NORTH AMERICAN INDEX FOSSILS

INVERTEBRATES

BY

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VOLUME II

CONULARIDA, PTEROPODA, CEPHALOPODA, ANNELIDA, TRILOBITA, PHYLLOPODA, OSTRACODA, CIRRIPEDIA, MALACOSTRACA, MEROSTOMATA, ARACHNIDA, MYRIOPODA, INSECTA, CYSTOIDEA, BLASTOIDEA, CRINOIDEA, OPHIUROIDEA, ASTEROIDEA, ECHINOIDEA AND APPENDICES

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PREFACE.

In the present volume the authors present the completion of their survey of those Invertebrata considered as the most important fossil species of North America. The general plan of Volume I. has been followed through the Mollusca, Annulosa and Echinodermata, each class having its separate structural descriptions, generally its key to genera, and its brief list of the more important reference works, as well as a separate numbering for its genera and species. In the Arthropoda, however, a departure from this method was found desirable, and the subclasses rather than the classes were emphasized. This was found necessary because of the great differences between the subclasses. In the Malacostraca, the structural descriptions and literature references were brought down to orders, though the numbering of genera and species is continuous throughout the subclass. The same is true of the subclass Merostomata among the Acerata, but the subclass Arachnida is treated as a unit, the important species being referred to by name merely, without descriptions. Each of the classes Myriopoda and Insecta is treated as a whole, the species being merely mentioned by name. In the class Insecta, the orders are described, with a mention and illustrations of representative species. The Echinodermata having such very slight relationship with any other phylum may properly occupy any position except that unnatural association with the Cœlenterata which in early days classed these two phyla as Radiata.

In the tables and summary of North American formations (Appendix A) the divisions of the earlier Palæozoic are those elsewhere advocated by the senior author. These and some other changes have been made since the early chapters of Vol. I. (Protozoa to Brachiopoda inclusive) have appeared. Thus a slight discrepancy will be found. The following differences are to be noted. The Chazy, formerly regarded as Lower Ordovicic, is now placed in the Middle Ordovicic. The Pogonip group of Nevada is now regarded as Beekmantown, not Chazy. The Norman's Kill shales are believed to be the approximate equivalent of the Black

River, instead of the Trenton. The Trenton is placed at the base of the Upper Ordovicic, and regarded as representing (with the Utica) a single stratigraphic unit. The Niagaran is regarded as Lower Siluric, instead of Middle as formerly, while the Salinan is of Middle Siluric age. The later usage of American geologists is followed in considering the two main divisions of both the old Carboniferous and Cretaceous as distinct periods. For the names Coal Measures or Upper Carboniferous and Lower or Sub-Carboniferous, the names Carbonic and Mississippic are here respectively used; for the Upper and Lower Cretaceous the names Cretacic and Comanchic.

In the faunal tables (Appendix B) the species are listed in the order in which they are described in the body of the work, and each is preceded by its corresponding number, so that ready reference to the figures and descriptions is possible.

The bibliography (Appendix C) while not complete, is very extensive including nearly all the important published works describing or listing fossils; in these, descriptions and illustrations of additional species as well as more detailed descriptions of the species included in this work will be found; the division under each period is for the convenience of the local student.

The directions for collecting and preparing fossils (Appendix D) are the result of the experiences of students in various parts of the world. Much must be left, however, to the individual who will have to adapt these methods to his particular field, or devise new methods where needed.

The glossary (Appendix E) is designed to provide short explanations of terms for quick reference and a general index to illustrations and more detailed explanations. Of the North American formation names generally only such are defined in the glossary as are referred to in the body of the text; in connection with this the tables of Appendix A should likewise be consulted.

In the arrangement of the indices, which cover both volumes, the same plan has been followed as in Vol. I. In addition, in the index of genera the gender of each genus is indicated by the letters *m* (masculine), *f* (feminine), or *n* (neuter). In the index of species the gender of the genus is indicated only when a species name of adjective form is followed by two or more genera of differing gender, and in such cases there is placed after the species name the appropriate endings in the order masculine, feminine and neuter; so that the proper endings may in each case be noted. When the endings in the species index disagree with the endings as given in the body of the work, the latter is to be regarded as erroneous. For the endings of specific names derived from proper nouns, a rule usually observed, is that names ending in final mute e change it to i and add a second i—as Lane, lanii; Barrande, barrandii, but names ending in consonants, or other vowels take only one i, *e. g.*, Hall, halli; Conrad, conradi; Dewey, deweyi, etc. Another rule is to drop the final a of a locality name when the ending is *ensis;* thus—Iowa, iowensis, Canada, canadensis, though iowaënsis and canadaënsis are often used. Final e is also dropped, as Delaware—delawarensis; Tennessee, tennesseensis. Other vowels are however retained, as Colorado, coloradoënsis, Mississippi, mississippiënsis; final y after a consonant changes to i, as Kentucky, kentuckiensis, but not after a vowel—*e. g.*, Jersey—jerseyensis.

To the acknowledgments made in Vol. I, should be added one to Professor Charles Prosser, who revised some of the proof of the Stratigraphic Summary.

New York and Boston,
May 15, 1910.

CONTENTS OF VOLUME II.

ERRATA.

Volume I.

Page 46. *Cryptozoon proliferum,* add to localities: Upper Cambric of New York and Pennsylvania.

Page 53. 12 lines from bottom, for XXXIX. *Alveolites,* read XL. *Alveolites.*

Page 77, no. 64. for *C. tenneseenensis* read *C. tennesseensis.*

Page 211. for *Protorthis* (*Billingsella*) *billingsi* read: *P. billingsi* (*Billingsella billingsi*).

Page 231. *Derbya* is synonym, not a subgenus.

Page 231. for *Orthotetes* read *Orthothetes,* and add to horizon Mississippic.

Page 276. *Barrandella* is a synonym of *Clorinda,* not subgenus.

Page 571. species 585, dele (Fig. 794).

Page 629. for *Euomphalopteris* read *Euomphalopterus.*

Page 648, species 141–143, for P. read T.

Page 658. Fig. 906, *c, e,* for *Eccyliopteris* read *Eccyliopterus.*

Page 668. Fig. 924 for *Polenmita* read *Poleumita.*

Volume II.

Page 113. for *Cyrtohoanites* read *Cyrtochoanites.*

Page 128. Fig. 1376, for after Hyatt read after Hall.

Page 133. for *Climenida* read *Clymenida.*

Page 263. for *Mesonaces* read *Mesonacis.*

NORTH AMERICAN INDEX FOSSILS.

PHYLUM. MOLLUSCA.

(*Continued.*)

Class **CONULARIDA** Miller and Gurley

Paleozoic shells, resembling in general shape some recent pteropods like *Styliola* but usually much larger, of varying form, and with thicker walls. The shells generally bear transverse septa toward the apical or posterior end.

Their systematic position is doubtful and their relationship to the pteropods is probably distant, that of a parallel rather than a genetically related group. Cambric–Permic.

LITERATURE.

American Conularidæ are described in faunal works — among which those of Walcott (Bull. U. S. G. S., 10 and 30, 10th Ann. Rep. U. S. G. S.) may be mentioned for the Cambric, Hall (Pal. N. Y., Vol. V., Pt. II. and VIII.) for the Devonic, and the volumes of the Pal. Ohio, and Pal. Ill. for the Mississippic and Carbonic. See also Ruedemann, R., "Note on the Discovery of Sessile Conularia" (*Am. Geol.*, Vol. XVII., pp. 158–165, Pls. VIII.–IX., and Vol. XVIII., pp. 65–71, Pl. II., 1896).

ARTIFICIAL KEY TO THE GENERA (INCLUDING PTEROPODS).

A. Shell chitinous.......VII. *Urotheca*.
B. Shell calcareous.......I.
  I. Shell wall thin.......1.
    1. Cross section circular.......*a*.
      a. Spiral longitudinal striæ present.......V. *Coleoloides*.
      a. Only faint growth lines present.......*Styliolina*.
    1. Cross section usually triangular, some varying to oval.......I. *Hyolithes*.
    1. Cross section rectangular.......*b*.
      b. Shell large.......X. *Conularia*.
      b. Shell small (about 1 inch long).......5. *Hyolithes quadricostatus*.
  I. Shell wall thick.......2.
    2. Cross section circular.......*c*.
      c. Annulations present.......IX. *Tentaculites*.
      c. No annulations present.......†.
        †. Shell made up of concentric cones.......VIII. *Salterella*.

†. Shell not made up of concentric cones.................................*.
*. Star-shaped muscle marking present on inside of operculum IV. *Hyolithellus*
*. No star-shaped muscle marking present..........................1′
1′. Transverse striæ more or less oblique......VI. *Coleolus*
1′. Transverse striæ straight ....II. *Orthotheca.*
2. Cross section usually triangular, sometimes oval...................I. *Hyolithes.*
2. Cross section elliptical, tube strongly curved.....................III. *Helenia.*

Family Hyolithidæ Nicholson.

I. Hyolithes Eichwald.

Shell, of calcium carbonate, straight or curved; cross section triangular or elliptical. The margin of the flattened dorsal side projects somewhat above the opposite wall causing thus a forward

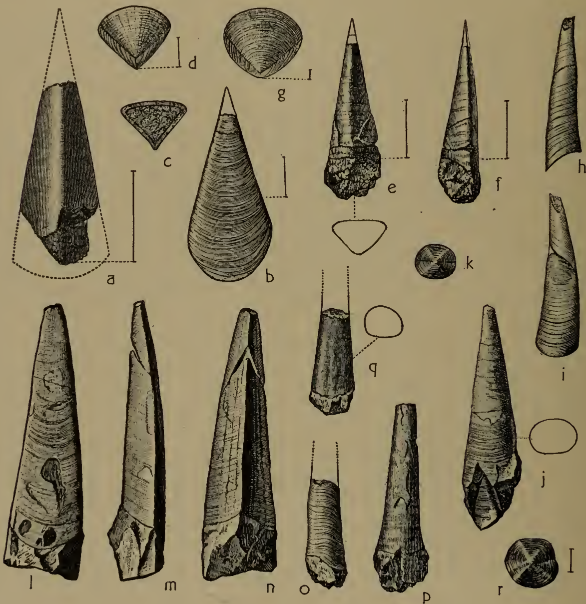

Fig. 1211. *a–d*, *Hyolithes americanus*; *c*, section; *d*, operculum; *e*, *f* *H. billingsi*; *g*, operculum; *h–j*, *H. impar*; *k*, operculum; *l–n*, *H. similis*; *o–q*, *H. communis*; *r*, operculum. (After Walcott.)

bending of the engirdling growth lines. The opening closed by a concentrically striated operculum. Cambric–Permic.

1. **H. americanus** Billings. (Fig. 1211, *a–d.*) Cambric.

Growth lines curve forward on the dorsal side, pass downwards over the sides at nearly a right angle and curve slightly backward over the ventral side. Shell wall thin.

Lower Cambric of Newfoundland, Quebec, Massachusetts and New York.

2. **H. billingsi** Walcott. (Fig. 1211, *e–g.*) Cambric.

Transverse section subtriangular. Shell thick, composed of successive layers.

Lower Cambric of Labrador, Massachusetts (?), Utah and Nevada.

3. **H. impar** Ford. (Fig. 1211, *h–k.*) Cambric.

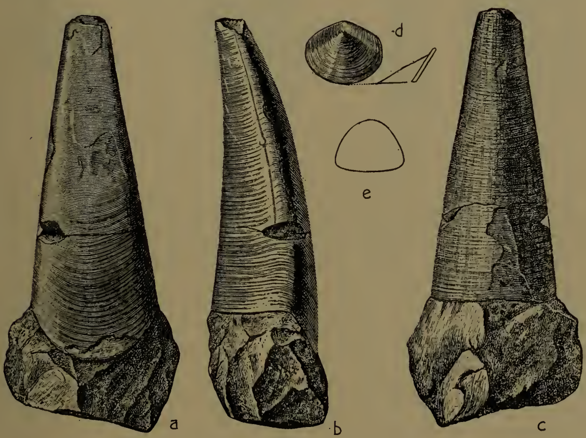

FIG. 1212. *Hyolithes princeps; d,* operculum; *e,* section. (After Walcott.)

Usual length, 1¼ inches; one or more transverse imperforate septa present near apex. Transverse section generally regularly oval. Apical angle about 10°. Shell wall thick, consisting of an inner layer irregularly separated from an outer one.

Lower Cambric of Massachusetts and New York.

4. **H. princeps** Billings. (Fig. 1212.) Cambric.

Apical angle 13° to 15°. Dorsal side flat to slightly convex produced anteriorly into a rounded lip. Ventral face varying from uniformly convex transversely to asymmetrical.

Lower Cambric of Newfoundland and Massachusetts.

5. **H. quadricostatus** Shaler and Foerste. (Fig. 1213, *a–c*.) Cambric.

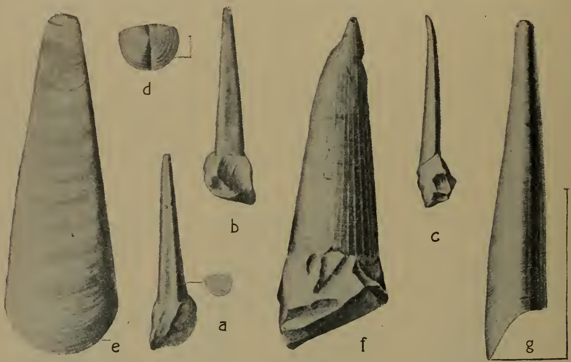

FIG 1213. *a–c, Hyolithes quadricostatus ; e–g, H. terranovicus ; d,* operculum. (After Walcott.)

Apical angle about 17°. Shell four-sided, the dorsal side broad, flat or slightly concave along the median line.

Lower Cambric of Newfoundland and Massachusetts.

6. **H. similis** Walcott. (Fig. 1211, *l–n*.) Cambric.

Transverse section subtriangular; ventral angle sharp. Shell wall thin. Ventral face with four raised lines on each side of median angle and between the raised lines are fine longitudinal striæ. Differs from *H. americanus* in the presence of the longitudinal striæ, and the smaller apical angle.

Lower Cambric of Conception Bay, Newfoundland.

7. **H. communis** Billings. (Fig. 1211, *o–q*.) Cambric.

Nearly cylindrical, except for slight flattening on one side.

Lower Cambric, Newfoundland to New York.

8. **H. terranovicus** Walcott. (Fig. 1213, *d–g*.) Cambric.

Transverse section subtriangular or semielliptical. Dorsal face less convex than ventral. In addition to the growth lines which cover the entire shell the ventral surface is marked by strong longitudinal raised lines with finer striæ between.

Lower Cambric of Conception Bay, Newfoundland.

9. **H. decipiens** Matthew. (Fig. 1214, *a–c.*) Cambric.

Apical angle 15°. Transverse section of shell subtriangular. Surface marked only with the concentric growth lines.

Middle Cambric St. John group (Protolenus beds) of New Brunswick.

10. **H. acadicus** Hartt. (Fig. 1214, *d.*) Cambric.

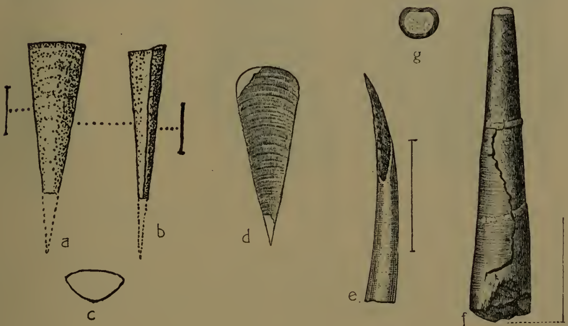

FIG. 1214. *a–c, Hyolithes decipiens*, enlarged, with section. (After Matthew.) *d, H. acadicus; e, H. danianus; f, g, Orthotheca emmonsi* and section. (After Walcott.)

Transverse section subtriangular, about twice as wide as high. The forward projecting anterior margin semicircular. Surface of shell with concentric growth lines and microscopic longitudinal striæ.

Middle Cambric St. John formation of New Brunswick.

11. **H. danianus** Matthew. (Fig. 1214, *e.*) Cambric.

Transverse section semielliptical; surface of the curved shell with concentric growth undulations.

Middle Cambric St. John formation of New Brunswick.

12. **H. shaleri** Walcott. (Fig. 1215.) Cambric.

Large shell with dorsal face the least convex transversely and slightly convex longitudinally, the growth lines arch forward forming a strong rounded anterior lip; surface with fine longitudinal lines. The ventral side is slightly concave longitudinally, its growth lines nearly transverse.

Middle Cambric of eastern Massachusetts.

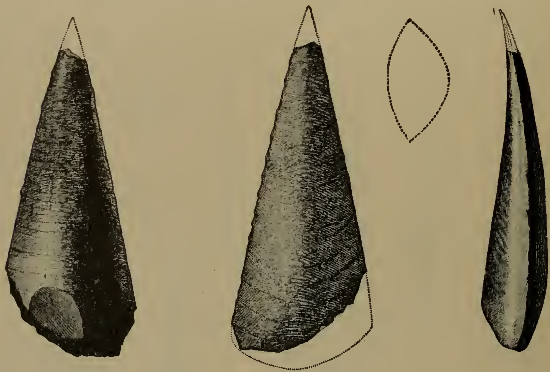

FIG. 1215. *Hyolithes shaleri*, with section. (After Walcott.)

13. **H. neapolis** Clarke. (Fig. 1216.) Devonic.

Convex side divided into three parts, two flattened marginal areas separated from the median convex area by narrow grooves; this condition is accentuated by compression. Entire surface of shell marked by concentric growth lines only.

Portage (Naples) of New York.

II. ORTHOTHECA Novak.

Differs from *Hyolithes* in the abrupt truncation of the anterior end; the growth lines are thus uniformly engirdling and do not bend forward upon the dorsal face. Cambric.

14. **O. emmonsi** (Ford). (Fig. 1214, *f, g.*) Cambric.

Shell elongate and slender; apical angle about 8°. Dorsal (?) face flattened or slightly concave. The older portion of the tube is septate.

Lower Cambric of Massachusetts and New York.

15. **O. cylindrica** Grabau. Cambric.

Shell small, circular to subcircular in transverse section. Apical angle about 2°–5°. Older portion of tube is septate, the septa convex backward.

Lower Cambric of Massachusetts and Newfoundland.

III. HELENIA Walcott.

Shell an elongate, narrow, flattened, curved tube; transverse section and aperture elliptical; surface with transverse, concentric imbricating growth lines. Cambric.

16. **H. bella** Walcott. (Fig. 1217.) Cambric.

FIG. 1216. *Hyolithes neapolis*, × 7, × 1.5, × 7. (After Clarke.)

FIG. 1217. *Helenia bella.* (After Walcott.)

Curvature nearly semicircular; cross section an elongated ellipse; apparently open at both ends; possibly referable to *Dentaliidæ*. Type of genus.

Lower Cambric (Etcheminian) of Newfoundland.

Family TORELLELLIDÆ Holm.

IV. HYOLITHELLUS Billings.

Differs from *Hyolithes* in the slender elongated form of its shell, the absence of a flattened face and especially in the star-shaped arrangement of the numerous muscle markings on the interior of the operculum. It likewise lacks the anterior lip and its accompanying forward bending growth lines upon the dorsal side. Cambric.

17. **H. micans** Billings. (Fig. 1218, *a–d.*) Cambric.

Shell long, very slender; apical angle about 1°–2°. Transverse section circular or broadly ovate. Type of genus.

Lower Cambric of Newfoundland, Quebec, eastern Massachusetts, eastern New York, Utah (?) and Nevada (?).

V. Coleoloides Walcott.

Shell elongate, slender, cylindrical. Differs from *Hyolithellus* in its spiral longitudinal striæ. Cambric.

18. **C. typicalis** Walcott. (Fig. 1218, *e, f*.) Cambric.

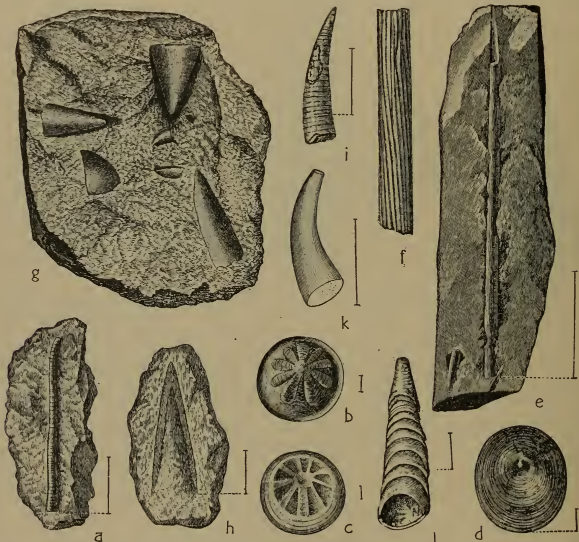

Fig. 1218. *a, Hyolithellus micans; b–d,* opercula of same; *e, f, Coleoloides typicalis,* with enlargement; *g–i, Salterella pulchella; j, S. rugosa.* (After Walcott.)

Apical angle exceedingly acute. Shell apparently very thin. The longitudinal striæ make one revolution around the tube in a length of sixteen diameters of the tube. Type of genus.

Lower Cambric of Conception Bay, Newfoundland.

VI. Coleolus Hall.

Shell very elongate conical, straight or slightly curved, thick-walled. External surface marked with engirdling striæ, more or less oblique to the axis of the shell. Devonic.

19. **C. tenuicinctus** Hall. (Fig. 1219, *b.*) Devonic.

Shell straight. Interrupted longitudinal striæ present.

Hamilton of New York and Falls of the Ohio.

20. **C. gracilis** Hall. (Fig. 1219, *a.*) Devonic.

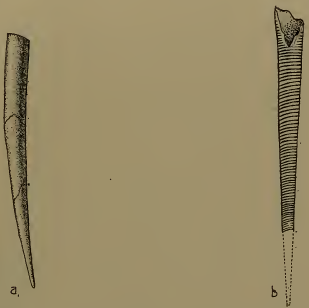

FIG. 1219. *a*, *Coleolus gracilis*; *b*, *C. tenuicinctus*, × ⅔.

Shell curved. Surface apparently transversely striate.

Hamilton-Chemung of New York.

VII. UROTHECA Matthew.

Shell a long, chitinous, cylindrical tube. Opening transverse, with no projecting lip. Cambric.

21. **U. perveta** Matthew. Cambric.

Tube gently curved; faint longitudinal striæ present upon the exterior.

Lower Cambric of Newfoundland and eastern Massachusetts.

VIII. SALTERELLA Billings.

Small, elongate, conical tubes, straight or slightly curved, and consisting of several hollow cones placed one within another, the last one forming the living chamber. Transverse section circular or subtriangular. Cambric and (?) Ordovicic.

22. **S. pulchella** Billings. (Fig. 1218, *g–i.*) Cambric.

Shell gently curved, its exterior with small encircling striæ just visible to the naked eye.

Lower Cambric of Labrador, Quebec and Vermont

23. **S. rugosa** Billings. (Fig. 1218, *j*.) Cambric.

Shell small, straight; surface unknown. The weathered specimen figured shows the projecting edges of the several ensheathing cones.

Lower Cambric of Labrador.

24. **S. curvata** Shaler and Foerste. (Fig. 1218, *k*.) Cambric.

Shell curved, tapering rather rapidly; surface smooth or marked by scarcely visible transverse striæ.

