of the Silurian, it seems highly unlikely that these Carboniferous species were directly connected with it.

Genus JONESINA, new.

Beyrichia (part) JONES and KIRKBY, Ann. and Mag. Nat. Hist. (5), XVIII, 1886, p. 258; Geol. Mag., Dec. 3, III, 1886, p. 438.

Beyrichiella (part) ULRICH and BASSLER, Proc. U. S. Nat. Mus., XXX, 1906, pp. 151-155.

Carapace small, about 1 mm. in length, usually elongate, the outline varying from subelliptical to oblong or approximating a parallelogram; greatest thickness in anterior half. Valves strongly convex, variously lobed, unequal, the left being the larger, sometimes overlapping the edge of the right on all sides. The most simple types (*J. craterigera* and *J. arcuata*) are marked with a rather deep dorsal sulcus situated somewhat behind the middle. The whole area in front of this sulcus may be almost uniformly convex, or a node may be obscurely defined in its post-dorsal quarter (that is, just in front of the sulcus). Behind the sulcus a more clearly defined node is always observable. In more complex species (*J. fastigiata*) three nodes are distinguishable, two, subequal, situated on opposite sides of the main sulcus, and a larger, less definitely outlined, lobe occupying the anterior third. Finally, in *J. fodicata*, the anterior lobe is divided by the separation of a node simulating the other two in size and form, while all three nodes will appear as connecting below with a low marginal ridge. A more or less obscure and variable ridge commonly unites the two median nodes, occasionally producing an effect simulating *Bollia*.

Genotype.—*Jonesina fastigiata* (*Beyrichia fastigiata* Jones and Kirkby).

The following additional species are referred to *Jonesina*: *J. arcuata* (Bean) (as figured by Jones and Kirkby under the genus *Beyrichia*);^b *J. bradyana* (*Beyrichia* Jones and Kirkby);^c *J. craterigera* (*Beyrichia* Brady Ms., Jones and Kirkby);^d *J. fodicata* (*Beyrichia*

^a Jones and Kirkby describe the latter as a variety of *B. fortis*. It seems to the writers as allied to *B. simplex* rather than *B. fortis*, the post-median node as well as the general expression of the valves, aside from the surficial crests, being the same as in the former and quite different from the latter.

^b Geol. Mag., Dec. 3, III, 1886, p. 438, pl. XII, figs. 12-14.

^c Idem., fig. 11.

^d Idem., figs. 7a, 7b.

Jones and Kirkby),^a all from the Carboniferous rocks of Great Britain, and *J. bolliiformis* and var. *tumida* (*Beyrichiella* Ulrich and Bassler),^b and *J. gregaria* (*Beyrichiella* Ulrich and Bassler)^c from rocks of Pennsylvanian age in Kansas and Texas. Other American species are known, but remain to be described.

Jonesina sometimes resembles *Klædenella* to a marked degree. This is true especially of *J. craterigera*, but with entire specimens the observer should experience little difficulty in distinguishing them, the matter of relative size of the valves being reversed in the two genera. In the older genus the right valve is the larger, whereas in *Jonesina* it is the left.

In correlating the nodes of *Jonesina* with those of a typical *Beyrichia*, it is to be observed that the median lobe of the latter corresponds to the post-median node of *Jonesina*, the one, two, or three nodes in front of the median sulcus being equivalent to the single or dissected anterior lobe of *Beyrichia*. Obviously the location of the homologous parts in the two genera is widely different.

^a Ann. and Mag. Nat. Hist. (5), XVII, 1886, p. 258, pl. VIII, figs. 4-6.

^b Proc. U. S. Nat. Mus., XXX, 1906, p. 158, pl. XI, figs. 7-11.

^c Idem., fig. 18.

EXPLANATION OF PLATE XXXVII.

Figs. 1-4. Group of *Beyrichia tuberculata*.

1. Four views of a left valve of *Beyrichia tuberculata*.
2. Similar views of a right valve of female individual of same.
3. Four views of a right valve of *B. tuberculata bigibbosa* Reuter.
4. Similar views of a right valve of *B. noctlingi* Reuter. All the figures are magnified five times and copied from Reuter.

5-10. Group of *Beyrichia klädeni*.

5. Two views of a left valve of *Beyrichia maccoyiana sulcata* Reuter, $\times 8$.
6. Similar views of left valve of female individual of same, $\times 8$.
7. Left valve of *Beyrichia lindstromi* Kiesow, $\times 8$.
Figs. 5 and 6 are copied from Reuter and fig. 7 from Kiesow.
8. Left and right valves of *Beyrichia moodeyi*, new species, $\times 10$.
Cayuga formation, Cacapon, Maryland.
- 9, 10. Right and left valves of *Beyrichia waldronensis*, new species, $\times 10$.
Niagara (Waldron), Waldron, Indiana.

11-13. Group of *Beyrichia buchiana*.