Lower Cambric of Labrador, Quebec and Massachusetts.

Family Tentaculitidæ Walcott.

IX. Tentaculites Schlotheim.

Shell straight or slightly curved, elongate, tapering, conical, with circular cross section and terminating posteriorly either acutely or in a bulb. Surface marked by strong transverse rings which are closely arranged near the apex and more distant and stronger near the mouth. Fine transverse and rarely longitudinal striæ are present. Apical portion often filled with calcareous

Fig 1220. *Tentaculites gyracanthus*, with enlargement. (After Hall.)

matter or divided off by transverse septa. Ordovicic–Devonic. (Extremely abundant in the Siluric and Devonic.)

25. **T. gyracanthus** (Eaton). (Fig. 1220.) Siluric.

Annulations irregular in strength and distribution, being from 6 to 12 in the space of one eighth of an inch. Length rarely more than one half inch.

Manlius of New York, New Jersey and Pennsylvania.

26. **T. scalariformis** Hall. (Fig. 1221.) Devonic.

Differs from *T. bellulus* in the more obtuse annulations of the distal portion, with narrower interspaces, and in the more rapidly narrowing apical portion.

Onondaga of New York, Ohio and Indiana.

27. **T. gracilistriatus** Hall. Devonic.

In small size and needle-like form very similar to *Styliolina fissurella* but distinguished by the presence of annulations and fine longitudinal striæ.

Hamilton and Marcellus of New York.

28. **T. bellulus** Hall. (Fig. 1222.) Devonic.

FIG. 1221. *Tentaculites scalariformis*, × 3. (After Hall.)

FIG. 1222. *Tentaculites bellulus*, × 2. (After Hall.)

Annulations acute; interspaces rounded and marked by concentric striæ.

Hamilton of New York.

29. **T. attenuatus** Hall. Devonic.

Slender, with distant, rather irregularly spaced and narrow annulations, the interspaces with concentric striæ; length 10–12 mm.; resembles *T. bellulus*, but smaller, and the annulations more irregular.

Hamilton of eastern New York, Pennsylvania and western Ontario.

30. **T. spiculus** Hall. Devonic.

Differs from the preceding in its thicker annulations, which are more strongly rounded, and often appear oblique, and in the fewer and coarser intervening striæ.

Chemung of New York and Pennsylvania.

Family Conularidæ Walcott.

X. Conularia Miller.

Shell elongated pyramidal, with the transverse section varying from quadrangular to octagonal. Each lateral face marked by a median longitudinal groove. Surface transversely striated or ribbed. Posterior (apical) portion of shell divided off by septa. Aperture constricted by four lobes incurved from the margin. Ordovicic–Jurassic.

31. **C. niagarensis** Hall. (Fig. 1223.) Siluric.

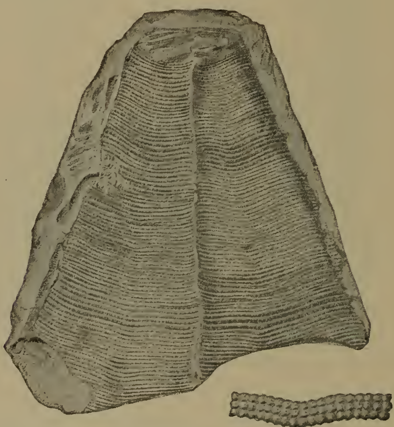

Fig. 1223. *Conularia niagarensis*, with enlargement of surface. (After Hall.)

Broadly pyramidal, tapering abruptly. Central depression of faces scarcely defined. Striæ granulate.

Rochester shale of New York.

32. **C. huntiana** Hall. (Fig. 1224.) Devonic.

Shell tapering very gradually, with deeply furrowed angles and crossed by transverse ridges.

Helderbergian of New York.

33. **C. undulata** Conrad. (Figs. 1225–26.) Devonic.

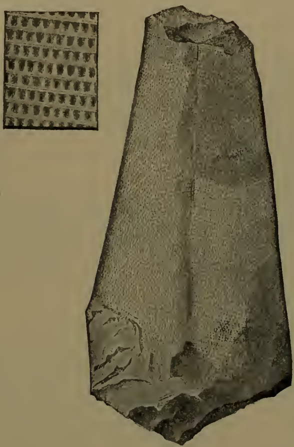

FIG. 1224. *Conularia huntiana*, with enlargement of surface. (After Hall.)

Transverse section quadrangular. Each face crossed by fine striæ which are slightly deflected at the median groove and at the angles of the shell, and which are finely crenulated.

Hamilton of New York.

34. **C. newberryi** Winchell. (Fig. 1227, *a*, *b*.) Mississippic.

More slender, less rapidly tapering than preceding; median groove on each face faint, scarcely interrupting the transverse lobes, which are coarse, distant, arched and minutely noded.

Waverly of Ohio.

35. **C. micronema** Meek. (Fig. 1227, *c–f*.) Mississippic.

Differs from preceding in more strongly pronounced median groove and finer surface striæ, which are finely crenate (*e*), and may become double (*f*).

Waverly of Ohio.

36. **C. missouriensis** Swallow. Mississippic.

Large, coarse, rapidly tapering; median groove faint or absent; marginal grooves deep; transverse ridges sharp, distant, arched, sometimes medially deflected.

Warsaw and St. Louis of Missouri, Illinois, Indiana; Mississippic of Nevada.

37. **C. byblis** White. Mississippic.

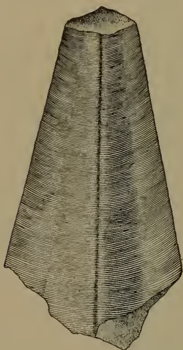

FIG. 1225. *Conularia undulata*, × ⅔.

FIG. 1226. *Conularia undulata*, enlargement of surface.

Large; sides depressed convex; median groove faint; transverse ridges narrow, raised, 45–50 to the inch, slightly curved and forming obtuse angle at median groove.

Waverly of Ohio and Tennessee; Kinderhook of Iowa.

38. **C. subulata** Hall. Mississippic.

Small (less than 1 inch long), moderately tapering; apical angle about 18°; ridges nearly flat; no median groove present; transverse striæ fine, arched.

St. Louis of Illinois and Missouri.

39. **C. crustula** White. Carbonic.

Like the preceding, but more rapidly tapering and with faint median groove; length 31 mm.

Coal Measures of Missouri, New Mexico and Arkansas.

Class **PTEROPODA** Cuvier.

Free-swimming mollusks, with or without a thin, transparent shell. No distinct head present. Eyes rudimentary and foot replaced by two lateral, wing-like fins on the anterior end of the body. Body sometimes straight, sometimes coiled posteriorly into a spiral. Many shell-covered forms develop a horny operculum. Shell mostly transparent and very variable in form (Fig. 1228).

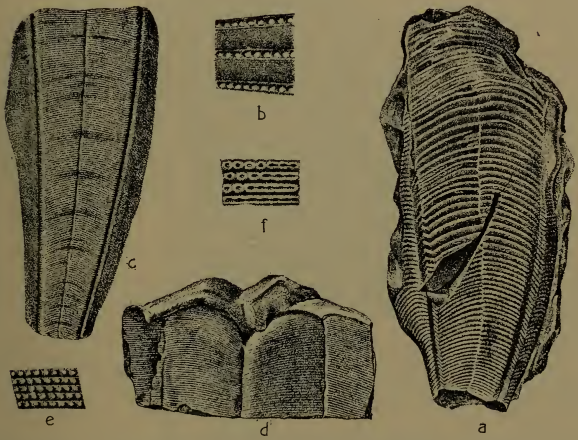

FIG. 1227. *a*, *b*, *Conularia newberryi*, × ¾, with enlargement of surface ; *c–f*, *C. micronema*, × ¾, with enlargement of surface. (Pal. Ohio.)

Pteropods lead a pelagic life, rising in vast numbers to the surface of the sea toward nightfall. The shells accumulate on the ocean floor, where they form pteropod oozes.

The class is most typically represented in Mesozoic and later deposits. In the Palæozoic they are represented by the Devonic *Styliolinidæ*.

For literature see under *Conularida*.

I. STYLIOLINA Karpinsky.

Shells small, needle-shaped, with a circular cross section. Apex solid and usually bulb-shaped. Surface smooth, marked only with fine lines of growth. Devonic.

1. **S. fissurella** (Hall). (Fig. 1229.) Devonic.

Minute. Sharply depressed central fracture line present in all the compressed specimens.

Especially abundant in the lower Genesee, where these shells make up the Styliolina limestone; also other Upper Devonic beds

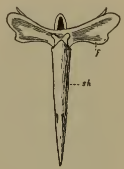

FIG. 1228. *Styliola recta; f*, foot; *sh*, shell. Recent, enlarged. (After Adams.)

FIG. 1229. *Styliolina fissurella*, with enlargement. (After Hall.)

of New York, Michigan, Ohio, Indiana, Maryland, Virginia, etc. Also abundant in the Marcellus shale of New York.

Class **CEPHALOPODA** Cuvier.

The cephalopods are the most highly developed of molluscs, possessing a distinct, well-defined head, a circle of eight or more arms or tentacles which surround the mouth; a funnel-like *hyponome* through which the animal is enabled to eject a stream of water and so propel itself backwards, and a highly developed nervous system. The majority of modern cephalopods are naked, or have only a rudimentary internal shell (*Dibranchiata*), though one of them, the female *Argonauta,* secretes a spiral non-septate shell, which, however, is not the homologue of the typical cephalopod shell. *Nautilus,* the only living representative of the *Tetrabranchiata,* is also the only modern cephalopod with a typical external shell (Fig. 1230), and our knowledge of the soft parts and their relation to the shell is wholly derived from this genus.* As the

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* See Griffin, Lawrence, "The Anatomy of *Nautilus pompilius*," *Memoirs Nat. Acad. Sciences*, Vol. VIII., no. 5, 1900.

name *Tetrabranchiata* implies, this animal possesses four gills, while the other recent cephalopods possess only two, hence they are classed as *Dibranchiata*. An internal "ink-bag," secreting an inky fluid (sepia), generally occurs in the Dibranchiates (squids, etc.), but is absent in *Nautilus*. The arms of the Dibranchiates are eight or ten in number. They are provided with suckers (*acetabula*) on

FIG. 1230. *Nautilus pompilius*. Section of shell with animal in place. (Owen's figure; after Clarke, Min. Pal.) *a*, mantle; *b*, its dorsal fold; *e*, nidamental gland; *g*, shell muscle; *i*, sipho; *k*, hyponome; *n*, hood; *o*, exterior digitation; *p*, tentacles; *s*, eyes; *x*, septa; *z*, body chamber.

their inner side, or with a double row of hooks. In forms with ten arms (*Sepioidea*), two are developed into very long tentacles with hooks or suckers only at their thickened extremities. In *Nautilus* the arms are represented by lobes, and there are in addition numerous (90) tentacles which are free from hooks or suckers (Fig. 1230, *p*).

The body of *Nautilus* is short and thick, and it is lodged in the last or *body chamber* of the coiled shell in such a position that the ventral or under side lies on the exterior of the coil. The inner or dorsal pair of tentacles is fused into a thick muscular lobe or *hood* (Fig. 1230, *n*), which acts as an operculum when the animal

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is withdrawn into the shell. A calcareous operculum (the *Aptychus* when double, *Anaptychus* when single) has been found in many Ammonoids. On the ventral side of the head is a distinct muscular leaf rolled into a tube by the infolding of its free edges, the ambulatory funnel or *hyponome* (Fig. 1230, *k*). It widens posteriorly and opens into the chamber in which the gills are situated. It often affects the shell, producing a distinct *hyponomic sinus* (see Figs. 1308 and 1319) commonly indicated by the course of the lines of growth. The head is further provided with a pair of large eyes (Fig. 1230, *s*), with a pair of powerful horny beak-like jaws with calcified tips, and with a lingual ribbon or *radula* armed with numerous rows of plates and hooks.

Posteriorly the body is rounded and completely enclosed by the *mantle,* the base of which is prolonged into a thin, fleshy, hollow tube or *siphon,* which perforates all the septa of the shell and extends to the apex of the initial chamber. This series of perforations, more or less complicated, constitutes the *siphuncle* of the shell.

The animal is fastened in the shell by two oval muscles (Fig. 1230, *g*), which are situated on either side of the animal and are connected by a dorsal and a ventral band of muscular fibers, the annular muscle or *annulus*. All the muscles leave shallow impressions on the shell, often visible in fossils, where their character becomes of systematic importance.

The *shell* of the *Nautilus* is coiled in a single plane, the later whorls being impressed on the earlier ones so as to hide most or all of the preceding volutions. In the latter case the shell is said to be completely involute, and this state generally marks the acme of development in the different evolutional series. When the inner whorls are visible in the central part or *umbilicus* the shell is said to be *umbilicated*. In this case the whorls are less deeply impressed by the preceding ones. In the more *evolute* forms this *impressed zone* is shallow and in the more primitive members it appears only late in individual development and may never pass beyond a mere flattening. Hyatt has shown that in early Palæozoic time the impressed zone appears only when the whorls are actually in close contact, and disappears again when in old age the whorls lose their power of close coiling. In the later nautiloid shells, however, the impressed zone appears, apparently by inheritance, before the whorls actually come into contact (see Hyatt, "Phylogeny of an Acquired Characteristic").

As long as an impressed zone exists, the shell is spoken of as a *nautilicone* (*Nautilus* in the broad sense); when the whorls are barely in contact, without being impressed, or when they coil in a plane without contact, it is spoken of as a *gyroceracone* (*Gyroceras* of early authors); when the tube is merely bent, without making a complete revolution, it is a *cyrtoceracone* (*Cyrtoceras* of early authors) and when it is straight it is an *orthoceracone* (*Orthoceras* of early authors). Many nautilicones pass through a gyroceraconic and even cyrtoceraconic stage in their own development, while gyroceracones are cyrtoceraconic in their early life history and cyrtoceracones when young are orthoceracones. Among the *Ammonoidea* the terms *ammoniticone, mimoceracone* and *bactriticone* are sometimes used for the close-coiled, loose-coiled and straight (primitive) forms. In some cases, both among Nautiloids and Ammonoids, coiling may be in an asymmetric spire resembling the gastropod shell. This is spoken of as a *trochoceracone* among the Nautiloids (*Trochoceras* of older authors), and *turriliticone* among the Ammonoids (*Turrilites* of older authors). In old-age individuals of both groups and in adults of decadent series, the last portion of the whorl often becomes free, or even straight again (*Lituites* of authors among Nautiloidea, *Scaphites* and *Baculites* among Ammonoidea). Such decadent forms among ammonoids assume a variety of form. The last whorl may curve to a greater radius, generally with a subsequent abrupt retral curve (*scaphitean*), or wholly straight except for a minute initial coil (*baculitean*); it may coil in a loose spiral throughout (*criocеran*), or with a final straight portion and subsequent retral curve (*ancyloceran*); it may consist of two or more straight "limbs" connected by abrupt curves separated (*hamitean*), or close in contact (*ptychoceran*), or it may become an irregularly twisting tube, generally with loss of ornamentation (*heteroceran*).

The initial point or *protoconch* of cephalopod shells is bulb-shaped, calcareous and generally preserved in the Ammonoids, but non-calcareous and generally lost in the Nautiloids, where its former presence is often indicated by a scar at the apex of the shell proper.

One of the characteristic features of the cephalopod shell is its camerated structure, *i. e.,* the greater part of the shell is divided by *septa* into air chambers or *cameræ.* The last formed septum constitutes the base of the *body chamber,* just as each preceding septum constituted the base of the body chamber at an earlier period when the animal was younger and the shell shorter. It thus appears that there is a periodic withdrawal of the animal from the base of the body chamber, followed by the building of a new septum, which cuts off the space which has become too small for the animal. The septa are pierced by the siphonal tube or *siphuncle,* each perforation being bordered by a backward prolongation or tube, the *siphonal funnel* (retrosiphonate), or a forward-bending *siphonal collar* (prosiphonate), or both. The retrosiphonate condition is characteristic of Nautiloids in general, and the prosiphonate of most Ammonoids. The funnels are either *tubular* or *nummuloidal, i. e.,* swollen out between the septa. Additional deposits may modify them in the latter case (*Actinoceras*) (Fig. 1351). In some Nautiloids (*Holochoanites*) the funnels continue backwards to the preceding septum (Fig. 1239), or even beyond, thus becoming inserted in the funnel of the preceding septum (see *Vaginoceras,* Fig. 1237), and sometimes an additional inner or tubular lining (*endosipholining*) is present (*Cameroceras*). An endosiphuncular filling in the form of cone-in-cone funnels (*endosiphosheaths*) is present in forms with a large siphuncle, and constitutes the base of the open siphuncle formed by the last of these sheaths. This is regularly conical (*endosiphocone*), or compressed (*endosiphocoleon*), while a narrow tube, the *endosiphotube* or *endosiphuncle,* continues to the apex of the shell (Figs. 1235, *b*; 1236, 1239). In some primitive forms the siphuncle with its endosiphonal filling alone exists in the early stages, the camerated portion appearing later. This "preseptal sipho" may be alone preserved and in some cases it is marked by a pronounced contraction where the cameræ begin (see *Nanno,* Fig. 1242). Not infrequently a part of the camerated portion is destroyed in fossilization, the solid siphuncle alone remaining (see Fig. 1240).

The position of the siphuncle varies in Nautiloids from centren to subventran or subdorsan, with intermediate stages as shown in the subjoined diagram (Fig. 1231). In Ammonoids it is subventran (exogastric), or in one group subdorsan (endogastric). In some primitive Goniatites it may be more nearly centren.

The Sutures.—This term is applied to septal edges, exposed on the removal of the shell. In Nautiloids they are simple, straight or slightly undulating lines which encircle the solid internal mold at nearly regular or slightly increasing intervals. In some specialized Nautiloids, and occasionally in the straight or curved forms as well, regularly disposed forward loops or *saddles* and backward bending loops or *lobes* occur, these becoming very pronounced in some cases (Figs. 1341–1344). In the Ammonoidea the sutures are characterized by well developed lobes and saddles; these are

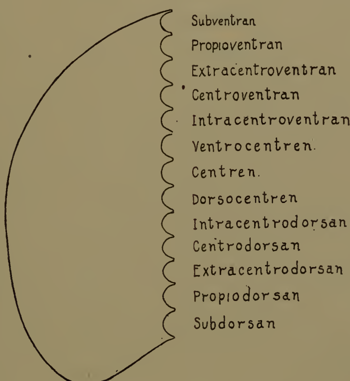

FIG. 1231. Diagram illustrating method of naming location of siphuncle. (After Hyatt.)

entire in the primitive types and the young of more specialized forms (*goniatitic sutures,* Figs. 1388–1396; *Goniatites* of authors generally); notched at the bottom of the lobe (*ceratitic suture,* Figs. 1401–1404; *Ceratites* of authors), or notched and lobed on both saddle and lobe (*ammonitic suture,* Figs. 1408–1469; *Ammonites* in the broad sense of authors). In general the degree of complexity of the suture is an index of the stage reached in development of both individual (ontogenetic) and race (phylogenetic), but owing to a process of retardation in development or degeneration of this especial feature, descendants of a highly specialized type and occurring in a late horizon, may have a very simple type of suture. This is the case with the Cretacic Pseudoceratites, Ammonites, in which the suture never passes beyond the ceratitic stage (see Figs. 1486–1490).

The suture of an ammonite septum may be divided into an *external* and an *internal* (*dorsal*) part. The division is at the point of involution or at the umbilical shoulder. The external suture has in its center the unpaired *siphonal lobe* or *ventral lobe,* which occupies the center of the outer part of the whorl (venter). This lobe, absent only in the early stages of the most primitive genera, is modified in the more specialized types by the appearance of a *saddle* (*ventral* or *siphonal saddle*) in its center. This saddle may be in turn notched or even deeply divided, while a new saddle may appear. The whole series may be modified by the secondary incision (*marginals*) of the arms of the ventral lobe or the division of the siphonal saddle, or the sides of the lateral saddles. This is the *ventral system* of the external suture. On either side are the paired saddles and lobes of the *lateral system,* those on opposite sides of the ventral system corresponding in character and complexity. The first is the ventro-lateral or *superior-lateral* saddle which bounds the ventral lobe; this is followed by the *superior lateral lobe;* then follows the *second* or *inferior lateral* saddle, and then the lobe of the same name. This is the full number in the more primitive forms, but in specialized types additional lobes and saddles appear between the second lobe and the umbilical margin. These appear progressively next the umbilical margin (margin of involution) and are called *auxiliaries,* and are numbered progressively towards the umbilical edge. In some cases the lateral saddles divide in a very definite order by the formation of lobes in their centers. Thus a complicated series of lobes and saddles arises, which can only be understood by a study of the individual development and for which a special nomenclature has been devised.*

The dorsal or inner part of the suture consists of an unpaired dorsal or *antisiphonal lobe.* This is entire in primitive species and in the young of specialized types, but becomes bifid or even trifid in the adults of the latter. In some cases, however (retarded or phylogerontic genera), the dorsal lobe remains entire in genera of comparatively late geologic occurrence. On either side of the unpaired dorsal lobe are the members of the paired saddles and

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*See Noetling, Fritz, "Die Entwickelung von *Indoceras baluchistanense,*" *Geologische und Palæontologische Abhandlungen*, Koken XII., Heft. 1, 1906.

lobes of the dorsal series. These are numbered from the center outward, to the line of involution. The *first dorsal saddles* bound the median dorsal lobe, one on each side; then follow the *first dorsal lobes* and the second dorsal saddles in regular order to the umbilical margin, where the new lateral and dorsal sutural elements appear.

The outlines of the paired lobes and saddles become modified in the later Palæozoic and the Mesozoic species by the appearance of secondary inflections or *marginals*. These first modify the lobes, which become bifid and trifid (ceratitic suture), and later on the saddles (ammonitic suture), which may become complexly incised.

Modification of the Aperture.—In nautiloids the aperture is mostly simple, and modified only by the *hyponomic sinus* (see *ante*) on the ventral side. In some specialized groups a contraction of the aperture occurs, often resulting in the formation of narrow slit-like openings or *sinuses*. The *hyponomic sinus* is generally the longest, and besides it there may be from two to six lateral or *brachial sinuses* (see *Hexameroceras*, Fig. 1378). In addition to the brachial, there is often a *median dorsal* sinus (*Trimeroceras, Pentameroceras, Septameroceras*, Fig. 1379). In the Ammonoidea the living chamber is also contracted towards the aperture, in many forms (phylogerontic), and in old-age individuals. Periodic constriction and thickening of the aperture, and subsequent expansion on resumption of growth, produces varices which, from the thickening of the margin, may be represented by grooves on the internal mold (Figs. 1393, *a, b, m;* 1417, 1420). In the Palæozoic Ammonoids a hyponomic sinus is commonly retained, but in the more specialized types and in the later forms this is commonly replaced by a *ventral* crest, or even by a long projecting *rostrum*. *Lateral crests* and *lappets* also develop in a number of genera (Fig. 1452).

Modification of the Venter.—In the more primitive coiled cephalopod shell the venter is rounded, and unmodified. It may be broader or narrower than the dorsum and may curve to a greater or less radius than that of the whorl as a whole. The modifications are, on the one hand, towards a flattening, and on the other towards acuteness. In the compressed forms it is often sharply acute (Figs. 1489, *b*; 1491), or it may be truncated by a flat band (Fig. 1403, *m*), or a channel, bounded by sharp ridges (Fig.

1486), or by a row of tubercles (Fig. 1495). A keel, solid or hollow, may further modify the venter in both compressed forms (Figs. 1409, *d*; 1442) and those with broad venter (Fig. 1503). This keel in some cases is bounded by depressed grooves (Fig. 1409, *g*) or distinct channels (Fig. 1507). It is continuous in most forms (Fig. 1510), but in some cases becomes broken into elongated nodes (Fig. 1509, *c*). In all cases the keel is a mark of specialization.

Ornamentation of the Surface.—In many forms the surface is perfectly smooth, though longitudinal *striations* and transverse *annulations* are characteristic of some of the earliest forms (Figs. 1241, 1258). In coiled forms the longitudinal markings are the *spirals,* and the transverse the *ribs* or *costæ.* Where costæ and spirals intersect, a cancellated structure is produced, when both are fine and uniform. When strong spirals cross the ribs, or where an angulation is crossed by the ribs, indefinite swellings, or *nodes,* definite rounded *tubercles,* or even *spines,* may be produced (see Figs. 1470, 1469 and 1458, respectively). The nodes may be elongate, as the result of disruption of a strong spiral (Fig. 1507). The ribs may be coarse or fine and sharp, simple or dividing, regularly or irregularly. Division may be by *forking* (*bifurcation, trifurcation,* etc.) : the regular division into two or three equal, and equally diverging branches (Fig. 1448), or by *branching*—a lateral branch being given off the main continuous one. Frequently a node or tubercle is formed at the point of furcation. Increase in the number of costæ is also effected by *intercalation,* or the appearance of a new secondary rib between the older ones. These secondary ribs often do not reach the umbilical margin (Fig. 1474). Furcation and intercalation may occur in the same shell. Various other surface features occur, such as angulations, channels which may interrupt the costæ, frilled growth lines, etc.

Special Features of the Dibranchiate Shell.—In the Dibranchiata, the camerated shell, when preserved, is known as the *phragmocone.* It is straight, curved, or coiled (*Spirula*), but in a number of specialized types it is wanting altogether. In the Belemnoidea, the delicate shell or *conotheca* of the phragmocone is prolonged forward into a delicate corneo-calcareous plate, the *proöstracum.* Posteriorly it is enveloped by a calcareous finger- or cigar-like *sheath* or *guard* (*rostrum*) (Figs. 1511–1515). The phragmocone is lodged in the conical *alveolus* or *alveolar cavity* at the summit, or anterior end, of the guard. The guard is often characterized by a well-marked *ventral furrow,* which runs from the edge of the alveolus, backwards, on the ventral side (Figs. 1512; 1515). Two symmetrical and slightly diverging grooves, the *dorso-lateral grooves,* occur in some species near the apex.

In modern Squids (*Loligo,* etc.) the proöstracum is alone preserved in the form of the delicate horny internal "pen" situated within a closed sac of the mantle. In the cuttle-fish (*Sepia*) the proöstracum is calcified and thickened by secondary lamellæ, forming the so-called "cuttle-fish bone." At the posterior tip of this is a vestige of the shell in the form of a small pointed mucro, with a more or less depressed alveolus at the upper end. This may be the rudimentary rostrum, or guard, but has also been regarded as the thickened phragmocone, the guard being absent. In *Belosepia* (Fig. 1516) the mucro is large and has a deep alveolar cavity in which some traces of a septation appears. In this case the cavity may represent the enlarged siphuncle.

Classification.—Formerly Nautiloid shells were classified by their form and mode of coiling into *Orthoceras, Cyrtoceras, Gyroceras, Nautilus, Trochoceras,* and the phylogerontic forms with a straight final portion as *Lituites.* Ammonoids were classed according to the suture, as *Goniatites, Ceratites* or *Ammonites* and the spiral irregular or non-coiling as *Turrilites, Hamites, Heteroceras, Cryoceras,* etc., with *Bacculites* as the final straight form. It is now recognized, however, that different modes of coiling, and different degrees of complexity of suture, occur in the same phyletic series and that these features appear in numerous parallel lines of development, and are not indicative of relationship. The general names are still often used in geologic writings when it is not necessary to indicate genetic relationship.

Habitat.—Modern cephalopods are marine organisms, actively swimming, floating or crawling. The larger straight forms of the Palæozoic probably were stationary, resting upon the sea-bottom, though even these may have been swimmers. The possession of a hyponomic sinus probably indicates swimming habits, while the possession of a crest or of lappets seems to suggest sedentary, crawling, or possibly floating habits. Walther has made the very fertile suggestion that the shells of the dead Ammonoids and Nautiloids were distributed widely by currents as pseudo-plankton, and that they hence may have come to rest where the animal never could have lived. This would account well for their wide distribution and excellent service as index fossils. The modern Dibranchiate *Spirula* is known to be widely distributed in this way and Clarke has shown that some Palæozoic Ammonoids were distributed in a similar manner.

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Artificial Key to the Genera.

A. Tetrabranchiata: Shelled cephalopods, the shell camerated and external, not enclosed in a calcareous "guard"—animal so far as known with four gills...I.

I. Nautiloidea: Shell with simple or gently (rarely strongly, but not angularly) lobed sutures, with concave septa and siphonal funnels of greater or less length (rarely with siphonal collars)....1.

1. *Protochoanites*: Minute orthoceracones with conical septa and flaring living chamber....I. *Volborthella*.

1. *Holochoanites*: Orthoceracones and cyrtoceracones (rarely coiled shells) with (usually) large siphuncle, the funnel extending to or beyond (within) the preceding septum....*.

*. Shell straight, cylindrical (orthoceraconic) with siphuncular filling which sometimes is alone preserved....a.

a. Siphuncle cylindrical or gradually enlarging, not abruptly expanded in apical portion and not absolutely in contact with shell on one side....11.

11. Surface annulated....V. *Cyclendoceras*.

11. Surface of shell not annulated....aa.

aa. Siphonal funnels extending to, but not beyond preceding septum....†.

†. With endosipholining....*a*.

a. With long non-camerate apical portion (preseptal cone). IIA. *Proterocameroceras*.

a. Without long non-camerate preseptal cone. II. *Cameroceras*.

†. Without endosipholining....IV. *Endoceras*.

aa. Siphonal funnels extending beyond the previous septum, and inserted in preceding funnel....III. *Vaginoceras*.

a. Siphuncle abruptly expanding in apical portion (preseptal cone) with funnels in contact at one side with shell in camerated portion, resulting in deflection of suture....VI. *Nanno*.

*. Shell short, thick and curved (breviconic cyrtoceracone)..VII. *Piloceras*.

1. *Orthochoanites:* Shells of varying form, straight, curved or coiled, with open aperature, with relatively small siphuncle, mostly cylindrical, though sometimes more or less distended between septa (nummuloidal)........**.

**. Straight forms..b.

b. Shell annulated throughout...22.

22. With longitudinal striæ only in young.........X. *Protocycloceras.*

22. With discontinuous longitudinal ridges throughout. XI. *Cycloceras.*

22. With continuous longitudinal striæ.. ....XVI. *Spyroceras.*

22. Without longitudinal ridges, but with frilled growth lines between the annuli...XII. *Dawsonoceras.*

b. Shell annulated in intermediate stages only. Longitudinal striæ in young...XIV. *Kionoceras.*

b. Shell not annulated or only faintly so.................................33.

33. Shell never strongly compressed.....................................bb.

bb. Surface smooth ....VIII. *Orthoceras.*

bb. With row of elongate tubercles on one side..IX. *Trematoceras.*

bb. With longitudinal striations or ridges..........................††.

††. Longitudinal sculpture only in young, surface sometimes faintly annulated..............................XIV. *Kionoceras.*

††. Longitudinal sculpture throughout, fine and generally close ....XIII. *Protokionoceras.*

33. Shell strongly compressed dorsoventrally. XLVII. *Tripteroceras.*

b. Shell annulated internally (shown in mold), smooth exteriorly. XV. *Orygoceras.*

**. Curved (cyrtoceraconic) or loose coiled (gyroceraconic) forms, the whorls not in contact...c.

c. Laterally compressed, section depressed elliptical. ....44.

44. Cyrtoceracones with frilled growth lines, venter narrowest. XXVII. *Zitteloceras.*

44. Gyroceracones, venter widest.................XXVIII. *Halloceras.*

c. Section subtrigonal or subcircular, whorls slightly compressed dorsoventrally...55.

55. With coarse lamellose expansions at frequent intervals, sometimes spinous...XXIX. *Ryticeras.*

55. Without coarse expansions; smooth or noded. XXVIII. *Halloceras.*

c. Section elliptical; the whorls strongly compressed dorsoventrally...66.

66. Cyrtoceracones.................................XLVII. *Tripteroceras.*

66. Gyroceracones..................................XLVIII. *Edaphoceras.*

**. Close-coiled gyroceracones, the whorls in contact, or nautilicones with more or less pronounced impressed zone.................................d.

d. Surface without annulations or nodes...................................77.

77. Whorls not angulate; venter flat or rounded.......................cc.

cc. Whorls in contact only or very slightly depressed, the last often free...†††.

†††. Venter narrower than dorsum...............................*b.*

b. Siphuncle near venter..................XVII. *Aphetoceras.*

b. Siphuncle near center...........XVIII. *Barrandeoceras.*

†††. Section nearly or quite circular (more rarely subquadrangular) ....*c.*

c. Siphuncle near venter..................XIX. *Tarphyceras.*
c. Siphuncle near dorsum............XXI. *Schrœderoceras.*
cc. Whorls impressed often to complete involution............††††.
††††. Impression moderate...*d.*
d. Whorls laterally compressed, rapidly enlarging.
XX. *Eurystomites.*
d. Whorls dorsoventrally compressed........................1′.
1′. Discoidal, whorls gradually enlarging.
XXII. *Trocholites.*
1′. Not discoidal, whorls rapidly expanding...........a′.
a′. Siphuncle nummuloidal near center, surface often spiraled..................XXX. *Nephriticeras.*
a′. Siphuncle not nummuloidal.......................‡.
‡. Siphuncle subventran in adult; sides of whorl rounded...............XLV. *Asymtoceras.*
‡. Siphuncle ventrocentren in adult; sides of whorl faintly angulated.........L. *Diodoceras.*
1′. Whorls subquadrangular...............................b′.
b′. Surface spiraled.......XXXVIII. *Thrincoceras.*
b′. Surface smooth.......................................‡‡.
‡‡. Sides parallel or diverging ventrally, dorsal lobe V-shaped............XLIX. *Remeleoceras.*
‡‡. Sides converging ventrally, dorsal lobe shallow.........................XLIV. *Domatoceras.*
††††. Impression profound to complete involution.............*e.*
e. Sutures faintly lobed...2′.
2′. Transverse diameter of adult whorls similar to or greater than height..................................c′.
c′. Suture with shallow ventral lobe..............‡‡‡.
‡‡‡. Siphuncle above the middle.
XXXV. *Stearoceras.*
‡‡‡. Siphuncle close to venter often shown in lobation....................XLVI. *Solenocheilus.*
c′. Sutures with broad ventral saddles, lateral and dorsal lobes. Whorls very gradually increasing in width, slightly umbilicated.
XXXVI. *Leuroceras.*
c′. Suture nearly straight, whorls rapidly widening, umbilicus closed..................LI. *Eutrephoceras.*
2′. Whorls laterally compressed..........................d′.
d′. Venter rounded...............LI. *Eutrephoceras.*
d′. Venter truncate, flat and narrow.
XXXVII. *Phacoceras.*
Sutures strongly lobed.......................................3′.
3′. Ventral saddle narrow, notched.
LIII. *Proclydonautilus.*
3′. Ventral saddle broad, undivided......................e′.
e′. Siphuncle small, centren or subcentren.
LIV. *Hercoglossa.*
e′. Siphuncle large, close to dorsum...LV. *Aturia.*

77. Whorls with pronounced angulation, but not annulated or noded in adult...dd.
dd. Venter channeled in adult...5†.
5†. With two pairs of revolving ridges...XXXI. *Strobocceras.*
5†. Without the revolving ridges......................................*f.*
f. Suture with ventral and lateral lobes and broad dorsal saddle.......................................XXXII. *Apheleceras.*
f. Suture with ventral subacute saddle and broad lateral lobes.................................XXXIII. *Ephippioceras.*
dd. Venter convex in adult, often channeled in young.........6†.
6†. Section triangular, whorls striate...XXXIV. *Triboloceras.*
6†. Whorls elliptical, not striate.......XLVIII. *Edaphoceras.*
d. Surface with annulations...88.
88. Shell close coiled; annulations fine, regular and crowded.
LII. *Cymatoceras.*
88. Shell widely umbilicated, gyroceraconic, or whorls slightly impressed...ee.
ee. Discoidal whorls very gradually enlarging, costæ sharp, distinct...XXIII. *Discoceras.*
ee. Whorls regularly enlarging; costæ low, crowded.
XXIV. *Plectoceras.*
88. Shell a trochoceran spire.......................XXV. *Sphyradoceras.*
d. Surface of shell with two or more rows of nodes........................99.
99. Whorls laterally compressed, higher than wide, with nodes on the ventrolateral margin...ff.
ff. Sides flat or concave, section subquadrangular...................7†.
7†. With ventrolateral rows of tubercles only (often obsolete).
XLII. *Metacoceras.*
7†. With double row of lateral as well as ventral tubercles.
XLIII. *Tainoceras.*
ff. Sides convex, height much exceeding width.
XXXIX. *Centroceras.*
99. Whorls as wide as high or vertically compressed.................gg.
gg. Venter gently arched, flat or with concavity, tubercles on ventrolateral angle, often flat spines.........XL. *Temnocheilus.*
gg. Venter strongly arched, tubercles near umbilicus or obsolete.
XLI. *Endolobus.*
**. Trochoceracones, coiled in more or less pronounced spiral..............e.
e. Surface smooth..ooo.
ooo. Spire high, whorls regularly enlarging. Coil right-handed.
XXVI. *Mitroceras.*
ooo. Spire low, coiling, left-handed.................LVII. *Nædyceras.*
e. Surface annulated, spire low........................XXV. *Sphyradoceras.*
1. *Cyrtochoanites:* Straight, curved or coiled shells, siphuncle generally highly nummuloidal, funnels bent outward or crumpled, short...................***.
***. Without contracted aperture ....f.
f. Siphuncle mostly without deposits...111.
111. Orthoceracones ....LVI. *Lcxoceras.*
111. Trochoceracones.....................................LVII. *Nædyceras.*
111. Gyroceracones.................................LVIII. *Gigantoceras.*

f. With internal deposits leaving annulated endosiphuncle............ 222.
222. Orthoceracones..LIX. *Actinoceras*.
222. Cyrtoceracones ....hh.
hh. Tube rapidly enlarging ....8†.
8†. Section only slightly compressed.....LX. *Cyrtactinoceras*.
8†. Section strongly compressed; siphuncle broad.
LXI. *Gonioceras*.
hh. Slender, slowly enlarging..................LXII. *Mœlonoceras*.
***. Aperture slightly contracted, form elongate (longicone), slender......g.
g. Section circular or compressed dorsoventrally............... ....333.
333. Rapidly enlarging ....LXIII. *Cyclostomiceras*.
333. Subcylindrical ....LXV. *Oöceras*.
g. Laterally compressed........... ....LXIV. *Oncoceras*.
***. Contraction moderate, below aperture, form slender, gently arcuate.
LXVI. *Clinoceras*.
***. Aperture generally strongly contracted, shell a breviconic cyrtoceracone or orthoceracone.................................... ....h.
h. Circular or dorsoventrally compressed ....444.
444. Aperture subtrigonal.........................LXVII. *Poterioceras*.
444. Aperture a narrow slit in form of cross..LXVIII. *Trimeroceras*.
444. Aperture with six lateral sinuses in addition to long hyponomic sinus...LXIX. *Hexameroceras*.
444. Aperture with six lateral and one median besides hyponomic sinus ....LXX. *Septameroceras*.
h. Laterally compressed ....LXXI. *Phragmoceras*.

I. Ammonoidea: Shell with strongly lobed sutures, the lobes and saddles compound in the more specialized division—siphuncle typically ventral and marginal in all but one group in which it is dorsally situated; siphuncle mostly with forward turning "collars"..2.

2. Suture straight or with simple lobes and saddles (goniatitic)..............****.
****. Shells straight...LXXIV. *Bactrites*.
****. Shells coiled..i.
i. Siphuncle situated dorsally or on inside of whorls....... ....555.
555. Discoidal, whorls but slightly enlarging, sutures scarcely lobed.
LXXIII. *Platyclymenia*.
555. Whorls regularly enlarging, sutures with few simple but pronounced lobes ....LXXII. *Acanthoclymenia*.
i. Siphuncle ventran or subventran...666.
666. Ventral lobe of suture undivided.......................................ii.
ii. With broad lateral lobe, the saddles at lateral angles.
LXXV. *Agoniatites*.
ii. With lateral lobes and saddles....................................9†.
9†. Lobes and saddles nearly equal ....*g*.
g. Minutely umbilicated................LXXVI. *Tornoceras*.
g. Non-umbilicate......................LXXIX. *Parodiceras*.
9†. With broad lateral saddle and sharp lobe.
LXXX. *Aganides*.
9†. With narrow pointed lateral lobes and generally spatulate saddles ....XCIII. *Prolecanites*.
666. Ventral lobe divided by saddle...jj.
jj. Ventral saddle notched...10†.

10†. Lateral saddle prominent, flanked by sharp lobes on each side..*h.*

h. Lateral saddle broad, round...LXXVII. *Manticoceras.*

h. Lateral saddle sharp..4′.

4′. Broadly umbilicated.......LXXVIII. *Probeloceras.*

4′. Minutely umbilicated or non-umbilicate...........f′.

f′. Ventral saddle with simple notch.
LXXXII. *Gonioloboceras.*

f′. Ventral saddle with complex lobing resulting in several narrow lobes and saddles.
LXXXIII. *Dimorphoceras.*

10†. Lateral saddle and superior lobe alone present on side of shell, the second lobe at umbilical margin.................*i.*

i. Shell with pronounced umbilicus with angular margin.
LXXXI. *Muensteroceras.*

i. Umbilicus minute or closed ; shell subglobose.
LXXXIV. *Goniatites.*

10†. Lateral saddle equal to or less prominent than superior lateral one; superior lateral and second lobe both present ....*j.*

j. Broadly umbilicated..5′.

5′. Ventral saddle mostly low or absent; whorls vertically compressed.............LXXXV. *Glyphioceras.*

5′. Ventral saddle moderate or high.....................g′.

g′. Shell with ribs or tubercles on side.
LXXXVI. *Gastrioceras.*

g′. Shell smooth, whorls scarcely embracing.
CI. *Paralecanites.*

j. Umbilicus narrow, but deep, shoulders flat. Shell helmet-shaped with constrictions or varices.
XCVI. *Nannites.*

jj. Ventral saddle undivided...11†.

11†. Whorls laterally compressed.................................*k.*

k. Lobes and saddles angular...LXXXII. *Gonioloboceras.*

k. Saddles rounded, long and narrow......................6′.

6′. Ventral saddle bottle-shaped.
LXXXVII. *Schistoceras.*

6′. Ventral saddle not bottle-shaped.
LXXXVIII. *Paralegoceras.*

11†. Whorls vertically depressed ; umbilicus large.
LXXXVI. *Gastrioceras.*

2. Suture simple (goniatitic) only in young ; in adult, one or more of the lobes are modified by secondary notches or serrations (ceratitic suture) ....5*.

5*. Lobes numerous and similar, serration bifid or trifid........................j.

j. Shell slightly compressed or subglobose................................777.

777. Umbilicus almost closed.................LXXXIX. *Popanoceras.*

777. Umbilicus rather wide..kk.

kk. Siphonal saddle bottle-shaped...............XC. *Shumardites.*

kk. Siphonal saddle not bottle-shaped.
LXXXIXA. *Parapopanoceras.*

j. Shell strongly compressed..888.

888. Venter channeled..ll.

ll. Superior saddles strongly notched (ammonitic), the others simple..XCV. *Medlicottia.*

ll. Superior lateral saddles not notched.................. ....12†.

12†. Umbilicus small...........................XCIX. *Sageceras.*

12†. Umbilicus closed.........................C. *Pseudosageceras.*

888. Venter not channeled...mm.

mm. Superior lateral lobe only divided; others pointed, venter broadly rounded.................................XCIV. *Pronorites:*

mm. Most of the lobes serrately divided, venter narrowly rounded. XCII. *Prodromites.*

5*. Lobes mostly dissimilar and not numerous; serrations more than two or three in each lobe .... k.

k. Shell laterally compressed................ ....999.

999. Venter sharply acute, often keeled..................................nn.

nn. Umbilicus small or closed, surface smooth... ....13†.

13†. With adventitious ventral lobes, second lateral largest. XCVIII. *Aspenites.*

13†. Without adventitious lobes, third lateral largest. CIV. *Longobardites.*

nn. Umbilicus moderate, surface ribbed and noded. CIII. *Eutomoceras.*

999. Venter rounded or obtusely angular...................................oo.

oo. Umbilicus small, surface smooth or nearly so. XCVII. *Paranannites.*

oo. Umbilicus moderately large.................... ....14†.

14†. Surface smooth............CII. *Meekoceras* (*Prionolobus*).

14†. Surface with low ribs...*l.*

l. Saddles faintly crenulated. CII. *Meekoceras* (*Beyrichites*).

l. Saddles smooth...........CII. *Meekoceras* (*Koninckites*).

14†. Surface strongly ribbed.......................................*m.*

m. Nodes faint or absent, ribs numerous..................7′.

7′. Venter keeled, saddles and lobes finely serrate. CVII. *Ceratites* (*Gymnotoceras*).

7′. Venter not keeled; lobes deeply and complexly notched; saddles entire.....CVIII. *Acrochordiceras.*

m. More or less strongly noded or with spines; ribs coarse...................... ....8′.