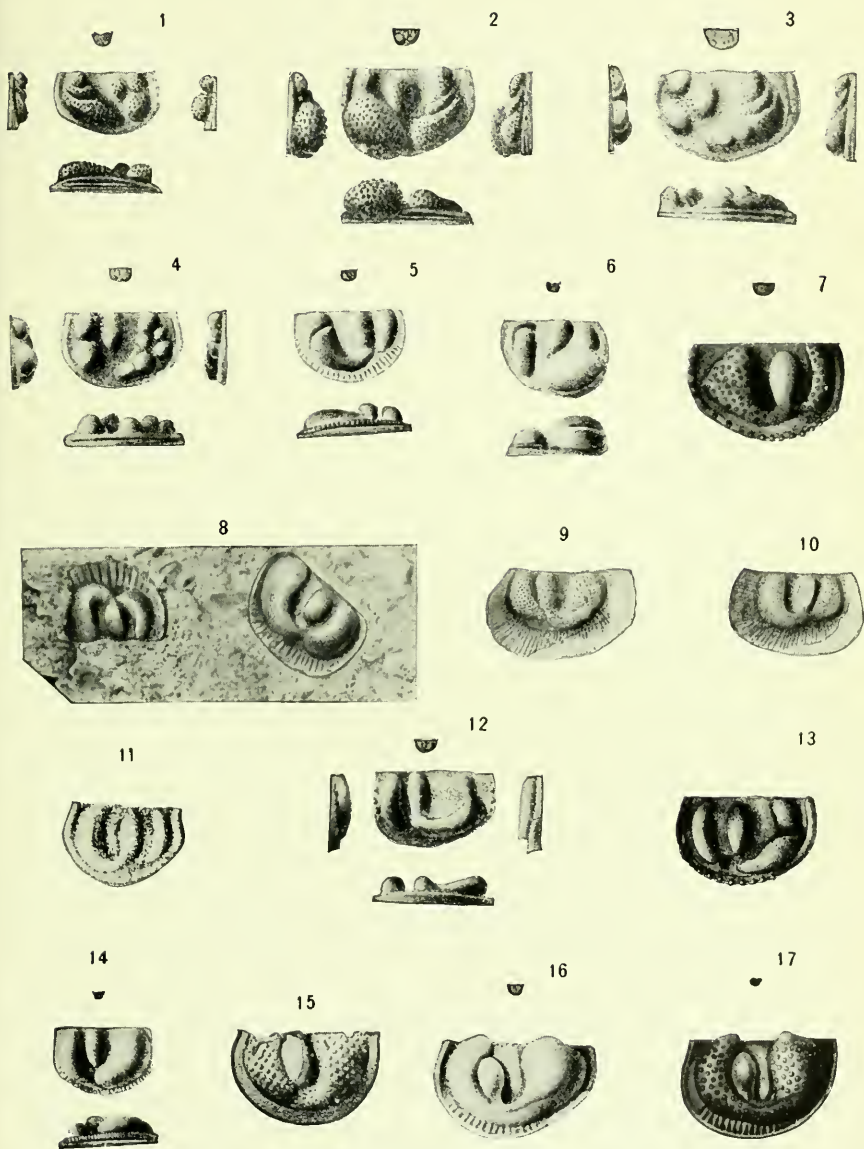
11. Left valve of *Beyrichia buchiana* Jones, $\times 8$. Copied from Jones.
12. Four views of a right valve of *Beyrichia buchiana angustata* Reuter, $\times 6$. (After Reuter.)
13. A right valve of *Beyrichia laucnsis* Kiesow. (After Kiesow.)

14, 15. Group of *Beyrichia salteriana*.

14. Lateral and ventral views of a right valve of *Beyrichia salteriana* Jones, $\times 10$. (After Reuter.)
15. Right valve of *Beyrichia granulosa* Hall. (After Hall.)

16, 17. Group of *Beyrichia clarata*.

16. Right valve of *Beyrichia clarata* Kolmodin. (After Kiesow.)
17. Right valve of *Beyrichia jonesii* Boll. (After Kiesow.)

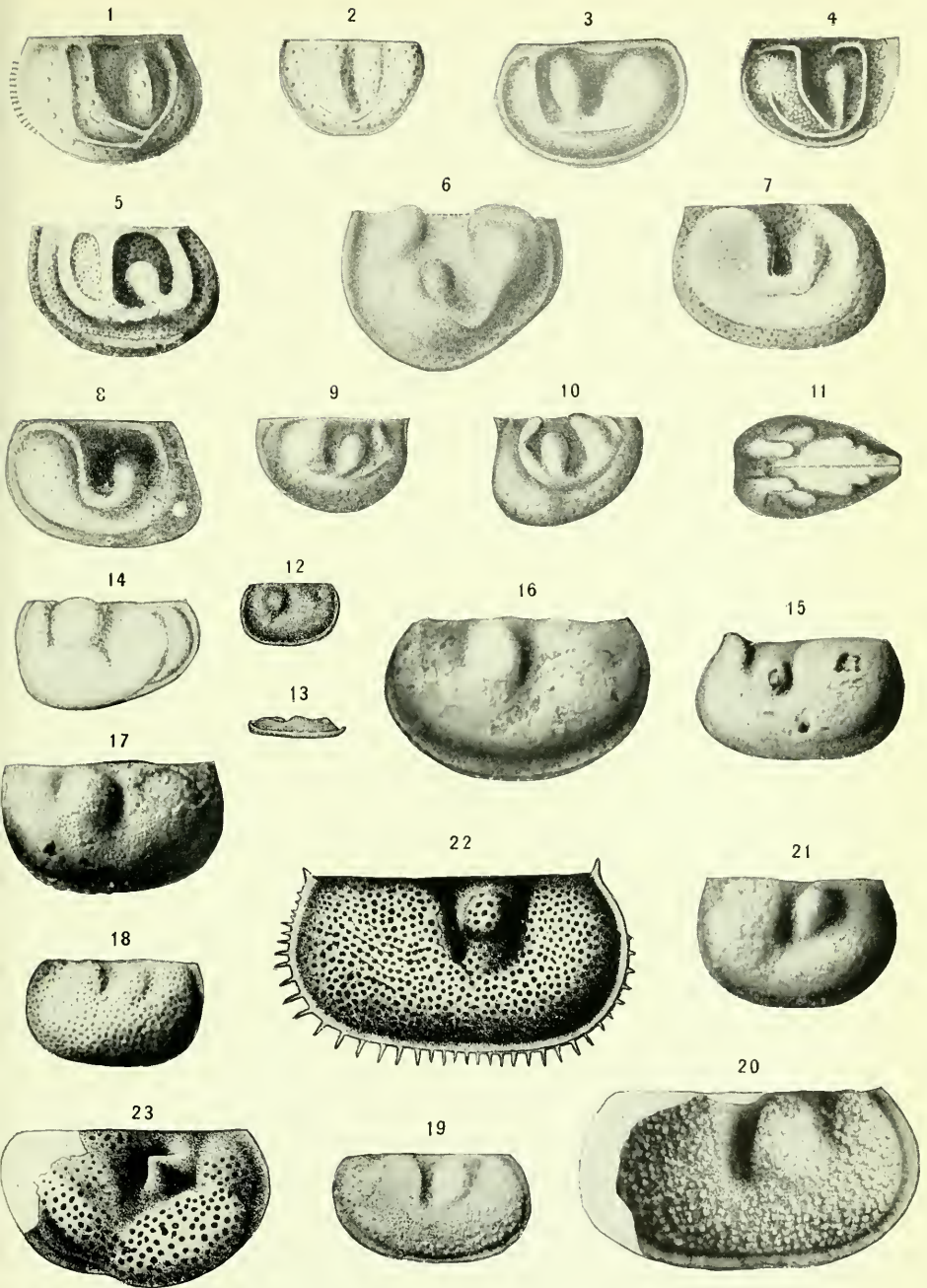


GROUPS OF BEYRICHIA.

FOR EXPLANATION OF PLATE SEE PAGE 326.

EXPLANATION OF PLATE XXXVIII.

- Figs. 1-5. Group of *Beyrichia linmarssoni* (= subgenus *Steusloffia*.)
1. Left valve of *Beyrichia (Steusloffia) linmarssoni* (Krause), $\times 20$.
 2. Left valve of *Beyrichia (Steusloffia) antiqua* (Steusloff), $\times 20$.
 3. Right valve of *Beyrichia (Steusloffia) simplex* (Krause), $\times 15$.
 4. Left valve of *Beyrichia (Steusloffia) acuta* (Krause), $\times 20$.
 5. Left valve of *Beyrichia (Steusloffia) signata* (Krause), $\times 10$.
- Figure 2 is copied from Steusloff; the rest are after Krause.
- 6-11. Group of *Beyrichia interrupta*.
6. Right valve of *Beyrichia interrupta* (Jones), $\times 20$.
 7. Left valve of *Beyrichia granulifera*, new name, proposed for *Bollia granulosa* Krause, preoccupied in the genus *Beyrichia*, $\times 15$.
 8. Left valve of *Beyrichia r-scripta* Krause, $\times 15$.
- 9-11. Left and right valves and dorsal edge view of the complete carapace of *Beyrichia danesi* Krause, $\times 15$.
- Figure 6 is copied from Jones, while 7 to 11 are from Krause.
- 12, 13. *Kladenia initialis* (Ulrich).
Side and ventral edge views of a right valve, $\times 20$. (After Ulrich.)
14. *Kladenia wilkensis* (Jones).
Right valve of female individual, $\times 8$. (After Jones.)
15. *Kladenia prauuntia*, new species.
Right valve, $\times 10$.
Ordovician (Hermitage). 4 miles south of Carthage, Tennessee.
16. *Kladenia marginalis*, new species.
A right valve, $\times 10$.
Helderbergian, Dalhousie, New Brunswick.
17. *Kladenia punctillosa*, new species.
Lateral view of a right valve, $\times 10$.
Helderbergian, Dalhousie, New Brunswick.
18. *Kladenia rctifera*, new species.
Left valve, $\times 10$.
Helderbergian, Dalhousie, New Brunswick.
- 19, 20. *Kladenia sussexensis* (Weller).
Two left valves, $\times 10$.
Helderbergian, Dalhousie, New Brunswick.
21. *Kladenia manliusensis* (Weller).
Left valve of a female individual, $\times 10$. This specimen agrees fairly well with Weller's description and figures of his *Beyrichia manliusensis* from Manlius of New Jersey, except in the apparently less development of the border. The surface is very finely punctate.
Helderbergian, Dalhousie, New Brunswick.
22. *Kladenia fimbriata*, new species.
Left valve, $\times 20$.
Coeymans limestone, Herkimer County, New York.
23. *Kladenia centricornis*, new species.
Left valve of a female individual, $\times 20$.
Coeymans limestone, Cumberland, Maryland.



BEYRICHIA, STEUSLOFFIA, AND KLÆDENIA.

FOR EXPLANATION OF PLATE SEE PAGE 328.

EXPLANATION OF PLATE XXXIX.

Unless otherwise marked, the figures on this plate are copied from Ulrich.

Figs. 1-3. *Tetradella subquadrans* Ulrich.

1. Left valve, $\times 20$.
2. Dorsal view of same.
3. Posterior end view.

4, 5. *Tetradella quadrilivata* (Hall and Whitfield).

4. Side view of a right valve, $\times 20$.
5. Posterior view of same specimen.

6. *Tetradella lunatifera* (Ulrich).

Side view of right valve, $\times 22$, showing the usual characters.

7. *Tetradella marchica* (Krause).

Right valve, $\times 15$. (After Krause.)

8, 9. *Tetradella ? digitata* (Krause).

Side views of left and right valves respectively of this doubtful *Tetradella*. The obsolescence of the ventral margin is particularly characteristic of this species.

10. *Tetradella (Kicsowia) dissecta* (Krause).

Left valve, $\times 10$. (After Krause.)

11. *Tetradella (Kicsowia) mamillosa* (Krause).

Left valve, $\times 20$. (After Krause.)

12. *Tetradella (Kicsowia) radians* (Krause).

Left valve, $\times 10$. (After Krause.)

13-16. *Ceratopsis chambersi* (Miller).

13. Side view of a left valve of the usual form, $\times 20$.

14. Ventral view of the same valve.

15. View of inner side of more elongate right valve, $\times 20$.

16. A right valve, $\times 20$, with the posterior median ridge divided.

17, 18. *Ceratopsis chambersi robusta* Ulrich.

Side and posterior end views of a complete carapace, $\times 20$.

19, 20. *Ceratopsis oculifera* (Hall).