8′. Nodes or spines on ventrolateral margin only. CVI. *Tirolites.*

8′. A second row of nodes near umbilicus. CVII. *Ceratites.*

999. Venter flat...pp.

pp. Umbilicus moderate with abrupt shoulder...CII. *Meekoceras.*

pp. Umbilicus large, shoulder abrupt, sides flat. CII. *Meekoceras* (*Gyronites*).

k. Shell discoidal, whorls rounded or subquadrate, umbilicus large. oooo.

oooo. Shell faintly ribbed...qq.
qq. Whorls rounded, scarcely embracing.........................15†.
15†. Young whorls trapezoidal, ventrolateral angles noded.
CXI. *Columbites.*
15†. Young whorls depressed, but not trapezoidal.
CV. *Celtites.*
qq. Whorls subquadrate, moderately embracing.
CVI. *Metatirolites.*
oooo. Shell strongly ribbed...rr.
rr. Venter with central furrow.......................................16†.
16†. Ribs coarse, straight, strongly noded or spinous, whorls slightly embracing..................CIX. *Clionites* (*Traskites*).
16†. Ribs sharp, curving, nodes fine, in spiral row, whorls moderately embracing.........CX. *Trachyceras* (*Anolcites*).
rr. Venter without furrow..................CVIII. *Acrochordiceras.*
2. Suture in adult complexly lobed, the lobes and saddles notched or with secondary lobation (ammonitic) ....6*.
6*. Ventral saddle strongly notched, the others simple or with a single notch on each side...XCV. *Medlicottia.*
6*. Lobes and saddles simple in form, both slightly notched..................l.
l. Whorls compressed or flat..llll.
llll. Venter rounded..ss.
ss. Surface faintly ribbed...17†.
17†. Venter flat, but not furrowed.
CII. *Meekoceras* (*sens. strict*).
17†. Venter furrowed.....CX. *Trachyceras* (*Protrachyceras*).
ss. Surface strongly ribbed..18†.
18†. Venter keeled...*n.*
n. Keel not flanked by depressed grooves.
CVIIA. *Gymnotoceras.*
n. Keel flanked by depressed grooves.
CXV. *Paratropites.*
18†. Venter not keeled, ribs strongly cancellated.
CXII. *Sagenites.*
ss. Surface smooth except for fine spirals. Umbilicus small or closed; venter narrowly rounded..............CXVIII. *Ussuria.*
llll. Venter acute...tt.
tt. With high keel..19†.
19†. Surface with dichotomous sickle-shaped ribs.
CXIV. *Discotropites.*
19†. Surface smooth........................CXXVII. *Hauericeras.*
tt. Without keel; surface smooth or costate.......................20†.
20†. Young with venter grooved or channeled.
CLXV. *Metengonoceras.*
20†. Young with venter not grooved or channeled.
CLXVI. *Sphenodiscus.*
tt. With ventral groove instead of keel.............................21†.
21†. Groove margined by smooth keels, surface smooth.
CLXIII. *Protengonoceras.*
21†. Groove margined by rows of nodes, surface generally noded or ribbed..........................CLXIV. *Engonoceras.*

l. Whorls depressed, form subglobose.................................2222.

2222. Venter with keel; umbilicus profound with margin noded. CXIII. *Tropites.*

2222. Venter without keel; umbilicus small...........CXVI. *Arcestes.*

6*. Saddles deeply incised by secondary lobes (except in retarded species)..m.

m. Whorls coiling in single plane.......................................3333.

3333. Close coiled throughout, with rounded venter..................uu.

uu. Surface without ribs, but often with varices.............. ...22†.

22†. Secondary saddles rounded, leaf-like, narrowed at base..*o.*

o. Whorls strongly compressed, umbilicus small or absent. CXIX. *Phylloceras.*

o. Whorls vertically depressed, umbilicus of moderate size. XCI. *Waagenoceras.*

22†. Secondary saddles not leaf-like...............................*p.*

p. Whorls broadly rounded or subangular...................9′.

9′. Umbilicus rather small, surface smooth, varices or constrictions absent or few..........................h′.

h′. Growth lines falcate, outlining lateral and ventral lappets....................CXXIII. *Haploceras.*

h′. Growth lines scarcely falcate. CXXII. *Pseudophyllites.*

9′. Varices or constrictions present. Umbilicus often closed by callus......................CXVII. *Joannites.*

p. Umbilicus large, varices or constrictions common...10′.

10′. Section trapezoidal..............CXX. *Tetragonites.*

10′. Section rounded, oblong, moderately embracing. i′.

i′. Young whorls trapezoidal. CXXVIII. *Gabbioceras.*

i′. Young whorls not trapezoidal. CXXI. *Gaudryceras.*

10′. Section elongate with flat or compressed sides. CXXIX. *Pleuropachydiscus.*

10′. Section nearly circular, whorls scarcely impressed. CXXXIII. *Lytoceras.*

uu. Surface with ribs more or less well developed........ ....23†.

23†. Ribs simple (rarely bifurcating near umbilicus), increasing by intercalation...*q.*

q. Ribs smooth, without tubercles or nodes...............11′.

11′. Ribs flexed in sigmoid curves, bending forward across venter............................CXXV. *Puzozia.*

11′. Ribs straight or simply curved; thin, distant, often obsolete in adult...........CXXX. *Pachydiscus.*

11′. Ribs forming coarse folds on venter, obsolete towards umbilicus............CXXIV. *Eurynoticeras.*

q. Ribs more or less strongly noded......... ....12′.

12′. Ribs extending across venter........................j′.

j′. Ribs bifurcating from umbilical tubercle. CXXX. *Pachydiscus.*

j′. Ribs simple or bifurcating tubercles on side and on venter .. ..CL. *Acanthoceras.*

j′. Ribs coarse, alternating in size; tubercles not strong in adult..................CLI. *Douvilleiceras.*

j′. Ribs broken by spirals into numerous uniform nodes..................... ...CXIIA. *Trachysagenites.*

j′. Ribs few, coarse, a double row of strong ventro-lateral tubercles..................CLII. *Metoicoceras.*

12′. Ribs not extending across the venter..............k′.

k′. Discoidal, with large umbilicus; end of costæ tubercled ....CXLII. *Aspidoceras.*

k′. Compressed, with small umbilicus..............4‡.

4‡. With sharp median geniculation of ribs marked by angulation on groove.
CXXXVII. *Œcotraustes.*

4‡. Without pronounced geniculation.
CXXXVI. *Oppelia.*

23†. Ribs bifurcating or trifurcating above umbilicus.........*r.*

r. Surface of shell without nodes..........................13′.

13′. Umbilicus large ....l′.

l′. Section transverse.................................5‡.

5‡. Ribs crossing venter uninterruptedly.
CXL. *Perisphinctes.*

5‡. Ribs bending forward on venter and becoming obsolete in center......................*a′.*

a′. Young coronate, of trapezoidal section.
CXLV. *Aulacostephanus.*

a′. Young not coronate.....CXLI. *Idoceras.*

l′. Section laterally compressed, whorls high...6‡.

6‡. Ribs bifurcating...CXLIII. *Olcostephanus.*

6‡. Ribs dividing into bundles of three or four.
CXLIV. *Virgatites.*

13′. Umbilicus small....CXXXVIII. *Macrocephalites.*

r. Surface of shells with nodes or tubercles at division or at end of branches or both.............................14′.

14′. Ribs interrupted ventrally..........................m′.

m′. With median ventral channel.
CXLVI. *Hoplites.*

m′. With flattening, but no channel, nodes weak.
CXLIX. *Lyticoceras.*

14′. Ribs continuous across venter ....n′.

n′. Ribs enlarging ventrally, with intercalated smaller ribs....................CXLVII. *Stoliczkaia.*

n′. Ribs continuous and strong from umbilical tubercle.......................CXLVIII. *Sonneratia.*

uu. Surface with coarse folds, tubercles and rather definite ribs; young with compressed, narrowly-channeled venter; suture highly complex............................CLXVIII. *Stantonoceras.*

3333. Close coiled throughout, with venter acute, angulated, flat, channeled or modified by keel which is often bordered by grooves ....vv.

vv. Surface strongly ribbed...24†.

24†. Venter rounded or flattened, with median keel well developed ....*s*.

s. Keel continuous, not bounded by groove..............15′.

15′. Ribs curved sigmoidally, often noded.
CLXX. *Schloenbachia*.

15′. Ribs bending forward and ending before reaching keel — nodes faint or absent.
CLXXIII. *Prionocyclus*.

s. Keel continuous, bounded by grooves..................16′.

16′. Whorls scarcely embracing, ribs continuous, geniculated at ventrolateral margin..............................o′.

o′. Young subquadrate, tuberculated.
CXXXIV. *Coroniceras*.

o′. Young ovoid, higher than wide.
CXXXV. *Arnioceras*.

16′. Whorls moderately embracing, ribs broken up into nodes (continuous in old age).......................*s*.

s. Keel discontinuous in adult — ribs ending in spines at ventrolateral margin...............CLXXII. *Prionotropis*.

24†. Venter acute with pronounced keel..........................*t*.

t. Keel strongly corded, shell with numerous fine bifurcating and curving ribs...............CXXXIX. *Cardioceras*.

t. Keel sharp, broken by costæ into tubercles — ribs coarse, with nodes... ....CLXIX. *Barroisiceras*.

24†. Venter channeled, without median keel, channel bounded by tubercles..................................CLII. *Metoicoceras*.

vv. Surface smooth or with discontinuous ribs or nodes........25†.

25†. Shell strongly compressed and closely involute.........*u*.

u. Venter acute, sharp; suture comparatively simple..17′.

17′. Young with grooved venter.
CLXV. *Metengonoceras*.

17′. Young not grooved.........CLXVI. *Sphenodiscus*.

u. Venter channeled..18′.

18′. Suture very complex, channel with or without marginal nodes...............CLXVII. *Placenticeras*.

18′. Suture relatively simple (almost ceratitic)......p′.

p′. Channel bounded by small ridges.
CLXIII. *Protengonoceras*.

p′. Channel flat or concave, generally bounded by elongate, alternating nodes.
CLXIV. *Engonoceras*.

25†. Shell not compressed, venter broadly rounded, surface smooth or with coarse folds or tubercles; young Placenticeroid. .... CLXVIII. *Stantonoceras*.

3333. Close-coiled except last portion in which the whorl is partly loose-coiled, with generally a final rectangular curve.
CXXXI. *Scaphites*.

3333. Loose-coiled throughout; generally costate...................ww.

ww. Form a regular loose spiral, the whorls not in contact; with two (or three) rows of nodes..................CLIII. *Crioceras*.

ww. Form a loose spiral in young, the adult straight with a final recurving portion.................................CLIV. *Ancyloceras.*
ww. Form a succession of straight limbs connected by curved portions..26†.
26†. Limbs distant, with continuous ribs, no tubercles. CLV. *Hamites.*
26†. Limbs in contact or even impressed; ribs smooth or tuberculated..................................CLVI. *Ptychoceras.*
m. Whorls coiled in a spire, which is more or less regular...........4444.
4444. Spire low, nearly in single plane; surface ribbed and noded. xx.
xx. Early whorls in contact; ribs with three rows of tubercles. CLVII. *Helicancyclus.*
xx. Whorls more or less free, early ribs with two rows of costæ. CLIX. *Exiteloceras.*
4444. Spire of medium height, with broad base, costæ tubercled, young portion straight............................CLXA. *Didymoceras.*
4444. Spire high, with ribs and nodes....................................yy.
yy. Whorls round, ribs extend from suture to suture, nodes few. CLVIII. *Helicoceras.*
yy. Whorls subangular, with regular spiral rows of nodes on angulations.......................................CLXII. *Turrilites.*
m. Whorls coiled irregularly or straight..................................5555.
5555. Early whorls in low spiral followed by long, straight portion with costæ, often bifurcating and sometimes tuberculated. CLXI. *Anisoceras.*
5555. Early whorls high-spired, growth in later stages very irregular, generally represented only by fragments..........CLX. *Heteroceras.*
5555. Coiled only in the youngest stages, all parts generally seen straight and smooth ....CXXXII. *Baculites.*

B. Dibranchiata: Mostly naked cephalopods, well represented in modern faunas (squid, cuttlefish, octopus, etc.); shell when present internal, often enclosed in a calcareous "guard." Animal with two gills.......................................II.
II. Belemnoidea: Camerated shell (phragmocone) enclosed in a calcareous guard..3.
3. Phragmocone long, guard short............................CLXXIV. *Atractites.*
3. Phragmocone much shorter than the guard........ ....7*.
7*. Guard with short, deep ventral furrow below alveolar margin, shell ending in mucronate point................................CLXXVI. *Belemnitella.*
7*. Guard with long furrow, or smooth, without mucronate terminal. CLXXV. *Belemnites.*
II. Sepioidea: Shell (internal) ending posteriorly in a mucro, the anterior portion expanded into a broad proöstracum...4.
4. Proöstracum long, thickened by calcareous lamellæ; mucro minute.....*Sepia.*
4. Proöstracum not known, mucro large, expanded........CLXXVII. *Belosepia.*

Subclass **TETRABRANCHIATA.**

Order I. NAUTILOIDEA.

Suborder PROTOCHOANITES* Grabau and Shimer.

I. VOLBORTHELLA Schmidt.

Minute, primitive orthoceracones with expanded, living chamber, conical septa and small, empty siphuncle. Cambric.

1. **V. tenuis** Schmidt. (Figs. 1232, 1233.) Cambric.
Small, rather rapidly tapering; septa deeply arcuate.

FIG. 1232. *Volborthella tenuis.* A slab with several individuals, ×1. (After Schmidt.)

FIG. 1233. *Volborthella tenuis.* Enlargement of the specimens. (After Matthew.)

Protolenus beds (base of Middle Cambric) of New Brunswick and Europe.

Suborder HOLOCHOANITES Hyatt.

II. CAMEROCERAS Conrad (emended Hyatt).

Orthocones, with large, excentric siphuncles, having the siphonal funnels extend to the preceding septum, and supplemented by an "endosipholining" or inner lining tube, and with funnel-form endosiphuncular filling (endosiphosheaths) only in connection with the living chamber, and with an endosiphotube in the center which may continue in the form of a compressed slit-tube (endosiphocoleon). Ordovicic–Siluric.

2. **C. (Proterocameroceras) brainardi** (Whitfield). (Fig. 1234.) Ordovicic.

Large (up to 4 ft. or more in length), expanding very gradually (1 in 30 mm.); cross section elliptical; cameræ with depth about one fifth of the width; septa from 3–4 mm. distant. Endosiphotube continued in endosiphocoleon in adult shell; apical portion long, without cameræ, but with endosiphosheaths.

Very common, Fort Cassin (Beekmantown) beds of Lake Champlain region.

3. **C. tenuiseptum** (Hall). (Fig. 1235.) Ordovicic.

FIG. 1234. *Protocameroceras brainerdi*, lateral and end views, × ½. (After Whitfield, Am. Mus. Nat. Hist. Bull.)

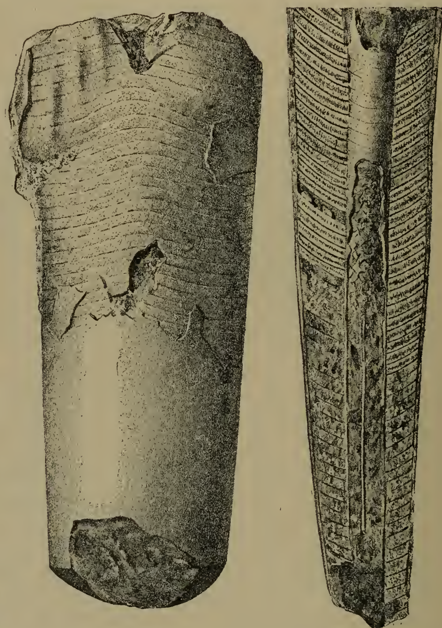

FIG. 1235. *Cameroceras tenuiseptum*, specimen showing part of shell, and natural section, showing endosiphotube, × ⅔. (After Ruedemann, Bull. 90, N. Y. State Mus.)

Differs from preceding in its more rapidly tapering shell (13 mm. in 100); circular section; large siphuncle which occupies one half the diameter of the adult; more closely crowded and very deep and exceedingly thin septa, with depth three times that of the cameræ; suture with low ventral saddle.

Chazy of Lake Champlain region. Common.

III. Vaginoceras Hyatt.

Differs from *Cameroceras* in having the siphonal funnels extend beyond the preceding septum, even to the one before. Endosiphosheaths very numerous. Ordovicic.

4. **V. oppletum** Ruedemann. (Figs. 1236, 1237.) Ordovicic.

Large (one meter or more), very slowly expanding; subcircular

Fig. 1236. *Vaginoceras oppletum*, section of fragment showing apical end of endosiphocone, and the endosiphosheaths. (After Ruedemann.)

Fig. 1237. *Vaginoceras oppletum*, enlargement of part of siphuncular wall of Fig. 1236, showing structure and extent of septal funnels, × 5. (After Ruedemann.)

in section, with large living chamber, shallow cameræ increasing progressively (20 mm. in adult); older ones with organic deposits often filling them; sutures with ventral saddle; siphuncle circular, two fifths the diameter of the conch, subventran; surface smooth.

Common in the Lower Chazy (C) of Lake Champlain region, of New York and Vermont.

IV. Endoceras Hall (emended Hyatt).

Like *Cameroceras* with siphonal funnels extending only to next preceding septum, but without the lining of the siphuncle (endosipholining); siphuncular cones (endosiphosheaths) fewer than in *Vaginoceras*.

5. **E. consuetum** Sardeson. (*E. champlainense* Rued.) Ordovicic.
Small, straight, and very slowly expanding; with elliptical section; septal concavity about one third diameter of shell, in contact with outer shell and somewhat flattened; filled only in apical portion; surface smooth.

Shakopee dolomyte of Wisconsin, Beekmantown (Div. D) of Lake Champlain region.

6. **E. montrealense** Ruedemann. (Fig. 1238.) Ordovicic.
Gently expanding, with circular section, siphuncle cylindrical with slight interseptal constrictions, and seven sixteenths the diam-

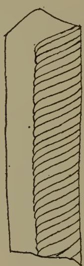

FIG. 1238. *Endoceras montrealense*, section showing diameter of siphuncle. (After Ruedemann.)

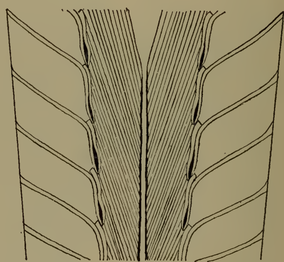

FIG. 1239. *Endoceras proteiforme*, diagrammatic section showing extent of septal funnels, endosiphosheaths and endosiphotube, expanding above in endosiphocone. (After Hyatt.)

eter of the shell; septal concavity twice the depth of cameræ; suture with deep ventral lobe, and small dorsal saddle (?); surface smooth.

Upper Beekmantown of Fort Cassin, Vermont and Quebec.

7. **E. proteiforme** Hall. (Figs. 1239, 1240.) Ordovicic.
Very large (up to 15 ft. or more); section circular; air chambers comparatively shallow; siphuncle very large, submarginal; siphonal funnels short, sometimes scarcely reaching next septum.

Stones River of Minnesota, Tennessee and Cincinnati region; Black River of Ontario-Quebec; Trenton and Utica (?) of same, New York and Minnesota.

V. Cyclendoceras* Grabau and Shimer.

Like *Endoceras* but with annulated surface. Ordovicic.

8. **C. annulatum** (Hall). (Fig. 1241.) Ordovicic.

Large (three inches or more in diameter), almost cylindrical; annulations broad; rounded, distant, and almost one fifth diameter

Fig. 1240. *Endoceras proteiforme;* siphuncle and part of cameræ preserved; cross-section showing the diameter of young shell (inner), the diameter of siphuncle and the diameter of the adult shell. All × ⅓. (After Hall, Pal. N. Y., I.

of shell and equal in width to the interspaces; septa deeply concave; siphuncle large, subdorsan, circular in section.

Trenton limestones of New York.

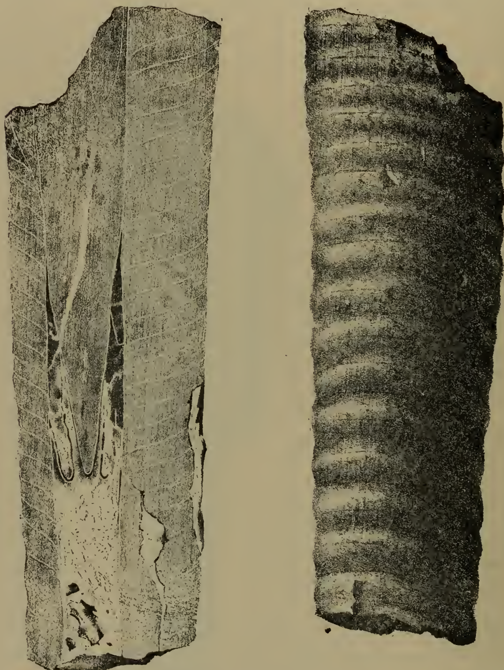

FIG. 1241. *Cyclendoceras annulatum*, section showing siphuncle, and septa, and exterior view of fragment. The fine dark lines indicate edges of septa, × ½. (After Hall, Pal. N. Y., I.)

VI. NANNO Clarke.

Apical end without cameræ, wholly occupied by siphuncle as in *Proterocameroceras,* but short and swollen, the siphuncle contracting at the camerate portion; endosiphuncle (endosiphotube) restricted to apical end; siphuncle in absolute contact with shell in camerate portion, the sutures making an apparent bend apically into a ventral lobe. Ordovicic.

9. **N. noveboracum** Ruedemann. Ordovicic.

Nepionic bulb (preseptal cone) plump; apex obtusely rounded, length 19 mm.

Chazy of Lake Champlain region. Rare.

10. **N. aulema** Clarke. (Fig. 1242.) Ordovicic.

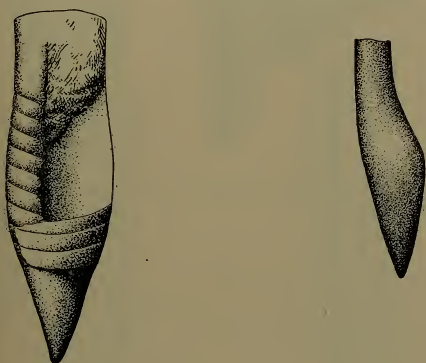

FIG. 1242. *Nanno aulema*, part of shell showing preseptal sipho and cameræ and siphuncle; also mold of siphuncle. (After Clarke, Pal. Minn.)

Type of genus; preseptal cone thinner and less plump than in preceding, with sharply pointed apex, and rather abruptly contracted at camerated end.

Black River of Minnesota.

VII. PILOCERAS Salter.

Breviconic cyrtoceracones, siphuncle very large; endocones well defined; septa strongly concave and cameræ empty. Ordovicic.

11. **P. explanator** Whitfield. (Fig. 1243.) Ordovicic.

Large (over 10 inches long) with a short preseptal cone; siphuncle with oblique interseptal annuli; surface smooth.

Upper Beekmantown (Cassian) of the Lake Champlain region; a closely related or identical form (*P. triton* Bill.) occurs in the Upper Beekmantown of Newfoundland.

FIG. 1243. *Piloceras explanator*, × ½, side view of lower end of large specimen with siphuncle protruding, and longitudinal section. (After Whitfield, Am. Mus. Bull.)

12. **P. wortheni** Bill. (Fig. 1244.) Ordovicic.

Smaller, less expanded, and with smaller siphuncle than preceding; from 8 to 12 septa in an inch.

Upper Beekmantown (H) of Newfoundland.

FIG. 1244. *Piloceras wortheni*, section of part of shell, with siphuncle filled by endosiphosheaths *b*, and cavity at *a*; and view of detached siphuncle. (After Billings.)

Suborder ORTHOCHOANITES Hyatt.

ORTHOCERATIDA.

VIII. ORTHOCERAS Breyn.

Longiconic orthoceracones (rarely cyrtoceraconic), gently tapering in the typical forms but more rapidly in *Geisonoceras* and nearly pencil-shaped in *Protobactrites;* siphuncle centran or slightly excentric—small in *Geisonoceras;* cameræ rarely with deposits

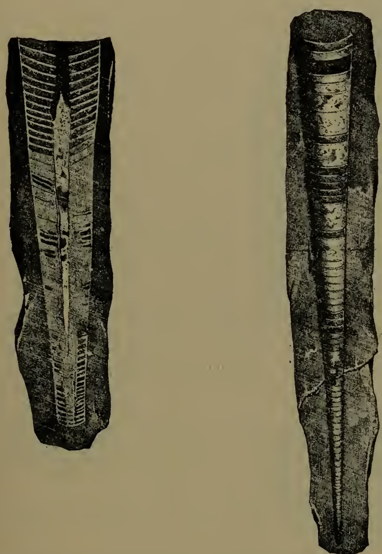

FIG. 1245. *Orthoceras multicameratum*, natural section, and apical end of large specimen, × ½. (After Hall, Pal. N. Y., I.)

about the siphuncle. Surface smooth or with lines of growth. Ordovicic–Triassic.