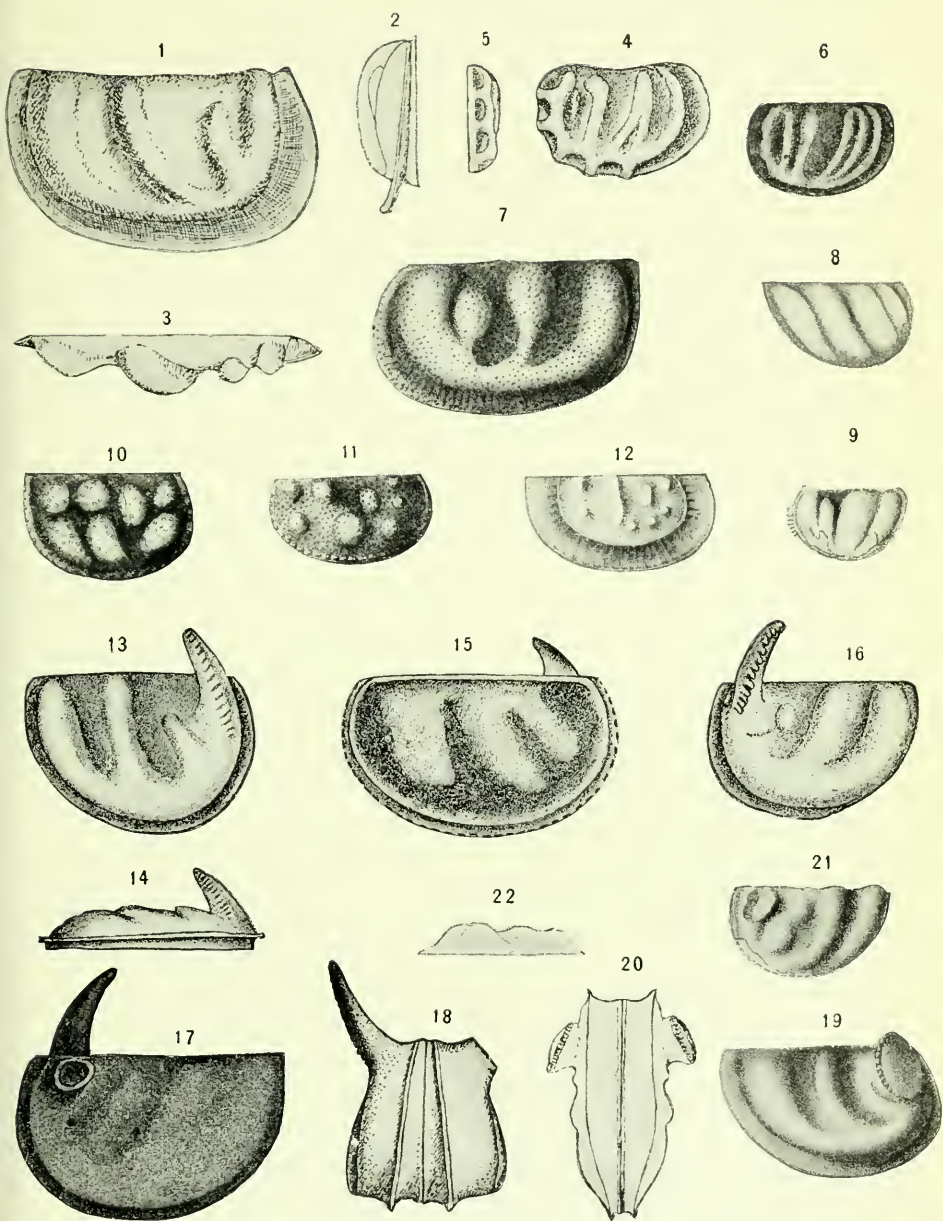
19. A left valve, $\times 15$, showing the mushroom shaped process. (After Jones.)

20. Dorsal view of a complete carapace, $\times 18$.

21, 22. *Ceratopsis quadrifida* (Jones).

21. Side view of right valve, $\times 15$. (After Jones.)

22. Ventral edge view of same. (After Jones.)



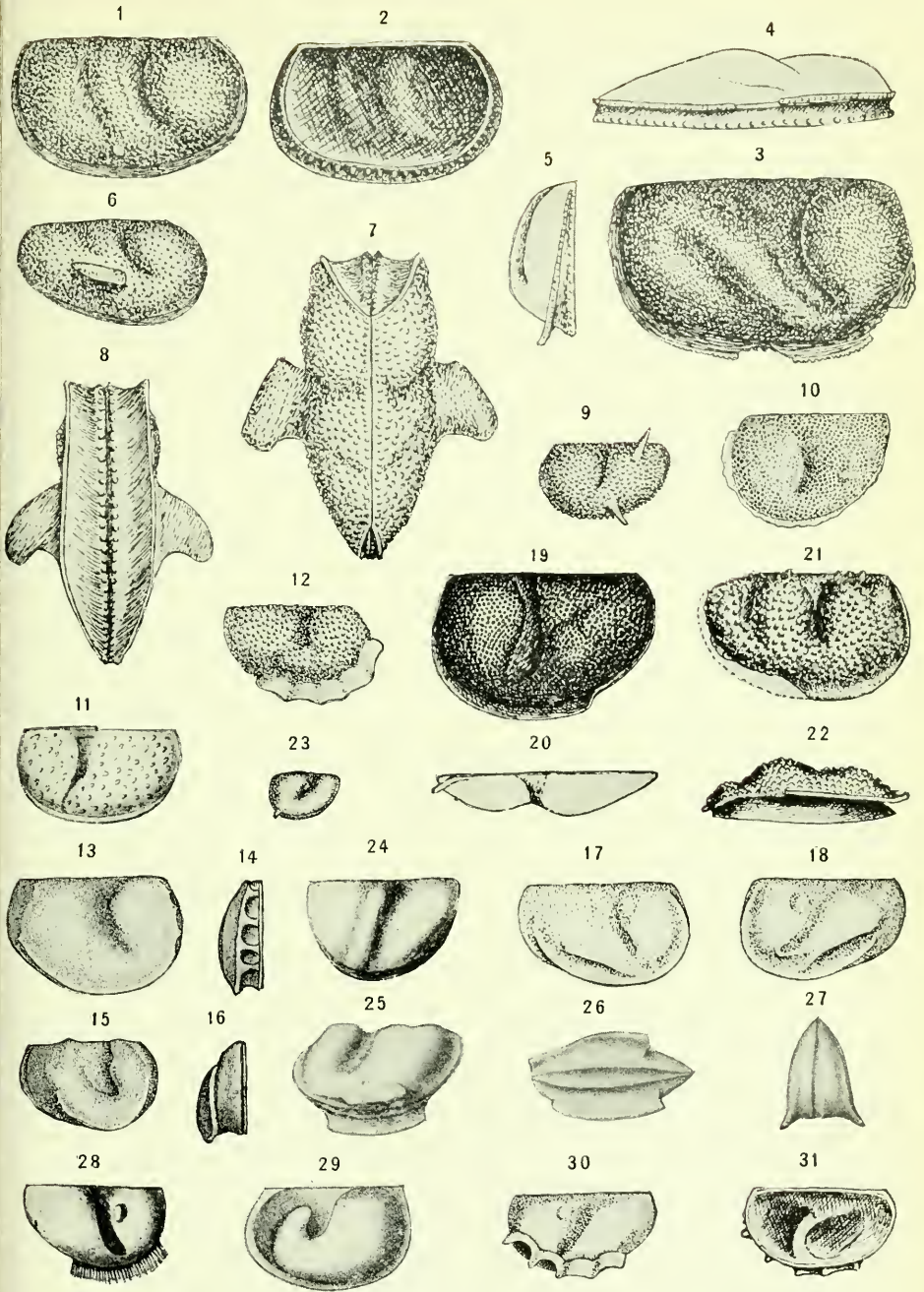
TETRADELLA, KIESOURA, AND CERATOPSIS.