13. **O. primigenium** Vanuxem. Ordovicic.

Section circular, tapering rather rapidly; septa thin and closely crowded, distant, one twenty-fifth diameter of shell. Surface smooth.

Common in the Beekmantown (Upper Little Falls dolomite) of the Mohawk Valley and elsewhere in New York.

14. **O. modestum** Ruedemann. Ordovicic.

Slender, nearly cylindrical, increasing at the rate of 1 in 30 mm., 5 cameræ in about 10 mm. in adult; living chamber long, with one or several constrictions; siphuncle small, centren; surface with exceedingly fine, regular, growth lines only.

Chazy (C6) of the Lake Champlain region, New York and Vermont.

15. **O. recticameratum** Hall. Ordovicic.

More rapidly expanding than preceding, somewhat deeper cameræ (4 in 10 mm.) and septa somewhat angular.

Lowville (Upper Chazyan) of Mohawk and Black River Valleys.

16. **O. multicameratum** Emmons. (Fig. 1245.) Ordovicic.

Cameræ more irregular in depth varying from one fourth to one half the diameter.

Lowville of New York; Stones River of Cincinnati region of Tennessee; Stones River, Black River and Trenton of Minnesota.

17. **O. junceum** Hall. (Fig. 1246.) Ordovicic.

More slender and more gently tapering than preceding; siphuncle centren; septa thin, one third to one fourth diameter apart, strongly arched, more closely arranged towards the deep living chamber.

Stones River and Black River and Trenton of Minnesota and Cincinnati region; Trenton of New York and Canada.

18. **O. amplicameratum** Hall. (Fig. 1247.) Ordovicic.

Larger than the preceding; septa strongly arched; about one third diameter apart; siphuncle excentric.

Black River and Trenton of Canada; Trenton of New York, Tennessee and Minnesota (?).

19. **O. (Geisonoceras) shumardi** Billings. Ordovicic.

Small, septa separated by nearly half a diameter; siphuncle somewhat larger proportionally and less excentric than in the preceding which it otherwise resembles.

Chazy of Mingen Island and New York (Div. B_2).

20. **O. (Geisonoceras?) sociale** Hall. (Fig. 1248.) Ordovicic.

More rapidly expanding than preceding; septa deeply concave, from six to nine to the inch; siphuncle changing from centren in the young to more or less excentric in the adult.

Trenton, Richmond and Maquoketa of Minnesota; Eden and Maysville of Cincinnati region; Maquoketa of Iowa.

21. **O. simulator** Hall. Siluric.

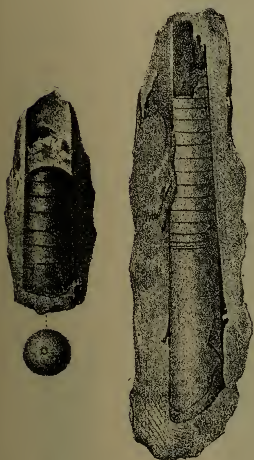

FIG. 1246. *Orthoceras junceum*, fragments and end view. (After Hall, Pal. N. Y., I.)

FIG. 1247. *Orthoceras amplicameratum*, side and end view of a fragment, × ⅔. (After Hall, Pal. N. Y., I.)

Cylindrical, gradually enlarging; siphuncle subcentral; septa about one fourth diameter of shell apart; surface finely striated transversely, often flattened.

Niagaran (Waldron) shales of Indiana, etc.

22. **O. rectum** Worthen. Siluric.

Medium sized, apical angle about 5°; cameræ large, from two to three equalling the diameter of the shell; siphuncle centren.

FIG. 1248. *Orthoceras sociale*, × ⅔. (After Clarke, Pal. Minn.)

FIG. 1249. *Orthoceras pelops*, × ⅔. (After Hall.)

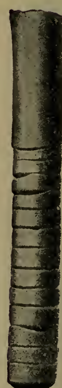

FIG. 1250. *Orthoceras* (*Protobactrites*) *stylus*, ⅔. (After Hall.)

Guelph of New York, Ohio and Illinois.

23. **O. procerum** Hall. Devonic.

Apical angle from 6°–8° ; depth of cameræ about equal throughout, being about one half diameter of the shell in the apical and one fifth the diameter in the apertural portion; siphuncle slightly excentric; no organic deposits.

Schoharie of New York.

24. **O. pelops** Hall. (Fig. 1249.) Devonic.

Large, robust, differing from the preceding in somewhat shorter cameræ, centren siphuncle, slightly moniliform, with an aureola at the point of insertion on the septum; living chamber with slight constriction.

Schoharie of New York and New Jersey (?); Onondaga of Ohio and Canada (?).

25. **O. tentalus** Hall. Devonic.

Septa more closely arranged and with less concavity than in preceding; siphuncular aureola larger and with additional organic deposit.

Schoharie of New York.

26. **O. fluctum** Hall. Devonic.

With unsymmetrically curved sutures, not oblique to axis, and siphuncle centren or nearly so.

Schoharie of New York.

27. **O. molestum** Hall. Devonic.

With rapidly expanding living chamber; straight and horizontal sutures about 4 mm. apart in adult; siphuncle near the ventral side; lamellose, subimbricating growth lines with slight ventral curve on the ventran siphuncle.

Onondaga of New York and Ohio.

28. **O. (Protobactrites) stylus** Hall. (Fig. 1250.) Devonic.

Cylindrical, slender, with long and unconstricted body chamber and nearly centren siphuncle.

Schoharie of New York.

29. **O. constrictum** Vanuxem. (Fig. 1251.) Devonic.

Apical angle 6°; section circular; siphuncle centren; cameræ from 2 to 3 mm. in adult; living chamber broadly constricted, anterior to the middle.

Hamilton of New York and Maryland.

30. **O. exile** Hall. (Fig. 1252, *a*.) Devonic.

Differs from the preceding in its excentric siphuncle, and rare, faint constriction of living chamber.

Hamilton of New York and Maryland.

31. **O. eriense** Hall. (Fig. 1253.) Devonic.

FIG. 1251. *Orthoceras constrictum*, × ⅔. (After Grabau.)

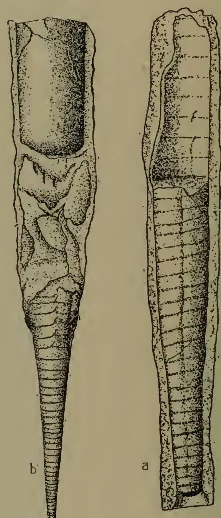

FIG. 1252. *a*, *Orthoceras exile*, × ⅔; *b*, *O.* (*Geisonoceras*) *subulatum*, × ⅔. (After Grabau.)

Large, straight, and robust, regularly and gradually enlarging to the slightly constricted aperture; section circular; apical angle 8°; septa moderately concave (arc of 116°); siphuncle central; surface with concentric and longitudinal striæ.

Hamilton of New York.

32. **O. (Geisonoceras) subulatum** Hall. (Fig. 1252, *b*.) Devonic.

Rather rapidly expanding, with circular section; siphuncle subcentral; living chamber three times as large as its basal diameter; septa thin, smooth, their arcuation 125°.

Hamilton beds of New York.

33. **O. (Geisonoceras) leander** Hall. Devonic.

Tube rapidly enlarging; body chamber constricted at aperture. Chemung of New York and Pennsylvania.

34. **O. indianense** Hall. Mississippic.

Small, straight and slender; apical angle 6°; living chamber

FIG. 1253. *Orthoceras eriense*, × ⅓. (After Grabau.)

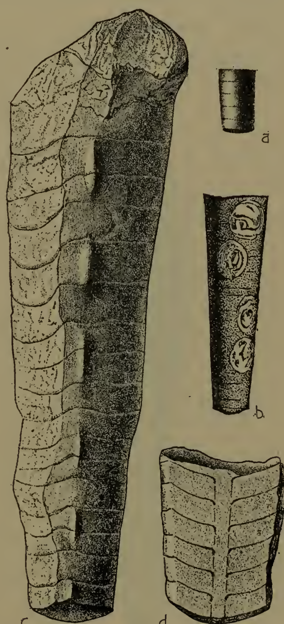

FIG. 1254. *a*, *Orthoceras epigrus*; *b*, *O. rushense*; *c*, *Trematoceras ohioense*, showing the nodes; *d*, section of same. (*b* after Ind. Surv., the others after Whitfield.)

gradually enlarging except for constriction at about one third its length from aperture; septa thin, moderately concave; chambers gradually increasing in depth (6 chambers in 22 mm. with increase in diameter from 9–12 mm.). Siphuncle subcentral.

Goniatite limestone of Indiana; Marshall of Michigan; Waverly of Ohio.

35. **O. epigrus** Hall. (Fig. 1254, *a*.) Mississippic.

Subcylindrical, very gradually tapering; section circular; siphuncle small; subcentral; septa slightly concave, distant about one third the diameter of the shell; surface with rather faint, distant, longitudinal lines.

St. Louis (Spergen) of Indiana.

36. **O. rushense** McChesney. (Fig. 1254, *b*.) Mississippic–Permic.

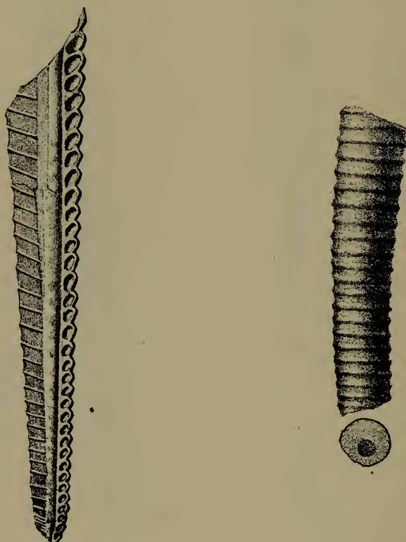

Fig. 1255. *Protocycloceras lamarcki*, sectional and exterior and end views of specimens. (After Ruedemann, Bull. 90, N. Y. State Mus.)

Rather rapidly tapering; septa moderately concave; siphuncle subcentral; surface finely striated.

Waverly of Ohio (?); Lower Coal Measures of Iowa and Indiana; Permic of Texas.

37. **O. cribrosum** Geinitz. Carbonic.

Slightly more tapering than preceding, with septa close together, 4 or 5 in the length of 5 mm. where the diameter is 5 mm.; surface with numerous, irregularly arranged, round pits (regarded by some as foreign to the shell).

Lower Coal Measures of Ohio and West Virginia; Upper Coal Measures of Nebraska, Illinois, Missouri and Oklahoma.

IX. Trematoceras Whitfield.

Like *Orthoceras* but with a series of elongate tubercles on one side, which appear to represent an interrupted series of elongate openings in the body chamber, progressively closed by shelly deposits, as in *Trematonotus* or *Haliotis*. Devonic.

38. **T. ohioense** Whitfield. (Fig. 1254, *c, d.*) Devonic.

Fig. 1256. *Cycloceras lesueuri*, × ⅔. (After Clarke, Pal. Minn.)

Fig. 1257. *Cycloceras olorus*, × ⅔. (After Clarke, Pal. Minn.)

Rather rapidly tapering; chambers short, about five equal to the diameter of the upper one of them; siphuncle slightly excentric; surface smooth except for nodes which are two to three times as long as wide, and situated at every third septum in lower and every second septum in upper part.

Columbus limestone of Ohio.

X. Protocycloceras Hyatt.

Annulated *Orthoceracones* and *Cyrtoceracones*, with longitudinal ridges or striations only in the early (nepionic) stages, in the earliest of which the longitudinal sculpture alone exists. Siphuncle large. Ordovicic.

39. **P. lamarckii** (Billings). (Fig. 1255.) Ordovicic.

Very gently expanding (1 mm. in 20), often slightly bent; annulations rounded, narrow, with wider concave interspaces; distance of septa similar to annulations; siphuncle large, excentric.

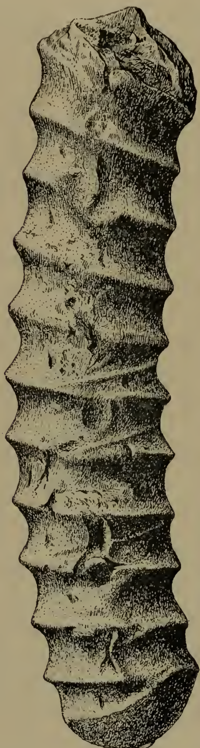

FIG. 1258. *Cycloceras nicolletti*, × ⅔. (After Clarke, Pal. Minn.)

FIG. 1259. *Cycloceras randolphense*, two views of same specimen. (After Meek & Worthen, Ill. Pal., II.)

Beekmantown (Cassin) beds of Lake Champlain, and similar beds of Mingen Island and Newfoundland.

XI. Cycloceras McCoy.

Like the preceding but with discontinuous longitudinal ridges. Annulations often become obsolete in old age. Ordovicic.

40. **C. lesueuri** Clarke. (Fig. 1256.) Ordovicic.

Small, nearly cylindrical, with slightly oblique, rounded annulations; sutures coincide with constrictions.

Stones River of Minnesota; Stones River and Black River of the Cincinnati region.

41. **C. olorus** Hall. (Fig. 1257.) Ordovicic.

Larger than preceding, with more widely separated, sharply

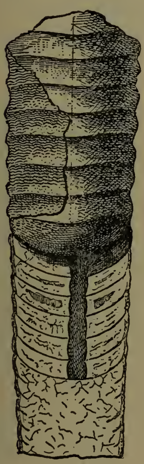

Fig. 1260. *Dawsonoceras annulatum.* (After Barrande.)

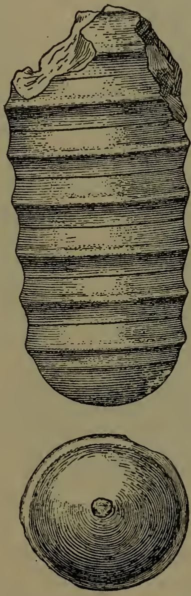

Fig. 1261. *Dawsonoceras annulatum.* (After Kindle, Ind., 28.)

rounded and somewhat flexuous annulations and deeply convex septa.

Stones River and Trenton of Minnesota; Stones River of Cincinnati; Trenton of New York; Bighorn of Wyoming.

42. **C. nicolletti** Clarke. (Fig. 1258.) Ordovicic.
Large, often slightly curved; annulations sharp, separated by broad, concave interspaces; septa profoundly concave.
Stones River of Minnesota; Bighorn of Wyoming.

43. **C. randolphense** Worthen. (Fig. 1259.) Mississippic.
Slightly compressed, rather rapidly tapering; annulations low, round, with shallow interspaces.
Chester group of Illinois; Mississippic of Nevada.

XII. Dawsonoceras Hyatt.

Differs from *Cycloceras* in having prominent, frilled or wrinkled growth lines between the annulations. Siluric–Devonic.

44. **D. annulatum** Sowerby. (Figs. 1260, 1261.) Siluric.
Annulations moderately strong, slightly nearer the older suture; siphuncle nearly centren. Interspaces asymmetrical.
Niagaran of Indiana, Wisconsin, etc.

44*a*. **Var. americanum** Foord. Siluric.
With stronger annulations midway between the sutures; interspaces symmetrically concave.
Widely distributed in the Niagaran of North America. Also in the Upper Monroe of Michigan and Canada.

XIII. Protokionoceras* Grabau and Shimer.

Non-annulated orthoceracones, with the surface marked by fine and generally rather close longitudinal striæ. Siphuncle more or less moniliform. Genotype *P. medullare* (Hall). Siluric–Devonic.

45. **P. medullare** (Hall). (Fig. 1262.) Siluric.
Large, tapering; sutures widely separated (by nearly half the diameter in the older part); surface striæ fine, alternating and close together. (Type of genus.)
Niagaran of Wisconsin, Indiana and Canada (Guelph), and doubtfully New York (Guelph).

46. **P. crebescens** (Hall). (Fig. 1263.) Siluric.
Differs from the preceding in the shorter cameræ, large, strongly nummulitic, centren siphuncle, and distant, rather broad longitudinal striæ.
Niagaran (Guelph) of Wisconsin, Canada and New York.

47. **P. trusitum** (Clarke and Ruedemann). Siluric.

Gradually tapering; septa close, from 3–6 mm. apart; sutures with broad, ventral saddle. Siphuncle small, ventrocentren, nearly cylindrical; striæ fine, seldom preserved.

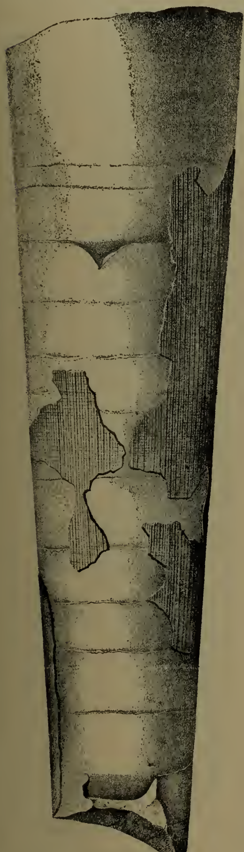

FIG. 1262. *Protokionoceras medullare*, × ½. (After Hall, 20th Mus. Rep.)

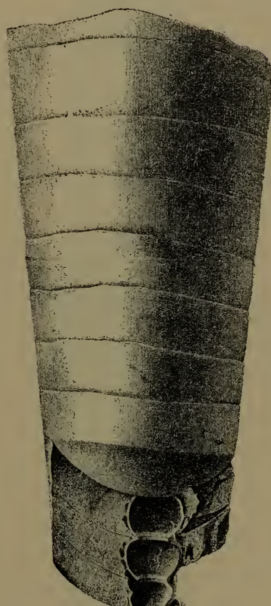

FIG. 1263. *Protokionoceras crebescens*, Hall, × ⅔. (After Hall, 20th Mus. Rep.)

Guelph of New York; Monroe of Michigan and Canada.

48. **P. marcellense** (Vanuxem). (Fig. 1264.) Devonic.

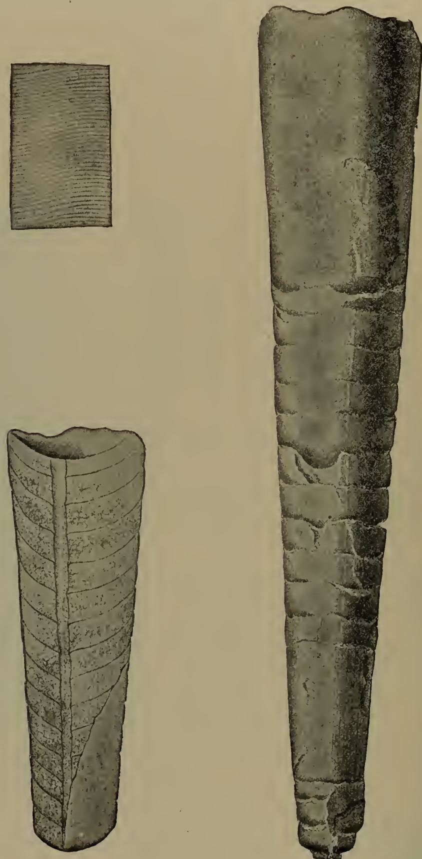

FIG. 1264. *Protokionoceras marcellense*, × ⅔, with enlargement of surface. (After Hall.)

Slender, tapering rapidly; cameræ of moderate depth; siphuncle small, excentric, scarcely nummuloidal. Longitudinal striæ fine, with finer, slightly undulating, transverse striæ.

Agoniatite limestone of the Marcellus of New York, etc.

XIV. Kionoceras Hyatt.

Orthoceracones and cyrtoceracones with longitudinal ridges in earlier stages (sometimes persistent), followed by inconspicuous annuli which mostly disappear again in the adult. Siphuncle often faintly nummuloidal. Siluric–Carbonic.

49. **K. angulatum** (Wahl). (Fig. 1265.) Siluric.

Fig. 1265. *Kionoceras angulatum*, × ⅔. (After Hall, 20th State Mus. Rep.)

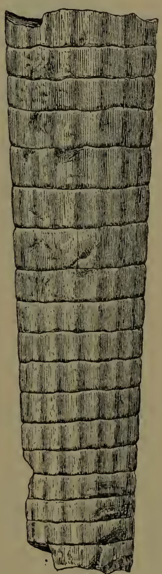

Fig. 1266. *Kionoceras orus*, × ⅔. (After Kindle, 28th Ann. Ind.)

Annulations faint or almost absent; longitudinal ridges strong and distant.

Niagaran of Wisconsin and Illinois.

50. **K. orus** (Hall). (Fig. 1266.) Siluric.

Larger than preceding and with coarser and more distant longitudinal ridges.

Niagaran of Wisconsin, Indiana, etc.

51. **K. darwini** (Billings). (Fig. 1267.) Siluric.

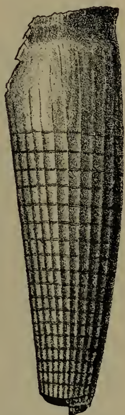

FIG. 1267. *Kionoceras darwini.* (Pal. Ohio.)

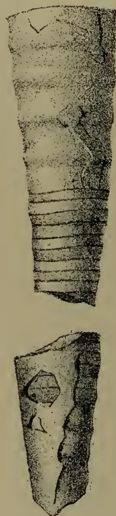

FIG. 1268. *Orygoceras cornu-oryx*, internal mold and specimen with shell partly preserved. (After Ruedemann.)

Slightly curved; annulations mostly near apical end, faintly visible in older portion; longitudinal ridges much as in *K. angulatum* but generally with intercalated, finer ones.

Niagaran (Guelph) of Ontario and New York.

XV. ORYGOCERAS Ruedemann.

Orthoceracones with subcircular or depressed oval section; annulations only internal; siphuncle excentric and tubular as in *Orthoceras*. Ordovicic.

52. **O. cornu-oryx** (Whitfield). (Fig. 1268.) Ordovicic.
Internal annulations faint, distant, and separated by shallow spaces; section depressed, elliptical; cameræ short. Surface smooth.
Beekmantown (Fort Cassin) of Vermont and New York.

XVI. Spyroceras Hyatt.

Like *Protocycloceras* but with the longitudinal ridges persisting into the adult, together with the pronounced annulations. Ordovicic–Carbonic.

53. **S. bilineatum** Hall. (Fig. 1269.) Ordovicic.

Fig. 1269. *Spyroceras bilineatum*, ribbed apical portion passing into annulated part. (After Clarke, Pal. Minn.)

Fig. 1270. *Spyroceras anellus*. (After Clarke, Pal. Minn.)

Early portion non-annulated; annulæ of later part strong, round, slightly oblique. Longitudinal ridges strong with finer ones between; cameræ short.
Stones River and Black River of Minnesota; Black River of Cincinnati region; Black River and Trenton of Canada; Trenton of New York and Tennessee.

54. **S. anellus** Conrad. (Fig. 1270.) Ordovicic.
Differs from the preceding in the more uniformly and regularly rounded annulations with similar interspaces, and in the fine, regular, longitudinal striæ.

Black River of Minnesota and the Cincinnati region; Black River and Trenton of Canada; Trenton of New York.