FOR EXPLANATION OF PLATE SEE PAGE 330.

EXPLANATION OF PLATE XL.

Unless otherwise stated, the figures are copied from Ulrich.

- Figs. 1, 2. *Ctenobolbina ciliata* (Emmons).
1. Side view of left valve, $\times 15$.
2. Interior of right valve.
- 3-5. *Ctenobolbina emaciata* (Ulrich).
3. Left valve, $\times 20$.
4, 5. Ventral and end views of same.
- 6-8. *Ctenobolbina alata* Ulrich.
6. Left valve, $\times 18$.
7. Dorsal edge view of complete carapace, $\times 25$.
8. Ventral edge view of same specimen.
9. *Ctenobolbina bispinosa* Ulrich.
Right valve, $\times 18$.
10. *Ctenobolbina obliqua* Ulrich.
A right valve, $\times 20$, in which some of the flange is missing.
11. *Ctenobolbina oblonga* (Steusloff).
View of a right valve of this species, $\times 20$. (Copied from Steusloff.)
12. *Ctenobolbina granosa* Ulrich.
View of a perfect left valve, $\times 20$.
- 13, 14. *Ctenobolbina fulcrata* Ulrich.
Lateral and posterior views of a left valve, illustrating the usual characters of the species, $\times 20$.
- 15, 16. *Ctenobolbina crassa* Ulrich.
Lateral and posterior views of a left valve, $\times 20$.
- 17, 18. *Ctenobolbina subcrassa* Ulrich.
Lateral views of a left and right valve, respectively, $\times 20$.
- 19, 20. *Ctenobolbina punctata* Ulrich.
Lateral and dorsal views of a right valve, $\times 20$.
- 21, 22. *Ctenobolbina papillosa* Ulrich.
Lateral and ventral views of a left valve, $\times 20$.
23. *Ctenobolbina minima* Ulrich.
A right valve, $\times 30$.
24. *Ctenobolbina impressa* (Steusloff).
Lateral view of a right valve, $\times 20$. (After Steusloff.)
- 25-27. *Ctenobolbina auricularis* (Jones).
25. Lateral right side view of the complete carapace which is slightly tilted, $\times 25$.
26, 27. Ventral and posterior views of the same carapace. (Copied from Jones.)
28. *Ctenobolbina umbonata* (Steusloff).
Left valve, $\times 20$. (Copied from Steusloff.)
29. *Ctenobolbina major* (Krause).
Lateral view of right valve, $\times 15$. (After Krause.)
- 30-31. *Ctenobolbina loculata* Ulrich.
30. Exterior of an apparently perfect right valve, $\times 20$.
31. Interior of a left valve, $\times 20$.



CTENOBOLBINA.

FOR EXPLANATION OF PLATE SEE PAGE 332.

EXPLANATION OF PLATE XLI.

Unless otherwise mentioned, all the figures on this plate are $\times 15$, and are copied from Ulrich.

Figs. 1-3. *Drepanella bigeneris* Ulrich.

1. Side view of left valve.
2. Posterior view of same valve.
3. Longitudinal sectional view across the central part of the same.

4-6. *Drepanella crassinoda* Ulrich.

4. Side view of right valve.
5. Dorsal view of same valve.
6. Posterior end view of complete carapace.

7, 8. *Drepanella nilida* (Ulrich).

7. Left valve of an average complete specimen.
8. Ventral view of same.

9. *Drepanella ampla* Ulrich.

Lateral view of right valve.

10, 11. *Drepanella elongata* (Ulrich.)

10. Left valve.
11. Longitudinal sectional view.

12-14. *Drepanella macra* Ulrich.

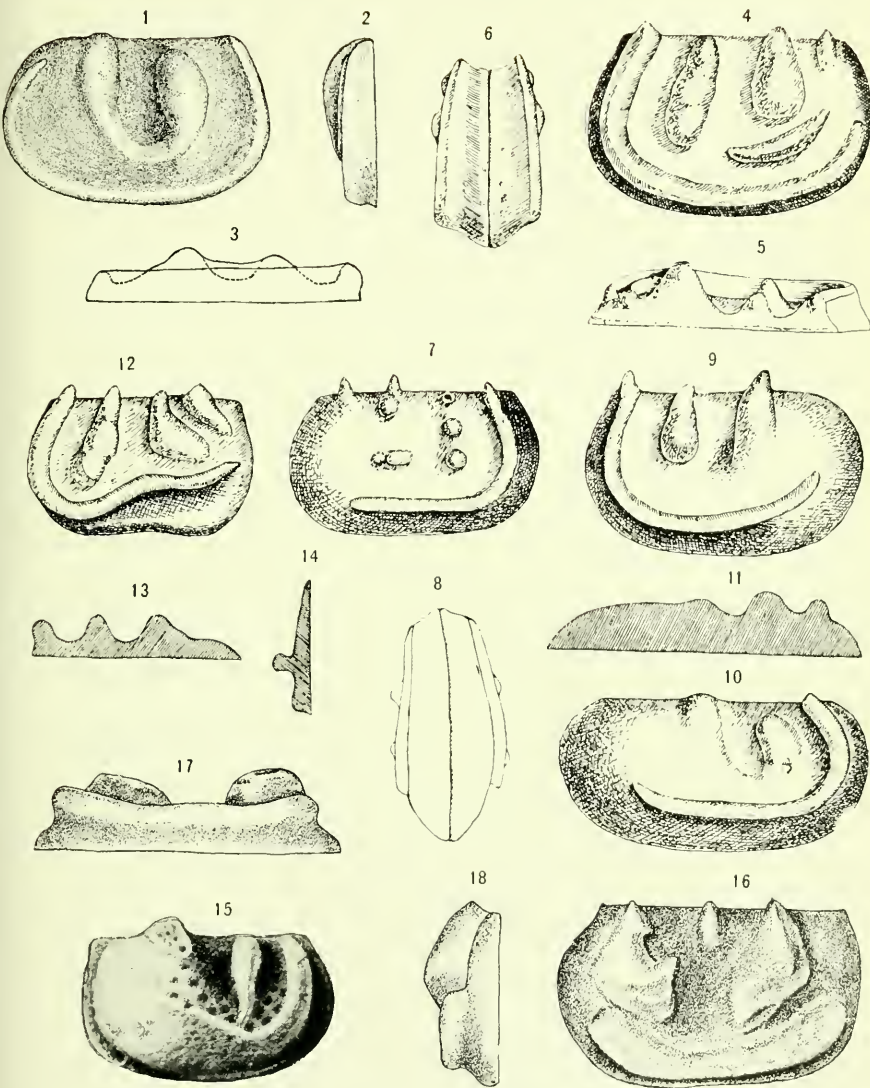
12. Side view of right valve.
13. Longitudinal and vertical sectional views across central part of same valve.

15. *Drepanella richardsoni* (Miller).

Side view of a left valve (original).

16-18. *Scofieldia bilateralis* (Ulrich).

16. Side view of a right valve of the usual appearance.
- 17, 18. Ventral and posterior views of a left valve.



DREPANELLA AND SCOFIELDIA.
FOR EXPLANATION OF PLATE SEE PAGE 334.

EXPLANATION OF PLATE XLII.

All of the figures on this plate, except 21 and 22, are copied from Ulrich and are $\times 20$.

Figs. 1-4. *Trepostella lyoui* (Ulrich).

1. Side view of a right valve.
- 2, 3. Dorsal and posterior views of the same specimen.
4. A left valve showing the subcentral ventral pouch.

5-7. *Hollina kolmodini* (Jones).

5. A right valve showing the similarity of the ridges to *Drepanella*.
6. Interior of a right valve.
7. Dorsal edge view of same.

8, 9. *Hollina insolens* (Ulrich).

8. Exterior of a left valve.
9. Interior of another left valve.

10-12. *Hollina carimarginata* (Ulrich).

- 10, 11. Lateral and posterior views of a left valve.
12. View of interior of another left valve.

13. *Hollina spiculosa* (Ulrich).

Side view of a nearly perfect right valve.

14. *Hollina armata* (Ulrich).

A right valve showing the usual characters.

15. *Hollina tricollina* (Ulrich).

Lateral view of a left valve.

16, 17. *Hollina granifera* (Ulrich).

Lateral and posterior views of a right valve.

18. *Hollina radiata* (Jones and Kirkby).

Right valve of an American example, apparently agreeing in all essential respects with the English types of the species.

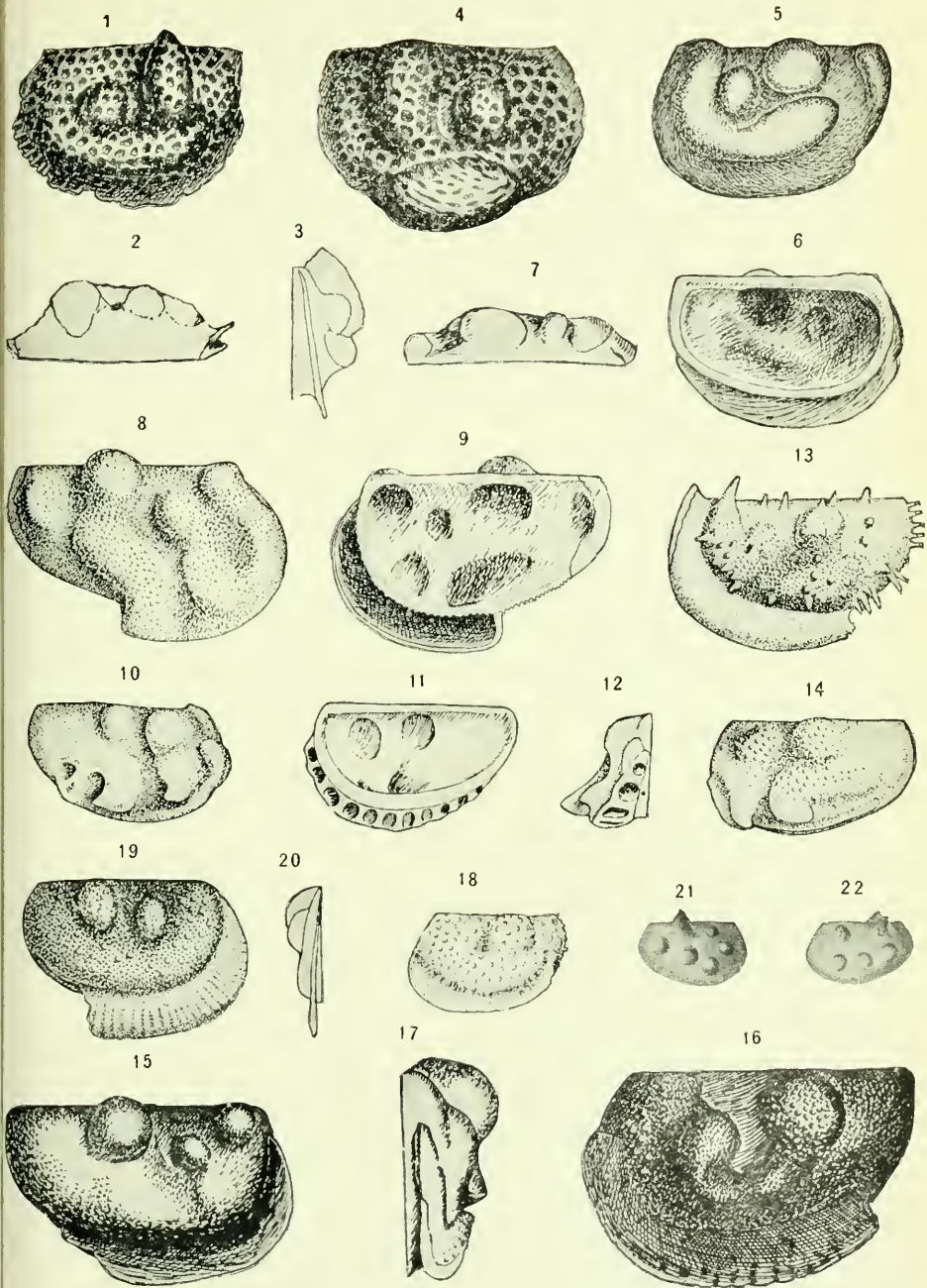
19, 20. *Hollina radiata cestriensis* (Ulrich).