55. **S. thoas** (Hall). (Fig. 1271.) Devonic.

Annulations straight, round, and distant, interspaces concave; resembles *Dawsonoceras annulatum* but is without the frills and has continuous fine striæ.

Schoharie and Onondaga of New York and Ohio.

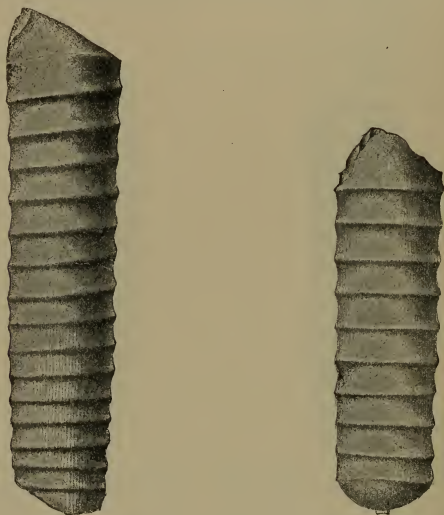

FIG. 1271. *Spyroceras thoas*, × ⅔. (After Hall.)

56. **S. crotalum** (Hall). Devonic.

Annulations sharper than in preceding, sometimes oblique or undulating; cameræ irregular, deeply concave; longitudinal striæ fine.

Hamilton of New York; Columbus of Ohio.

57. **S. nuntium** (Hall). (Fig. 1272.) Devonic.

Differs from the preceding in the closer set, horizontal annulations, and more pronounced, longitudinal striæ.

Hamilton of New York.

Plectoceratida.

XVII. Aphetoceras Hyatt.

Gyroceracones, sometimes with last whorl deviating from the spiral, not in contact at any stage, compressed elliptical, or oviform in section; the venter narrower than the dorsum; siphuncle subventran; surface smooth. Ordovicic.

58. **A. farnsworthi** (Billings). (Fig. 1273.) Ordovicic.

Fig. 1272. *Spyroceras nuntium*, part of internal mold, × ⅔, and enlargement of surface. (After Whitfield.)

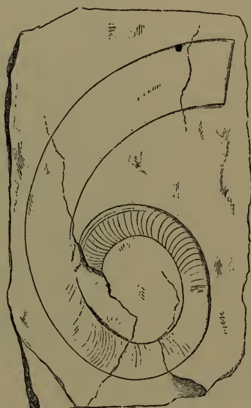

Fig. 1273. *Aphetoceras farnsworthi*, × ½. (After Billings, Pal. Foss.)

Septa crowded; siphuncle propioventran; last whorl strongly deviating.

Beekmantownian of Lake Champlain region.

59. **A. americanum** Hyatt. Ordovicic.

Whorls becoming laterally compressed in adult; coil regular; last whorl deviating but slightly; abdomen more or less flattened in last stages; sutures with ventral and dorsal saddles.

Beekmantownian of Newfoundland.

XVIII. Barrandeoceras Hyatt.

Whorls barely in contact, or with very slight contact furrow; venter usually narrower than dorsum; siphuncle near but above center. Septa deeply concave, with usually ventral and dorsal saddles and lateral lobes. Surface smooth or slightly costated. Ordovicic–Siluric.

60. **B. natator** (Billings). (Fig. 1274.) Ordovicic.

Whorls slender, compressed, oval in sections; siphuncle extra-

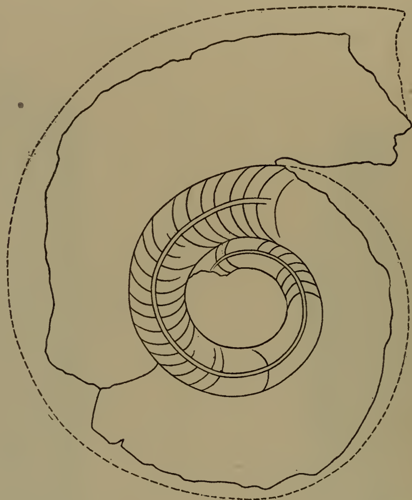

FIG. 1274. *Barrandeoceras natator*, section showing septa partially preserved, × ½. (After Ruedemann, Bull. 90, N. Y. State Mus.)

centroventran; no contact furrow; surface costated except in adult.

Chazy limestone of Lake Champlain region.

61. **B. convolvans** (Hall). Ordovicic.

Section of whorls much compressed, oval; siphuncle centroventran to intracentroventran. Surface smooth.

Black River of New York.

XIX. Tarphyceras Hyatt.

Discoidal, with gradually enlarging whorls in contact and slightly impressed. Last whorl often diverging. Siphuncle ventran in young, proprioventran later. Surface smooth except for growth lines; hyponomic sinus deep and broad. Ordovicic.

62. **T. seeleyi** (Whitfield). (Fig. 1275.) Ordovicic.

Very slowly expanding tube of subcircular section; impressed

FIG. 1275. *Tarphyceras seeleyi*, × ⅔. (After Ruedemann, Bull. 90, N. Y. State Mus.)

zone faint; small, subcentral siphuncle; septa closely arranged and strongly concave.

Beekmantownian (Fort Cassin beds) of Vermont, and Valcour, New York.

63. **T. clarkei** Ruedemann. (Fig. 1276.) Ordovicic.

Differs from the preceding in its larger size and lateral compression of later whorls, the last being partly free; siphuncle large, tubular, proprioventran.

Beekmantownian (Fort Cassin beds) of Champlain region, New York.

64. **T. multicameratum** Ruedemann. (Fig. 1277.) Ordovicic.

Small, with rapidly expanding tube, laterally compressed in later whorls, the last being partly free; cameræ numerous, short; siphuncle tubular, small and proprioventran.

Chazy of Lake Champlain region.

FIG. 1276. *Tarphyceras clarkei*, × ½. (After Ruedemann.)

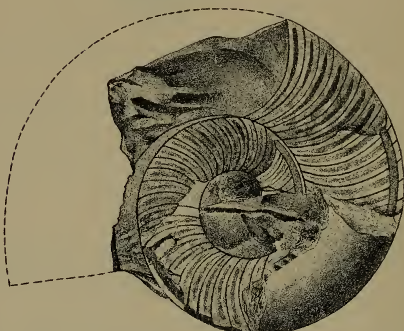

FIG. 1277. *Tarphyceras multicameratum*, natural section, × ⅔. (After Ruedemann, Bull. 90, N. Y. State Mus.)

XX. EURYSTOMITES Schroeder.

Differs from *Tarphyceras* in its less discoidal form, more rapidly enlarging and less numerous whorls which embrace more strongly and are laterally compressed in adult. Aperture with prominent lateral crests. Ordovicic.

65. **E. kelloggi** (Whitfield). (Fig. 1278.) Ordovicic.

Large, rather closely coiled, rapidly enlarging; living chamber free in old age; whorls slightly compressed laterally; impressed zone marked, but not deep; sutures with broad lateral lobes in

FIG. 1278. *Eurystomites kelloggi*, type specimen, × ½. (After Whitfield, Am. Mus. Bull.)

adult; siphuncle tubular, subventran in earlier, extracentroventran in adult stages.

Beekmantownian (Fort Cassin beds) of Lake Champlain region.

66. **E. virginianus** Hyatt. Ordovicic.

More cylindrical whorls than preceding, with more numerous and straighter sutures, and siphuncle nearer the venter.

Beekmantownian of Lake Champlain region (Fort Cassin), and near Lexington, Va.

67. **E. undatus** (Emmons). (Fig. 1279.) Ordovicic.

With fewer whorls than *E. kelloggi;* strongly compressed in adult, the last whorls not embracing and loosing impressed zone.

The western representative of this species (var. *occidentalis* Hall) has broad whorls with flattened dorsum and simple concave septa.

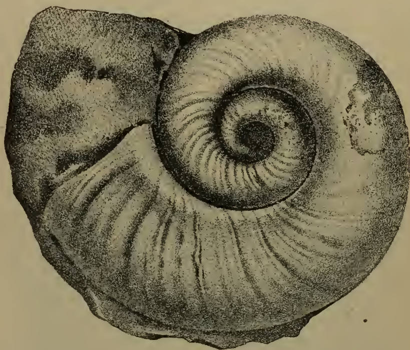

FIG. 1279. *Eurystomites undatus*, × ⅔. (After Hall, Pal. N. Y., I.)

Black River of New York; Stones River of Minnesota and Illinois.

XXI. SCHROEDEROCERAS Hyatt.

Differs from *Tarphyceras* in the dorsally placed siphuncle, and the frequent tetragonal section of the whorls. Ordovicic.

68. **S. eatoni** (Whitfield). (Figs. 1280, 1281.) Ordovicic.

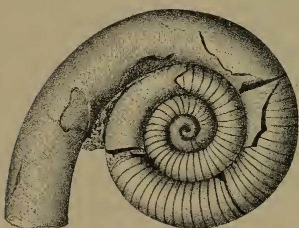

FIG. 1280. *Schroederoceras eatoni*, × ⅔. (After Ruedemann, Bull. 90, N. Y. State Mus.)

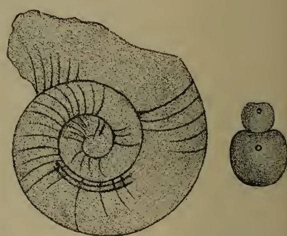

FIG. 1281. *Schroederoceras eatoni*, longitudinal and transverse sections. (After Ruedemann, Bull. 90, N. Y. State Mus.)

Externally much like *Tarphyceras seelyi*, but smaller and with shallower septa, deeper impressed zone and siphuncle near the inside of the whorls.

Beekmantownian (Fort Cassin beds) of Lake Champlain region.

69. **S. cassinense** (Whitfield). Ordovicic.

More quadrangular in section, with flattened venter; sutures straight; whorls less rapidly enlarging.

Occurs with the preceding.

XXII. TROCHOLITES Conrad.

Living chamber always in contact with preceding whorls; whorls in section always wider than high; aperture expanded with ventral

FIG. 1282. *Trocholites ammonius*, with section. (After Hall, Pal. N. Y., I.)

sinus; sutures simple or slightly lobed; siphuncle dorsal or subdorsal. Ordovicic.

70. **T. ammonius** Hall. (Fig. 1282.) Ordovicic.

FIG. 1283. *Trocholites planorbiformis*, × ⅔. (After Hall, Pal. N. Y., I.)

Regularly enlarging, slightly impressed; sutures with gentle, lateral saddle; siphuncle propriodorsan in young, centrodorsan in adult; surface rough, fretted.

Trenton and Utica of New York.

71. **T. planorbiformis** Conrad. (Fig. 1283.) Ordovicic.

Larger than preceding; whorls more compressed vertically, with deeper, impressed suture, and straight, ventral, hyponomic sinus. Surface with longitudinal striæ.

Lorraine of New York and Canada.

XXIII. Discoceras Barrande (*Lituites* of American authors.)

Discoidal, costated nautilicones, the costæ as in *Plectoceras* except the gerontic stage. Young like *Trocholites*. Differs from *Plectoceras* in its less rapidly enlarging whorls. Ordovicic–Siluric.

72. **D. graftonense** M. and W. Siluric.

Whorls scarcely impressed; costæ weak, bending obliquely backward, and rather closely crowded. Siphuncle subdorsan.

Niagaran of Wisconsin.

73. **D. marshii** (Hall). (Fig. 1284.) Siluric.

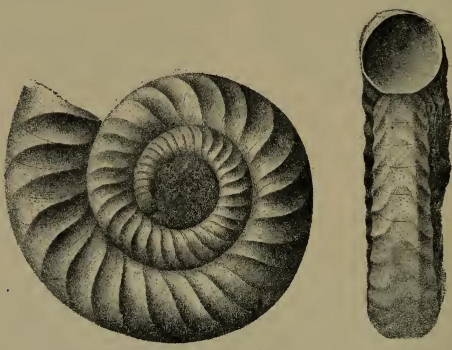

Fig. 1284. *Discoceras marshii*, lateral and profile views, × ⅔. (After Hall, 20th Mus. Rep.)

Venter flattened; costæ sharp and strong, forming a deep, backward curve on the venter; interspaces broad and concave.

Niagaran of Illinois, Indiana, Kentucky, etc.

XXIV. Plectoceras Hyatt.

Gyroceracones and discoidal nautilicones of quadrate section with the abdomen narrower than the dorsum; surface costated, the costæ curving backwards on the side; siphuncle ventral of center. Ordovicic–Siluric.

74. **P. jason** (Billings). (Fig. 1285.) Ordovicic.

Nautilicones with faintly impressed whorls gradually enlarging; costæ separated by broader concave spaces, which are finely striated parallel to the costæ; siphuncle large, propioventran.

Chazy of Mingen Island, Newfoundland and the Lake Champlain region.

75. **P. bondi** (Safford). Ordovicic.

FIG. 1285. *Plectoceras jason*, × ½, shell with inner whorls broken away. (After Ruedemann, Bull. 90, N. Y. State Mus.)

Loosely coiled gyroceracones, with rapidly enlarging whorls of oval section. Costæ sharp, strong, separated by broad concave interspaces.

Stones River of Minnesota (?) and Tennessee; Stones River and Black River of Cincinnati region.

76. **P. bickmoreanum** (Whitfield). Siluric.

Whorls forming an open gyroceracone, the last whorl in gerontic individuals becoming free and sometimes completely straightened out.

Niagaran of Indiana.

XXV. Sphyradoceras Hyatt.

Costated trochoceracones, the last whorl often free; costæ as in the preceding, often with faint longitudinal ridges. Siluric–Devonic.

77. **S. desplainense** (McChesney). (Fig. 1286.) Siluric.

Often large, dextrally coiled; costæ curving gently backwards, rounded.

Niagaran and Guelph of Wisconsin; Guelph of New York, Ontario, Illinois, Indiana, etc.

78. **S. costatum** (Hall). (Fig. 1287.) Siluric.

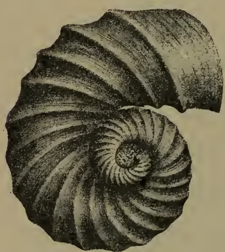

Fig. 1286. *Sphyradoceras desplainense*, × ⅔. (After Hall, 20th Mus. Rep.)

Fig. 1287. *Sphyradoceras costatum*, from below, × ⅔. (After Hall, 20th Mus. Rep.)

Sinistrally coiled; whorls less rapidly enlarging than preceding; costæ somewhat sigmoid, sharper and narrower.

Racine and Guelph of Wisconsin; Guelph of New York, Ohio, etc.

79. **S. clio** (Hall). (Fig. 1288.) Devonic.

Sinistrally and more closely coiled than preceding, forming higher spire; costæ closer and rounded, slightly sigmoidal, rather faint; longitudinal striæ in well preserved specimens.

Schoharie of New York, Michigan, etc.

XXVI. Mitroceras Hyatt.

Trochoceracones coiling in a high, turbinate spire of gradually enlarging whorls, with deep umbilication. Non-costate. Siluric.

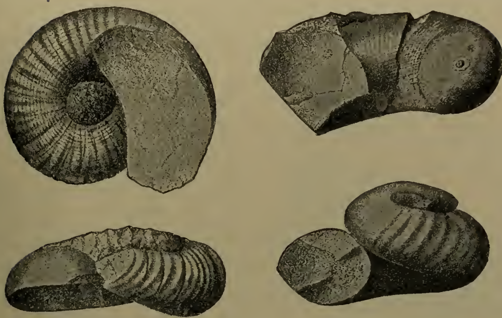

FIG. 1288. *Sphyradoceras clio.* (After Hall.)

FIG. 1289. *Mitroceras gebhardi,* basal view, × ⅔. (After Hall.)

80. **M. gebhardi** Hall. (Figs. 1289, 1290.) Siluric.

Spire moderate apical angle about 60° ; umbilical region sharply angulate; surface smooth.

Upper Siluric (Cobleskill and Akron) of New York, etc.

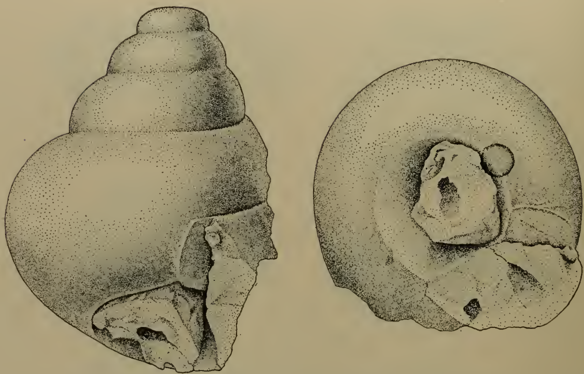

FIG. 1290. *Mitroceras gebhardi*, side and umbilical view of a nearly perfect internal mold, not showing the septa however, × ¾. (After Grabau.)

RYTICERATIDA.

XXVII. ZITTELOCERAS Hyatt.

Cyrtoceracones with depressed, elliptical or ovate section venter narrower than dorsum; lines of growth frilled, alternately fine and coarse. Ordovicic–Devonic.

81. **Z. hallianum** (D'Orbigny). (Fig. 1291.) Ordovicic.

Arcuate, with somewhat distant, strongly frilled, growth lines, and short cameræ.

Black River of Minnesota and Wisconsin, and Trenton limestone of New York and Canada.

82. **Z. billingsi** (Salter). Ordovicic.

More strongly arcuate than preceding, shell more rapidly expanding, growth lines more crowded and less strongly frilled.

Stones River of Minnesota, Canada, and the Cincinnati region.

83. **Z. nereus** Hall. Devonic.

Large, strongly curved, adult less so; strong concentric frills with finer ones between; section subcircular.

Onondaga of New York, etc.

XXVIII. HALLOCERAS Hyatt.

Gyroceracones of subtrigonal section, the young like the adult of *Zitteloceras;* venter broadest, dorsum subangular; typically with a row of large nodes at ventrolateral angles. Siphuncle small and tubular. Siluric–Devonic.

84. **H. (?) hercules** Winchell and Marcy. (Fig. 1292.) Siluric.

Large, gyroceraconic, making one entire volution or more; whorls smooth, not in contact, rapidly expanding; outer portion

FIG. 1291. *Zitteloceras hallianum*, lateral view of a fragment. (After Clarke, Pal. Minn.)

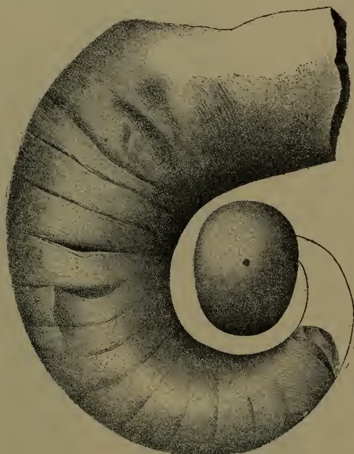

FIG. 1292. *Halloceras* (?) *hercules*, lateral view and septum, of a specimen denuded of the shell, × $\frac{4}{9}$. (After Hall, 20th Mus. Rep.)

less arcuate. Section broadly elliptical, a little flattened on sides and wider ventrally than dorsally; siphuncles small, centren or subcentren; aperture with hyponomic sinus; septa rather distant.

Niagaran of Wisconsin and Indiana.

85. **H. undulatum** (Vanuxem). (Fig. 1293.) Devonic.

Whorls two to three, not in contact; section subtriangularly ovate; septa distant; nodes faint.

Onondaga of New York.

86. **H. paucinodum** Hall. (Fig. 1294.) Devonic.

Closer coiled than preceding; section more triangular; nodes strong, distant, and elongate transversely.

Onondaga of New York.

FIG. 1293. *Halloceras undulatum*, × ⅔. (After Hall.)

FIG. 1294. *Halloceras pauci-nodum.* (After Hall.)

FIG. 1294*a*. *Halloceras paucinodum.* (After Hall.)

XXIX. Ryticeras Hyatt.

Cyrtoceracones and gyroceracones similar to preceding, but larger and with coarser, crenulated bands often expanded into spout-like, spinous processes, which sometimes form coarse, longitudinal ridges; siphuncle ventral, less nummuloidal, and larger than in preceding.

87. **R. jason** Hall. (Fig. 1295.) Devonic.

Fig. 1295. *Ryticeras jason*, × ½. (After Hall, Pal. N. Y., V.)

Large and robust cyrtoceracones of subcircular transverse section; septa regular; growth lamellæ expanding at regular intervals into sharp, foliate and coarse spinous processes. Siphuncle marginal, sometimes exposed by weathering.

Schoharie and Onondaga of New York.

88. **R. eugenium** Hall. (Fig. 1296.) Devonic.

Slender cyrtoceracones, with adult portion straight, and with subcircular section. Septa regular, the sutures with ventral lobe; regular, sharp expansions, fine lamellose growth lines and irregular

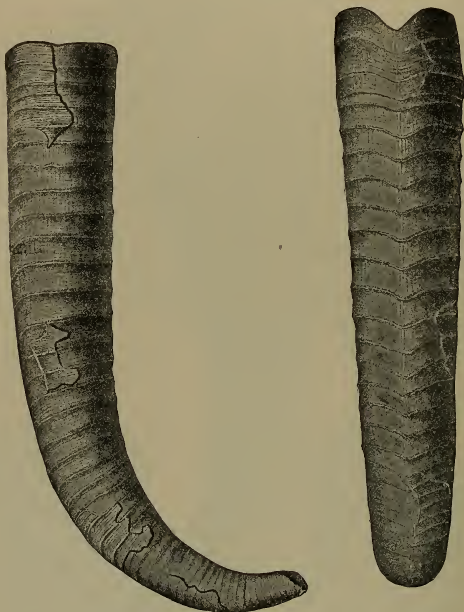

FIG. 1296. *Ryticeras eugenium*, × ⅔. (After Hall.)

longitudinal lines characterize the surface. Siphuncle as in preceding.

Schoharie and Onondaga of New York.

89. **R. æmulum** Hall. Devonic.

Like the preceding, but regularly curved, of smaller apical angle, and with less regular, prominent, transverse expansions.

Schoharie of New York, and Pendleton sandstone of Indiana.

90. **R. citum** (Hall). Devonic.

Like *R. eugenium,* but more regularly curved, with the expansions close-set and short, projecting only about 3 mm., and somewhat frilled. Internal mold with low annulations.

Onondaga of New York and Ontario.

91. **R. trivolve** (Conrad). (Figs. 1297, 1298.) Devonic.

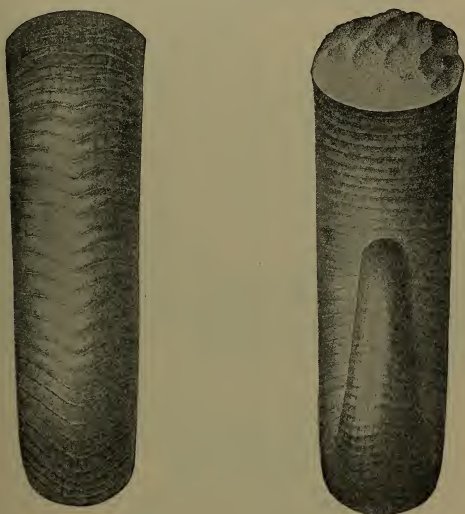

FIG. 1297. *Ryticeras trivolve*, × ⅔. (After Hall.)

A loose gyroceracone, with the characters of the preceding.

Onondaga of New York.

92. **R. matheri** (Conrad). (Fig. 1299.) Devonic.