19. Side view of a left valve, $\times 28$.

20. Posterior view of same example.

21, 22. *Beyrichia? tuberculospinosa* Jones and Kirkby.

Side views of two examples of this doubtfully placed Carboniferous species, which may be a *Hollina*, $\times 25$. (After Jones and Kirkby.)



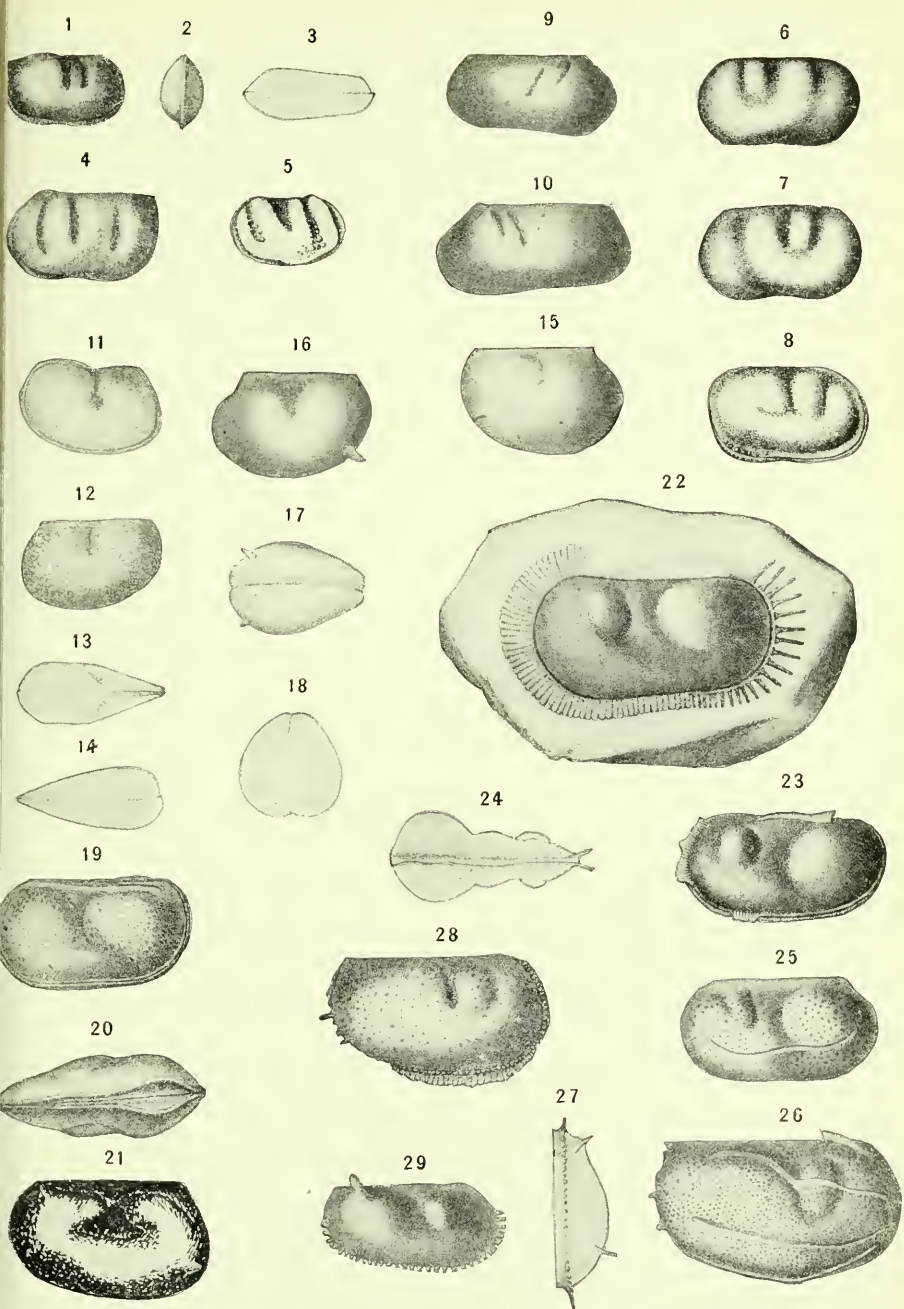
TREPOSELLA AND HOLLINA.

FOR EXPLANATION OF PLATE SEE PAGE 336.

EXPLANATION OF PLATE XLIII.

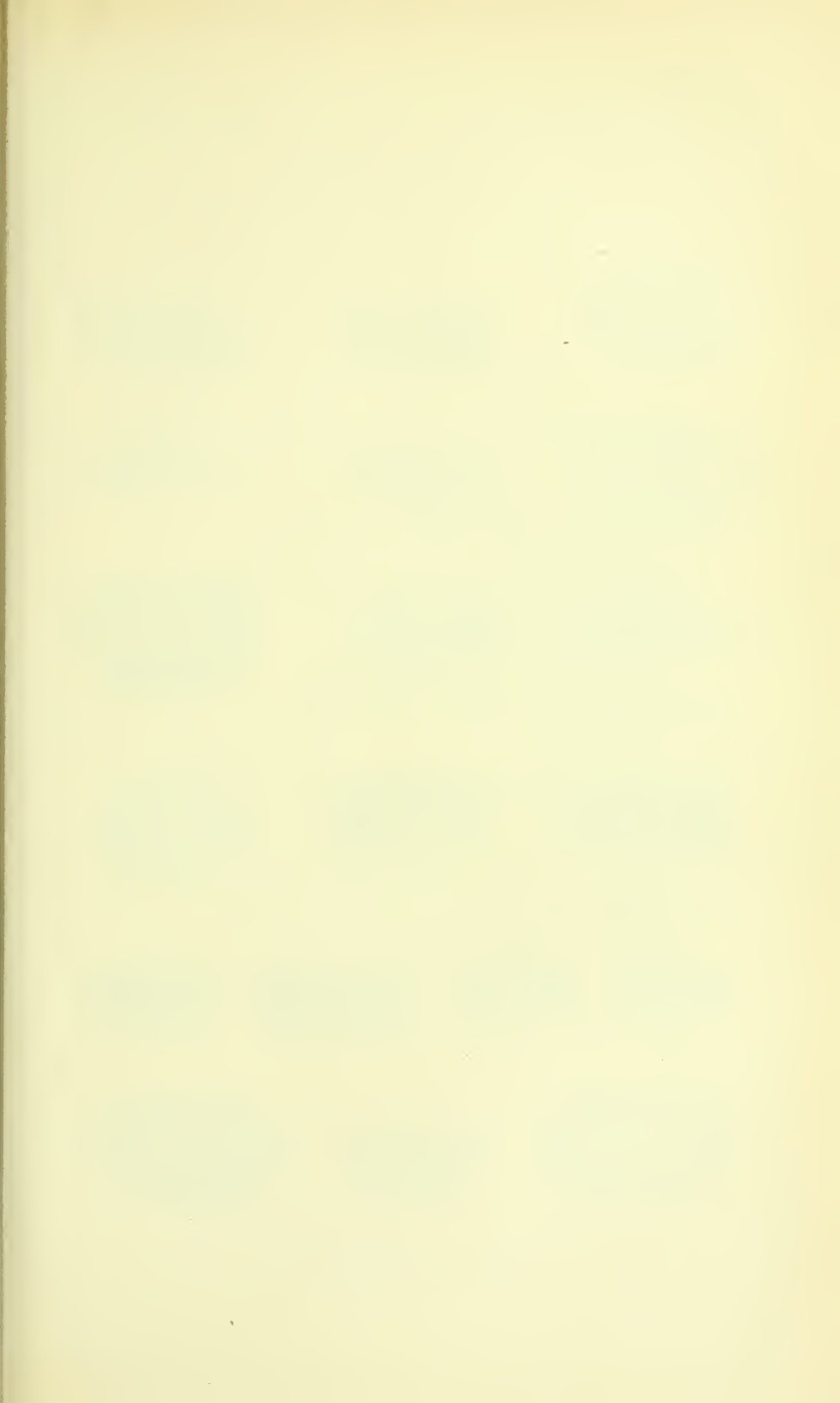
Figures 1-4 and 9-29 are copied from Jones.

- Figs. 1-3. *Kladenella pennsylvanica* (Jones).
Left side, end and ventral views of complete carapace, $\times 15$.
4. *Kladenella hallii* (Jones).
A right valve, $\times 20$.
5. *Kladenella clarkii paupera*, new variety.
Lateral view of left valve, $\times 20$.
Coeymans limestone, Cumberland, Maryland.
- 6, 7. *Kladenella turgida*, new species.
Right and left valves, respectively, $\times 20$.
Coeymans limestone, Cumberland, Maryland.
8. *Kladenella turgida ventrosa*, new variety.
Lateral view of a left valve, $\times 20$.
Coeymans limestone, Cumberland, Maryland.
- 9, 10. *Kladenella bicatena* (Jones and Kirkby).
Left and right valves of this Carboniferous species, $\times 25$.
- 11-14. *Kirkbyina reticosa* (Jones and Kirkby).
11. Left valve, $\times 25$.
12. Right valve, $\times 25$.
- 13, 14. Dorsal and ventral views of a complete carapace.
- 15-18. *Kirkbyina ventricornis* (Jones and Kirkby).
15. A left valve, $\times 25$.
16. A right valve showing the spine more conspicuously, $\times 25$.
- 17, 18. Ventral and end views of complete carapace.
- 19, 20. *Beyrichiella cristata* Jones and Kirkby.
Right side and dorsal view of complete carapace, $\times 25$.
21. *Beyrichiella confluentis* (Ulrich).
Left valve, $\times 20$, of the only known American species.
- 22-24. *Beyrichiopsis fimbriata* Jones and Kirkby.
22. Right valve, $\times 40$, apparently perfect.
23. Right valve with the fringe partially broken away, $\times 25$.
24. Ventral view of complete carapace.
25. *Beyrichiopsis subdentata* Jones and Kirkby.
Lateral view of a right valve, $\times 25$.
- 26, 27. *Beyrichiopsis granulata* Jones and Kirkby.
26. A left valve, $\times 25$.
27. End view of same.
28. *Beyrichiopsis simplex* Jones and Kirkby.
Lateral view of left valve, $\times 25$.
29. *Beyrichiopsis cornuta* Jones and Kirkby.
Left valve, $\times 25$.



KLÆDENELLA, KIRKBYINA, BEYRICHIELLA, AND BEYRICHIOPSIS.

FOR EXPLANATION OF PLATE SEE PAGE 338.



EXPLANATION OF PLATE XLIV.

Figs. 1-6 are copied from Ulrich and Bassler and are $\times 30$; figs. 7-19 are from Jones and Kirkby and are $\times 25$.

Figs. 1, 2. *Jonesina bolliiformis* (Ulrich and Bassler).

1. Left valve of entire carapace.
2. Dorsal view of same showing channeled back.

3-5. *Jonesina bolliiformis tumida* (Ulrich and Bassler).

3. Left valve, incomplete at the antero-dorsal angle.
4. Lateral view of another left valve.
5. Ventral view of original of fig. 4.

6. *Jonesina gregaria* (Ulrich and Bassler).

Left valve of an average old example.

7-9. *Jonesina fodicata* (Jones and Kirkby).

7, 8. Two left valves showing slight variation in outline and surface characters.

9. A right valve in which the surface is further modified.

10-12. *Jonesina fastigiata* (Jones and Kirkby).

10. Lateral view of a right side of complete carapace.

11, 12. Two left valves.

13, 14. *Jonesina craterigera* (Jones and Kirkby).

Right side and ventral view of complete carapace.

15, 16. *Jonesina bradyana* (Jones and Kirkby).

15. Right side of complete carapace.

16. Ventral view of same specimen.

17-19. *Jonesina arcuata* (Beau).

17, 18. Two left valves showing variation in outline.

19. Right side of complete carapace.