Differs from the preceding in its closer coil with the final portion less curved, the section elliptical, the septa more distant and the expansions more emphasized in the internal mold by regular, rib-like undulations.

Onondaga of New York.

93. **R. cyclops** (Hall). (Fig. 1300.) Devonic.

Larger and more robust than preceding; coil regular and rapidly expanding; section broadly oval; undulating lamellose growth lines and obscure, broad, longitudinal ridges occur.

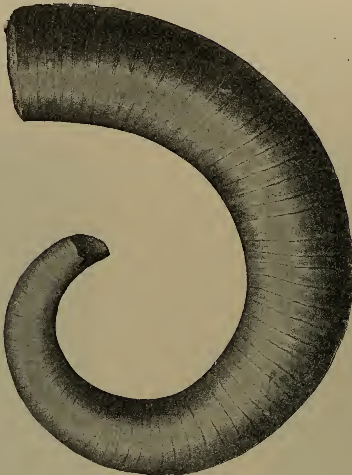

FIG. 1298. *Ryticeras trivolve*, × ⅔, side view. (After Hall.)

FIG. 1299. *Ryticeras matheri*, × ⅔. (After Hall.)

FIG. 1300. *Ryticeras cyclops*, × ½, with septal view. (After Hall, Pal. N. Y., V.)

FIG. 1301. *Ryticeras spinosum*, × ⅔. (After Hall.)

Onondaga of New York, Ohio, and Kelley's Island, Lake Erie.

94. **R. spinosum** (Conrad). (Fig. 1301.) Devonic.

Loose and open gyroceracones of more than one volution, of subcircular section; expansions in the form of tubular spines, which make two ventral ridges, and often an additional one on either side, when the section becomes subhexagonal.

Schoharie of New York.

95. **R. columbiense** Whitfield. (Fig. 1302.) Devonic.

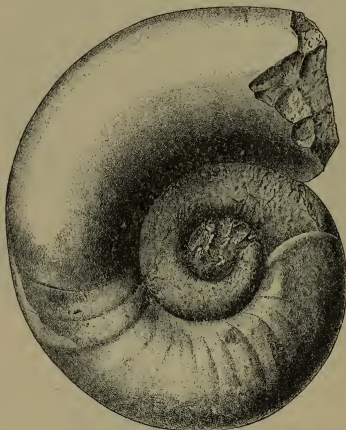

FIG. 1302. *Ryticeras columbiense*, × ⅔. (After Whitfield.)

Similar to *R. cyclops,* but smaller, with more rapidly increasing and more closely coiled volutions which are in contact and of nearly circular section; shell apparently without the foliate expansions characterizing most of the species.

Columbus limestone of Ohio. Common.

RHADINOCERATIDA.

XXX. NEPHRITICERAS Hyatt.

(*Nautilus* in part of authors.)

Nautilicones in adult, gyroceracones in young, with elliptical or broad, kidney-shaped whorl section; umbilicus large; siphuncle nummuloidal, slightly excentric. Sutures with broad ventral saddles in adolescent and usually with slight, ventral lobes in adult. Living chamber from one fourth to one half volution. Surface with revolving ridges, or striæ, often smooth in adult. Devonic.

96. **N. bucinum** (Hall). (Fig. 1303.) Devonic.

Comparatively small; volutions rapidly enlarging, contiguous, but not embracing; section broadly elliptical; siphuncle near concave dorsal side; surface with regular, sharply elevated spirals, about four in 10 mm. near aperture, with finer spirals between.

FIG. 1303. *Nephriticeras bucinum*, × ½; the middle figure shows part of shell remaining. (After Hall, Pal. N. Y., V.)

Agoniatite limestone and Hamilton of New York; Hamilton of Maryland.

97. **N. liratum** (Hall). Devonic.

Similar to preceding, but volutions rapidly enlarging, barely contiguous, siphuncle centren or subcentren, and spirals coarse, rib-like.

Goniatite limestone (Marcellus) of New York; Lower Hamilton of Pike County, Pennsylvania.

98. **N. magister** (Hall). (Fig. 1304.) Devonic.

Large; whorls subglobose, embracing to one third the diameter of the preceding volution, rapidly expanding; section of whorls elliptical, with broad, rounded sinus; siphuncle large, expanding abruptly and becoming cylindrical between septa; surface with lamellose growth lines and wide, obscure, radiating lines.

Hamilton of New York.

99. **N. maximum** (Hall). Devonic.

Large; differs from the preceding in the more circular, transverse section of the whorls, and less coiled volutions; siphuncle

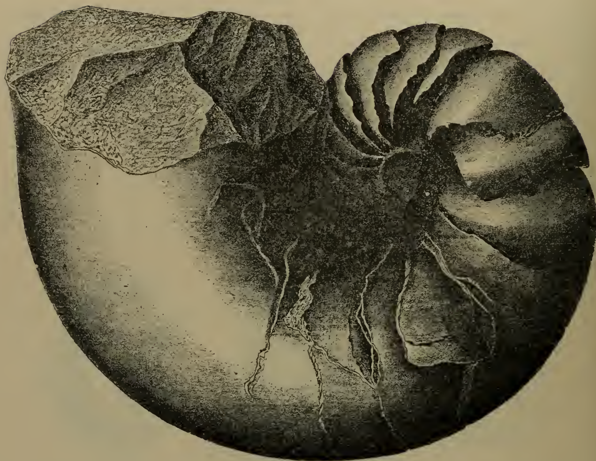

FIG. 1304. *Nephriticeras magister*, × ½. (After Hall, Pal. N. Y., V.)

large, subcentral, expanding slightly between the septa; surface with rounded or sharp undulating spirals, 5 or 6 in space of 5 mm.

Hamilton of New York; Falls of Ohio.

XXXI. Stroboceras Hyatt.

Gyroceracones or nautilicones of slight involution, with gibbous, umbilical shoulders making the dorsum wider than the venter, and with two pair of lateral, revolving ridges. Sutures with broad, abdominal saddles, small, acute saddles at the lateral ridges, and narrow lobes on either side; broad lateral saddles on swollen or gibbous part of whorl, and small, subacute, dorsal lobes; aperture contracted and dumb-bell shaped; siphuncle centroventran; young like *Trigonoceras*. Mississippic–Carbonic.

100. **S. trisulcatum** (Meek and Worthen). (Fig. 1305.)
Mississippic.

With three concave sulci, or channels separated by sharp, ventral ridges; impressed zone slight.

Rockford Goniatite bed of Indiana; Waverly of Ohio.

101. **S. hartti** (Dawson). Carbonic.

Loose coiled gyroceracones; whorls subquadrate, with two broad flutings at the sides, and two narrower flutings at the ventral

FIG. 1305. *Stroboceras trisulcatum.* (After Meek and Worthen, Ill. Pal., II.)

margins; venter flat, dorsal surface regularly rounded; siphuncle near ventral margin.

Windsor limestone of Nova Scotia.

XXXII. APHELECERAS Hyatt.

Gyroceracones and nautilicones of moderate involution; adult with hollow or channeled venter, compressed whorls and without the revolving ridges characterizing the preceding genus; sutures with ventral and lateral lobes, and broad, dorsal saddle. Mississippic.

102. **A. disciforme** (Meek and Worthen). (Fig. 1306.) Mississippic.

Large, disc-like, with sides of whorls gently convex, and more strongly arched towards the venter which is doubly channeled.

Keokuk of Illinois.

XXXIII. EPHIPPIOCERAS Hyatt.

Nautilicones differing from the preceding genera in having subacute, prominent, ventral saddles near the shoulders, and broad, shallow, dorsal lobes, generally with slight, median, dorsal saddle; septa creased or raised into a median ridge between the two saddles; siphuncle centren or slightly excentric. Carbonic.

103. **E. divisum** (White and St. John). Carbonic.

Large (living chamber 195 mm. long by 200 mm. wide), strongly flattened dorso-ventrally to half the transverse diameter or less;

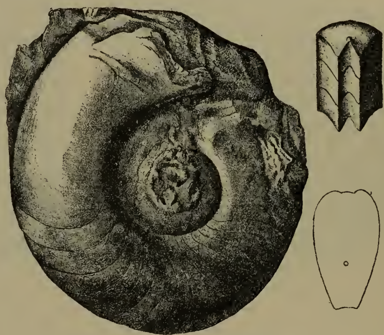

FIG 1306 *Apheleceras disciforme*, nearly complete specimen, × ¼; with view of inner side of septa, × ⅓, and transverse section, × ⅓. (After Meek and Worthen, Ill. Geol., V.)

venter with faint depression or flattening; increase in width very rapid.

Lower Coal Measures of Kansas, Missouri and Texas; Upper Coal Measures of Iowa.

104. **E. ferratum** (Cox). Carbonic.

Much smaller than preceding, whorls less strongly compressed, enlargement of whorls less rapid; umbilicus profound, with nearly vertical walls.

Coal Measures of Arkansas and Kentucky.

XXXIV. Triboloceras Hyatt.

Gyroceracones and nautilicones in form, similar to preceding genera, but venter channeled only in young, when the shell is also characterized by subspinous ridges; adult whorls more or less depressed, biangular with gibbous dorsum and convex venter, or approximately triangular with concave abdomen. Siphuncle above center; sutures with broad ventral and lateral lobes, and dorsal saddles without annular lobes. Mississippic.

105. **T. digonum** (M. and W.). (Fig. 1307.) Mississippic.
Venter broadly convex, with shallow lateral concavities and pronounced lateral angles. Surface with revolving striæ.

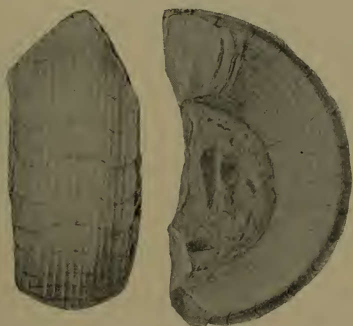

FIG. 1307. *Triboloceras digonum.* (After Meek and Worthen, Ill. Pal., II.)

Rockford Goniatite bed of Indiana; Kinderhook of Illinois and Missouri.

XXXV. STEAROCERAS Hall.

Nautilicones with adult considerably involute, with deep, narrow umbilicus, broad, smooth, rounded venter, shallow ventral lobe and small dorsal and annular lobes. These features distinguish it from *Endolobus.* Carbonic.

106. **S. gibbosum** Hyatt. (Fig. 1308.) Carbonic.
Rapidly enlarging whorls of broadly rounded, nautilian aspect with deep hyponomic sinus.
Carbonic of Texas.

XXXVI. LEUROCERAS Hyatt.

Similar to preceding, but with ventral saddle instead of lobe, the young striate in typical forms. Mississippic–Carbonic.

FIG. 1308. *Stearoceras gibbosum*, lateral and ventral views. (After Hyatt, Texas Survey.)

107. **L. chesterense** Meek and Worthen. (Figs. 1309, 1310.)
Mississippic.

Strongly involute with deep umbilicus; whorls rounded, narrower and less rapidly enlarging than in preceding.

Chester of Illinois.

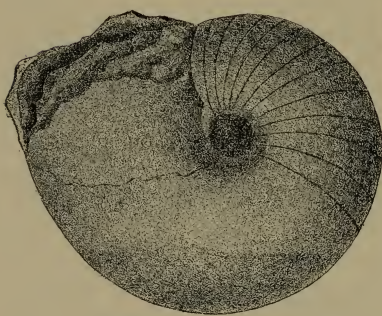

FIG. 1309. *Leuroceras chesterense*, umbilical view. (After Meek and Worthen, Ill. Pal., II.)

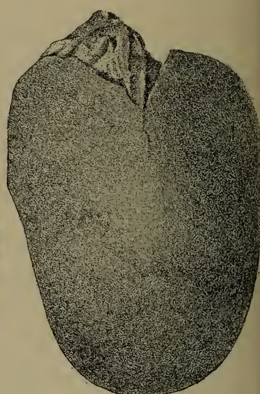

FIG. 1310. *Leuroceras chesterense*, ventral view. (After Meek and Worthen, Ill. Pal., II.)

XXXVII. Phacoceras Hyatt.

Strongly involute nautilicones with compressed acute whorls in adult, but young quadragonal as in *Discitoceras;* impressed zone

Fig. 1311. *Phacoceras dumblii*, × ½. (After Hyatt, Texas Survey, II.)

deep; suture with ventral saddle and broad lateral lobes. Mississippic–Permic.

108. **P. dumblii** Hyatt. (Fig. 1311.) Carbonic.

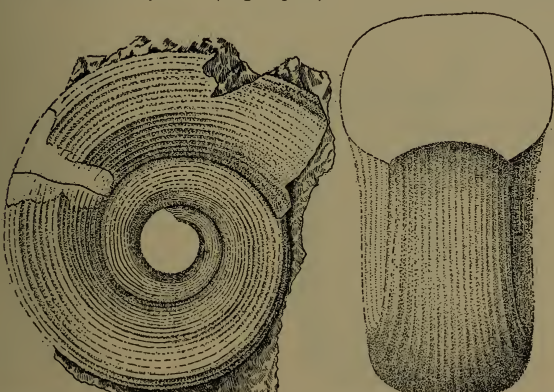

Fig. 1312. *Thrincoceras depressum*, × ½. (After Hyatt, Texas Surv.)

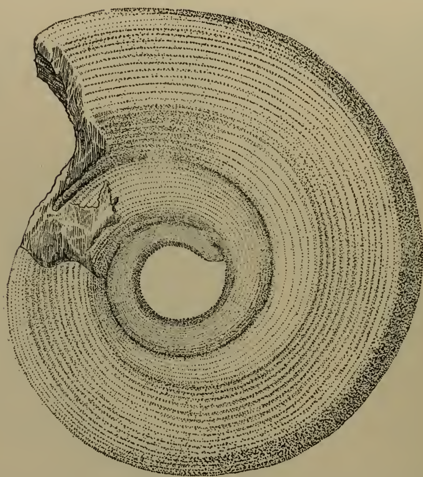

FIG. 1313. *Thrincoceras kentuckiense*, × ½. (After Hyatt, Kentucky Surv.)

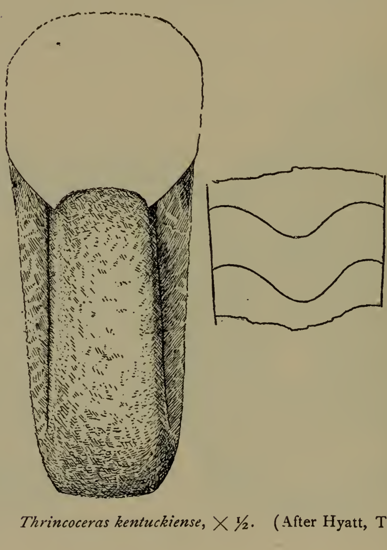

FIG. 1314. *Thrincoceras kentuckiense*, × ½. (After Hyatt, Texas Surv.)

Strongly compressed, with narrow whorls, small umbilicus, and abruptly rounded venter. Aperture with broad, rounded, lateral lobes and moderate hyponomic sinus.

Carbonic of Kansas.

XXXVIII. Thrincoceras Hyatt.

Nautilicones of disc-like form, with slight involution in adult and no contact furrow in young; section of whorls subquadrangular; umbilical perforation large; surface longitudinally striate.

109. **T. depressum** Hyatt. (Fig. 1312.) Carbonic.

Whorls broader than high; angles rounded.

Carbonic of Kentucky.

110. **T. kentuckiense** Hyatt. (Figs. 1313, 1314.) Carbonic.

Larger than preceding; height and width of whorls about equal; sides flat, bounded by faint angulations.

Carbonic of Kentucky.

Hercoceratida.

XXXIX. Centroceras Hyatt.

Gyroceracones and nautilicones with slightly impressed zone in later stages only, with quadragonal adult but digonal young whorls (nepionic); later (neanic stage) the form is trapezoidal in outline and furnished with tubercles, as in the young of *Temnocheilus*. Devonic–Carbonic.

111. **C. ohioense** (Meek). (Fig. 1315.) Devonic.

Large, the whorls not impressed, but just in contact. Tubercles broad and low, disappearing in last portion.

Onondaga (Columbus) of Ohio.

112. **C. marcellense** (Meek). (Fig. 1316.) Devonic.

Volutions scarcely embracing in adult; umbilical margin strongly angulated; sides more flattened than in preceding. Tubercles two to each camera; sutures with angular saddles on inner and outer margins, and broad lateral lobes; siphuncle near ventral surface. (Type of genus.)

Marcellus of New York, etc.

FIG. 1315. *Centroceras ohioense*, × ½. (After Meek, Ohio Pal.)

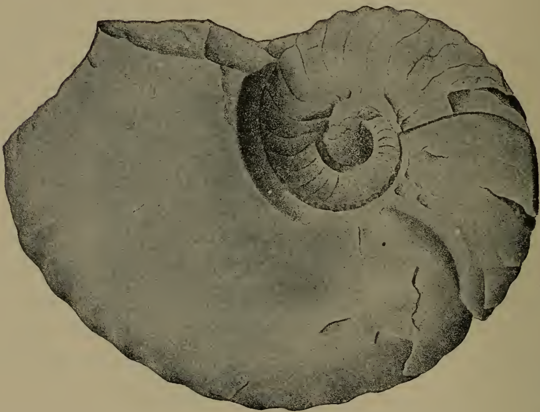

FIG. 1316. *Centroceras marcellense*, × ⅔. (After Hall.)

XL. Temnocheilus McCoy.

Discoidal nautilicone of trapezoidal section throughout, with a persistent row of spines on each ventrolateral angle. Easily distinguishable from the preceding genus by the vertical instead of lateral compression of the whorls. Devonic–Carbonic.

113. **T. coxanus** (M. and W.). (Fig. 1317.) Mississippic–Carbonic.

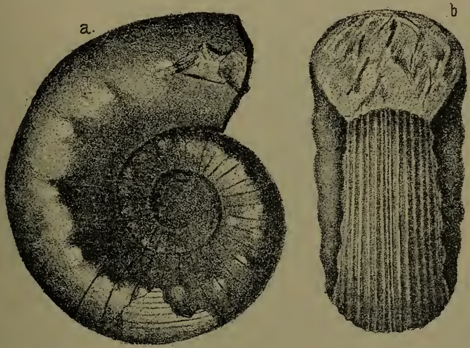

Fig. 1317. *Temnocheilus coxanus.* (After Meek and Worthen, Geol. Ill., V.)

Distinguished by its rounded venter, rather faint, ventrolateral angles with broad, low nodes, and by strong, revolving striæ of the shell.

St. Louis of Indiana and Illinois; Carbonic (?) of Texas.

114. **T. forbesianus** (McChesney). (Fig. 1318.) Carbonic.

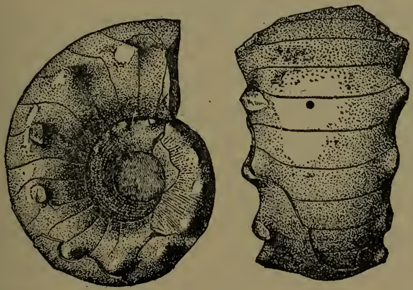

Fig. 1318. *Temnocheilus forbesianus.* (Ind. Survey.)

Whorls broader than in preceding and with flatter venter, and stouter, more distant nodes; also septa more distant.

Coal Measures of Ohio, Indiana, Illinois, Missouri and Texas.

115. **T. latus** (Meek and Worthen). (Fig. 1319.) Carbonic.

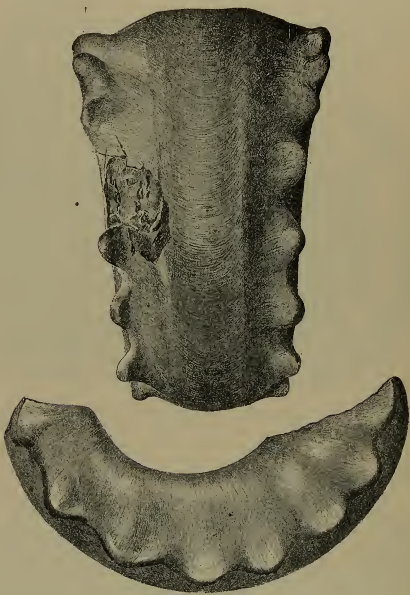

FIG. 1319. *Temnocheilus latus*, two views of a fragment, × ½. (After Meek and Worthen, Ill. Geol., V.)

Broad and strongly depressed whorls, with strong, rounded and compressed ventrolateral spines, and two ridges dividing the venter into thirds, and bounding a flat or slightly concave median area marked by strongly reflected growth lines.

Coal Measures of Illinois, Kansas, etc.

116. **T. winslowi** (Meek and Worthen). (Fig. 1320, *a, b.*) Carbonic–Permic.

Differs from the preceding in its stronger, generally less flattened spines, and in the absence of the bounding ridges of the median concave area of the venter.

Coal Measures of Illinois, Indiana, Missouri; Permic of Texas

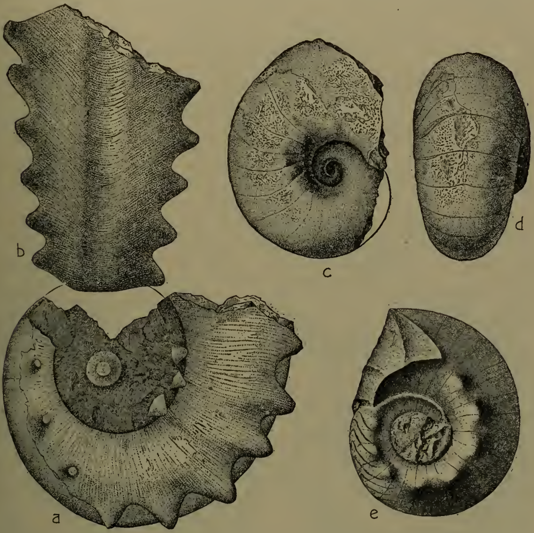

FIG. 1320. *a*, *b*, *Temnocheilus winslowi*, × ½; *c*, *d*, *Endolobus missouriensis*, × ½; *e*, *E. spectabilis*, × ½. (*a–d*, Ind. Survey; *e*, after Whitfield.)

XLI. Endolobus Meek and Worthen.

Differs from *Temnocheilus* in its strongly arched venter, and in having the row of tubercles nearer the umbilical margin. Mississippic–Carbonic.

117. **E. spectabilis** Meek and Worthen. (Fig. 1320, *e*.) Mississippic.

Lateral nodes somewhat elongate, distant, almost one to every camera. (Type of genus.)

Chester of Illinois and Missouri; Maxville limestone of Ohio.

118. **E. ortoni** (Whitfield). (Fig. 1321, *a*.) Carbonic.

Nodes more rounded, blunt and more closely crowded than in preceding, becoming obsolete towards the aperture.

Coal Measures of Ohio.

119. **E. missouriensis** (Swallow). (Fig. 1320, *c, d.*) Carbonic.

Strongly rounded, with the nodes faint or obsolete and septa distant.

Coal Measures of Indiana, Arkansas and Missouri.

XLII. Metacoceras Hyatt.

Like *Temnocheilus,* but with ventrolateral row of nodes faint or obsolete, the whorls quadrangular, generally higher than wide, and the sides flattened or concave; siphuncle centren or near venter; sutures with broad ventral, lateral and dorsal lobes, but no annular lobes. Carbonic.

120. **M. subquadrangulare** Whitfield. (Fig. 1321, *b.*) Carbonic.

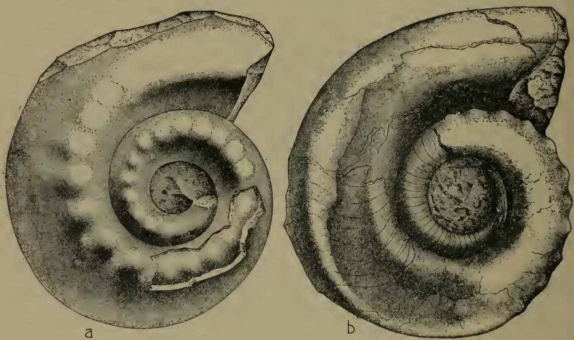

Fig. 1321. *a, Endolobus ortoni,* × ½; *b, Metacoceras subquadrangulare,* × ½. (After Whitfield.)

Large, subquadrangular in section; nodes passing into angulation in final whorl.

Coal Measures of Ohio.

121. **M. walcotti** Hyatt. (Fig. 1322.) Carbonic.

Whorls higher than wide, the venter flat with deep hyponomic sinus. Ventrolateral angles rounded, without nodes; sides with median concavity.

Coal Measures of Texas.

122. **M. sangamonense** M. and W. Carbonic.

Whorls subquadrate, slightly wider dorsally than high; sides

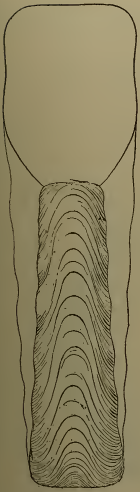

FIG. 1322*a*. *Metacoceras walcotti*, end view, × ½. (After Hyatt, Texas Survey, II.)

FIG. 1322*b*. *Metacoceras walcotti*, × ½. (After Hyatt, Texas Survey, II.)

strongly concave; ventrolateral angulation with elongated nodes; venter rounded; siphuncle ventral of center; impressed zone moderate. (Type of genus.)

Coal Measures of Illinois, Missouri, Kansas, etc.

123. **M. cavatiforme** Hyatt. (Fig. 1223.) Carbonic.

Whorls broader and more quadrate than preceding; angle

FIG. 1323. *Metacoceras cavatiforme*, fragment showing internal whorls, × ⅔. (After Hyatt.)

noded; venter broadly convex; sides flat; sutures with strong, lateral lobe.

Upper Coal Measures of Kansas City, Missouri.

XLIII. TAINOCERAS Hyatt.

Like *Metacoceras,* but with a double row of nodes on the side

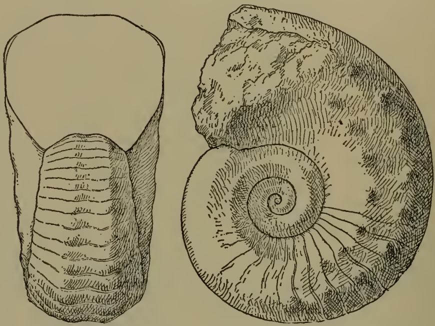

FIG. 1324. *Tainoceras cavatum,* × ½. (After Hyatt, Texas Survey, II.)

and a row of similar or fainter nodes on each side of the ventral, flat or concave space in the adult. Siphuncle above center; sutures

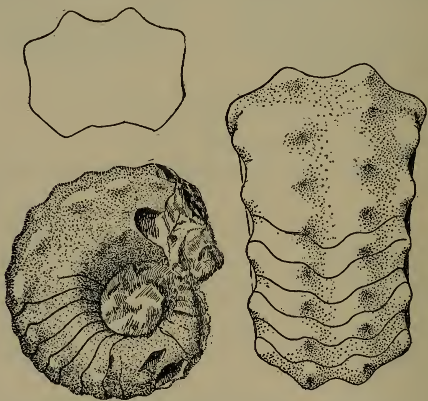

FIG. 1325. *Tainoceras occidentale,* young, adult and section, × ⅔. (After Hyatt. Texas Survey.)

with ventral, lateral and dorsal lobes, but no annular lobes. Carbonic–Triassic.

124. **T. cavatum** Hyatt. (Fig. 1324.) Carbonic.

Tubercles round and blunt, about two cameræ apart; ventral tubercles faint; spaces between tubercles flat, or scarcely concave.

Coal Measures of Texas.

125. **T. occidentale** (Swallow). (Fig. 1325.) Carbonic–Permic.

More robust than preceding, with coarser, somewhat elongate tubercles on ventrolateral angle, and the inner row of tubercles faint or almost obsolete, the space between the two being wider than in the preceding. Ventral rows of tubercles strong, rounded; all spaces between rows of tubercles concave. (= *T. quadrangulum* McChesney, type of genus.)

Coal Measures of Illinois, Iowa, Missouri, Kansas, Nebraska, Texas, Pennsylvania and West Virginia; Permic of Kansas and Texas.

Koninckoceratida.

XLIV. Domatoceras Hyatt.

Nautilicones with slightly impressed zone in adult; biangular in young; whorls tetragonal in section; surface smooth; sutures with marked umbilical saddles; siphuncle ventral of center. Carbonic.

Fig. 1326. *Domatoceras lasallense*, two views of a fragment, × ½. (After Meek and Worthen, Ill. Geol., V.)

126. **D. lasallense** (Meek and Worthen). (Fig. 1326.) Carbonic.

Whorls subquadrangular with rounded angles and ventral flattening. Enlargement very gradual. Surface smooth.

Coal Measures of Illinois, Iowa, etc.

XLV. Asymptoceras Ryckholt.

Nautilicones with broad dorsum and lateral expansions towards the aperture; section of whorls depressed elliptical to hemispheric; surface smooth; siphuncle subventran. Carbonic.

127. **A. newloni** Hyatt. (Fig. 1327.) Carbonic.

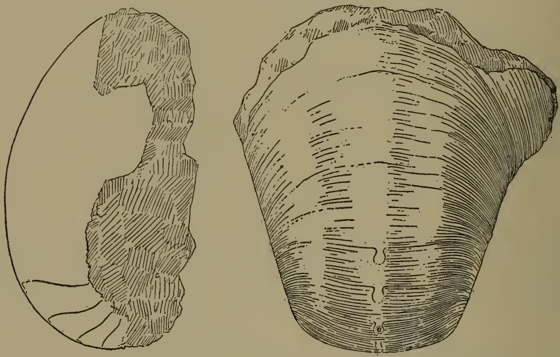

Fig. 1327. *Asymptoceras newloni*, × ½. (After Hyatt, Texas Survey, II.)

Venter broad, marked by two faint flattenings or concavities, separated by faint median ridge.

Coal Measures of Kansas.

XLVI. Solenocheilus Meek and Worthen.

Similar to preceding but whorls less rapidly enlarging; siphuncle small, in contact or nearly so, with venter; lip auriculate near dorsal angles. Mississippic–Carbonic.

128. **S. collectus** Meek and Worthen. (Fig. 1328.)
Mississippic–Carbonic.

Subquadrangular; venter gently rounded; sides flat; involution moderate, umbilicus small but profound.

St. Louis of Indiana, Illinois, etc.; Carbonic of Texas.

Digonioceratida.

XLVII. Tripteroceras Hyatt.

Compressed orthoceracones or cyrtoceracones, subtriangular in section, with broad, dorsal and ventral lobes and acute lateral saddles; siphuncle ventral and nummuloidal. Ordovicic–Devonic.

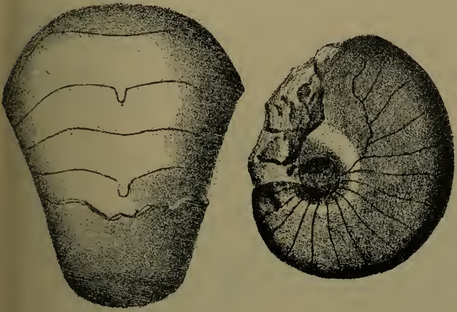

Fig. 1328. *Solenocheilus collectus*, views of two individuals. After Meek and Worthen, Ill. Geol., V.)

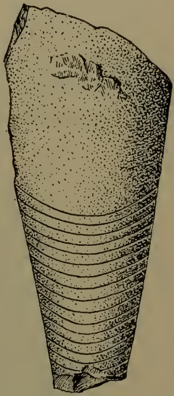

Fig. 1329. *Tripteroceras planoconvexum*. (After Clarke, Pal. Minn.)

129. **T. planoconvexum** (Hall). (Fig. 1329.) Ordovicic.

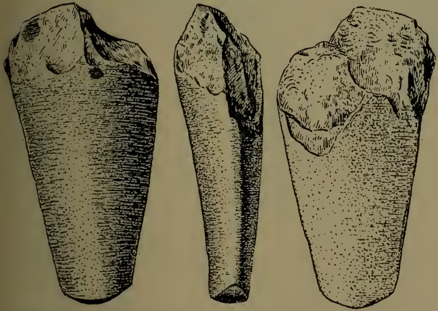

Fig. 1330. *Tripteroceras oweni*, three views of specimen. After Clarke, Pal. Minn.)

Fig. 1331. *Tripteroceras planidorsatum*, fragment. (After Clarke, Pal. Minn.)

Medium-sized, rapidly expanding, planoconvex; section semicircular to subtriangular.

Stones River and Black River beds of Cincinnati region; Stones River and Trenton of Minnesota.

130. **T. oweni** Clarke. (Fig. 1330.) Ordovicic.

Gently arcuate, rapidly widening; incurved dorsal side strongly and subtriangularly convex.

Stones River of Minnesota; Black River of Cincinnati region.

131. **T. planidorsatum** (Whitfield). (Fig. 1331.) Ordovicic.

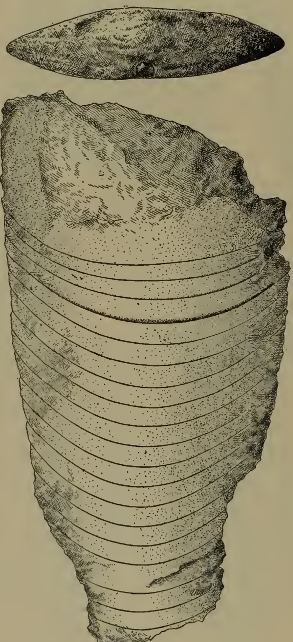

FIG. 1332. *Tripteroceras lambi*, with septal view showing siphuncle, × ½. (After Clarke, Pal. Minn.)

Slightly arcuate, gently tapering; incurvation on depressed convex dorsal side; venter flat in middle, curved at side.

Trenton of Minnesota and Wisconsin.

132. **T. lambi** (Whiteaves). (Fig. 1332.) Ordovicic.

Large, biconvex, with lenticular cross section; rapidly tapering; siphuncle subventran and moniliform.

Trenton (Galena) of Minnesota and Manitoba.

XLVIII. Edaphoceras Hyatt.

Gyroceracones and nautilicones with faintly impressed zone in adult. Whorls compressed, biangular; sutures with dorsal and ventral lobes and angular lateral saddles; V-shaped annular lobe in middle of dorsal lobe in adult. Carbonic.

Fig. 1333. *Edaphoceras niotense*, side and dorsal views of a fragment. (After Meek and Worthen, Ill. Geol., V.)

133. **E. niotense** Meek and Worthen. (Fig. 1333.) Mississippic.

Smooth; impressed zone appears only in adult; lateral angles sharp, septa deep. Type of genus.

Keokuk of Illinois.

XLIX. Remeleoceras Hyatt.

Discoidal nautilicones with well-developed but shallow contact furrow; wide umbilicus and subquadrangular section in later whorls; suture with ventral and lateral lobe, and dorsal V-shaped lobe, ventrolateral and dorsolateral saddles. Missippic–Carbonic.

134. **R. clarkense** Miller and Gurley. (Fig. 1334.) Mississippic.

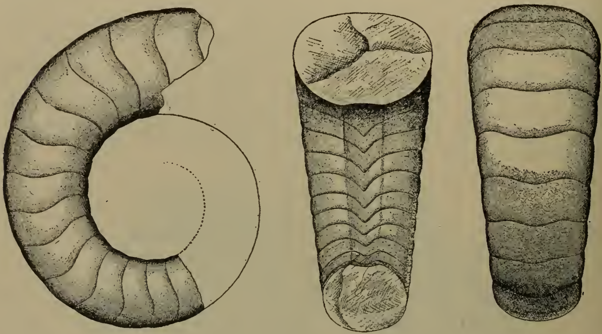

FIG. 1334. *Remeleoceras clarkense*, M. & G., × ⅔, lateral, dorsal and ventral views. (After Miller and Gurley, Bull. 12, Ill. State Mus.)

Whorls regularly and rather rapidly enlarged; venter and sides flattened, non-ornate.

Knobstone of Indiana.

L. DIODOCERAS Hyatt.

Nautilicones with young (neanic) as in the adult of arcuate *Tripteroceras,* with ventral saddles, faint lateral lobes, and minute shallow, dorsal lobe. Dorsal contact furrow begins in the neanic; siphuncle small, changing from subventran in young to ventrocentren in adult; whorls markedly digonal; surface smooth. Carbonic.

135. **D. avonense** Dawson. Carbonic.

Whorls much flattened dorso-ventrally, slightly angulated at inner edge; siphuncle near ventral margin; septa convex, about ⅛ inch apart.

Common in Windsor limestone of Nova Scotia, also at Joggins. Nova Scotia.

LI. Eutrephoceras Hyatt.

(*Nautilus* in part of authors.)

Highly involute nautilicones, with globose young (nepionic) showing only minute umbilical perforation, and marked by longitudinal ridges and transverse bands; whorls increasing in all diameters, changing little in form in adult, but becoming smooth. Sutures nearly straight. Cretacic.

136. **E. dekayi** Morton. (Fig. 1335.) Cretacic.

Fig. 1335. *Nautilus* (*Eutrephoceras*) *dekayi*, two views of a small (young) individual with surface enlarged (right) and a large specimen of var. *mortonense* with surface enlarged (left), all × ⅔. (After Meek.)

Wholly involute in adult; section of whorl strongly transverse; axis extended so as to make the whorls appear auriculate; septa distant and very concave; siphuncle subcentren; surface with growth lines. In the variety *mortonense*, the ornamentation of the young is retained.

Ripleyan of New Jersey, Delaware, Alabama, Minnesota, Arkansas; Montanan of Texas, Nebraska, Montana and Canada.

137. **E.(?) bryani** (Gabb). (Fig. 1336.) Cretacic.

More compressed laterally than preceding and with moderate umbilicus.

Jerseyan of New Jersey.

LII. Cymatoceras Hyatt.

(*Nautilus* in part of authors.)

Strongly involute nautilicones with strong transverse costæ extending across the entire shell; abdomen rounded; sides gibbous, becoming compressed in adults of some species; sutures with ventral saddles; shallow lateral and dorsal lobes; siphuncle usually subcentren; young non-costate. Comanchic–Cretacic.

138. **C. carlottense** Whiteaves. (Fig. 1337.) Comanchic.

Fig. 1336. *Nautilus* (*Eutrephoceras ?*) *bryani*, × ⅔. (After Whitfield, Pal. N. J., II.)

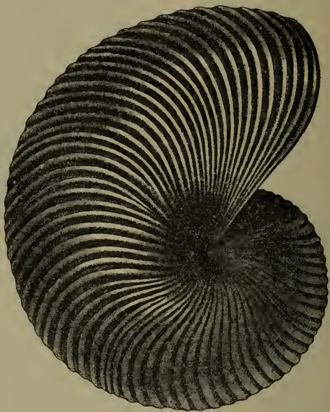

Fig. 1337. *Cymatoceras carlottense*, × ½. (After Whiteaves, Mes. Foss., I.)

Large (maximum diameter 7 inches), subglobose, but depressed in umbilical region which is closed or nearly so; aperture subcircular to subquadrate, with deep, impressed zone; ribs flattened, numerous (about 60), curving forward with moderately deep recurve; interspaces of about same width or less.

Queen Charlotte formation (Div. C) of Queen Charlotte Islands.

139. **C. suciensis** Whiteaves. (Fig. 1338.) Cretacic.

Differs from the preceding in having fewer, coarser, more distant and more curving ribs.

Nanaimo group of Vancouver Islands.

140. **C. elegans** Sowerby. (Fig. 1339.) Cretacic.

FIG. 1338. *Cymatoceras suciensis*, cross section, × ½. (After Whiteaves.)

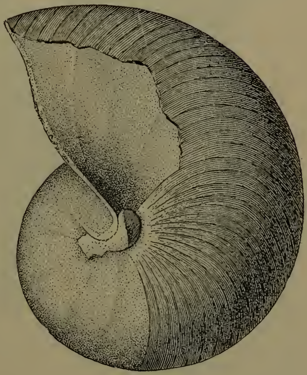

FIG. 1339. *Cymatoceras elegans*, × ⅔. (After Stanton.)

Subglobose, of broadly rounded, transverse whorls; umbilicus closed in young but slightly open in adult; costæ broad, flattened, about five times as broad as interspaces; marked by growth lines.

Benton shales of Missouri, similar horizon in Texas.

PLEURONAUTILIDA.

LIII. PROCLYDONAUTILUS Mojsisovics.

Strongly involute nautilicones, with rounded whorls, nearly central siphuncle and strongly lobate sutures; the abrupt ventral saddle divided by a median lobe; lateral lobe broad and deep. Triassic.

141. **P. triadicus** Mojsisovics. (Fig. 1340.) Triassic.

Umbilicus closed; umbilical shoulders broadly rounded; adult whorls slightly broader than high; surface marked only by growth lines.

Upper Triassic of Shasta County, California, abundant. Also European.

FIG. 1340. *Proclydonautilus triadicus*, two views and section, × ½. (After Hyatt and Smith.)

LIV. HERCOGLOSSA Conrad.

(*Nautilus* in part of authors.)

Highly involute nautilicones, with deeply-lobed sutures, broad, undivided ventral saddle, and small siphuncle, centren or dorsad of center. Triassic–Tertiary.

142. **H. paucifex** (Cope). (Fig. 1341.) Cretacic.

FIG. 1341. *Hercoglossa paucifex*, lateral view of type, × ⅓ +. (After Weller, Pal. N. J., IV.)

Large; septa distant (nearly three inches apart on venter of adult), lateral nodes narrow and deep, lateral saddles high.

Jerseyan of New Jersey.

143. **H. tuomei** Clark and Martin. (Fig. 1342.) Eocenic.

FIG. 1342. *Hercoglossa tuomei*, × ⅔. (Md. Survey.)

Slightly umbilicate with wide aperture, narrowing rapidly; venter narrowly rounded; sides flattened; lateral lobes and saddles moderate, rounded; ventral saddle broad.

Nanjemoy and Aquia formations of Maryland, Virginia, etc.

144. **H. (Enclimatoceras) ulrichi** (White). (Fig. 1343.) Eocenic.

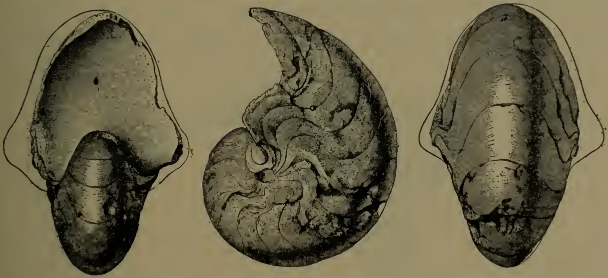

FIG. 1343. *Hercoglossa* (*Enclimatoceras*) *ulrichi*, × $\frac{4}{15}$. (After White.)

Very slightly umbilicate, with rounded venter and extended axial portion; less rapidly enlarging aperturally than the preceding, and with more pronounced ventral saddles.

Lower Eocenic of nearly all the Gulf States.

LV. Aturia Bronn.

Differs from *Hercoglossa* in having large siphuncle close to

Fig. 1344. *Aturia vanuxemi*, × ½. (After Whitfield, Pal. N. J., II.)

dorsum from an early stage, the funnels of which are very long (see Fig. 1345). Eocenic and Miocenic.

145. **A. vanuxemi** Conrad. (Figs. 1344, 1345.) Eocenic.

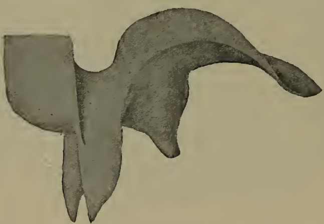

Fig. 1345. *Aturia vanuxemi*, filling between two septa, × ½. (After Whitfield, Pal. N. J., II.)

Of moderate size; non-umbilicate; strongly compressed laterally, with very deep, narrow, lateral lobes.

Shark River Eocenic of New Jersey.

Suborder CYRTOHOANITES Hyatt.

LVI. LOXOCERAS McCoy.

Smooth orthoceracones of circular or elliptical section; siphuncle highly nummuloidal in later stages, centren or near center; septa single, cameræ mostly empty. Ordovicic–Carbonic.

146. **L. moniliforme** (Hall). (Fig. 1346.) Ordovicic.

Of circular section and moderate rate of enlargement; septa

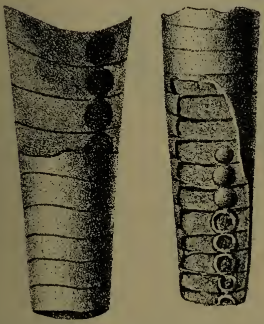

FIG. 1346. *Loxoceras moniliforme.* (After Ruedemann, Bull. 90, N. Y. State Mus.)

FIG. 1347. *Loxoceras luxum,* × ⅔. (After Hall.)

shallow; siphuncle large, propiocentren, strongly nummuloidal and empty; surface with growth lines only.

Chazy of Lake Champlain region.

147. **L. luxum** (Hall). (Fig. 1347.) Devonic.

More rapidly tapering than preceding, with deeper septa; siphuncle central; organic deposits occur on septa around siphuncle and on ventral walls.

Schoharie of New York.

LVII. NÆDYCERAS Hyatt.

Gyroceracones and trochoceracones with whorls of subtriangular section, nummuloidal siphuncle near the venter, sutures with pronounced dorsal lobe, no annular lobes, and no impressed zone. Siluric–Devonic.

148. **N. eugenium** Hall. (Fig. 1348.) Devonic.

Dextrally coiled shells of about one and one half volutions; aperture contracted, opening directly outward; sutures slightly curved and oblique, with slight lobe on ventral side; surface smooth.

FIG. 1348. *Nædyceras eugenium.* (After Hall.)

Schoharie of New York and Michigan.

LVIII. GIGANTOCERAS Hyatt.

Gyroceracones with stout volutions of compressed elliptical form, with long living chambers. Siphuncle large, nummuloidal, empty, near the center. Sutures with broad ventral saddles, dorsal and lateral lobes. Devonic.

149. **G. inelegans** (Meek). (Fig. 1349.) Devonic.

Large, with whorls rapidly enlarging, in contact. Surface smooth.

Columbus limestone of Ohio and Michigan.

LIX. ACTINOCERAS Bronn.

Orthoceracones and cyrtoceracones, generally of depressed elliptical section, with large and strongly nummuloidal siphuncles, short, compressed funnels and nearly globular sheaths. Internal deposits leave annulated endosiphuncle with tubuli radiating from the

FIG. 1349. *Gigantoceras inelegans*, × ⅜. (After Meek, Pal. Ohio.)

annuli; septa often double, an interspace near siphuncle, solid near shell. Ordovicic–Carbonic.

150. **A. bigsbyi** Stokes. (Fig. 1350.) Ordovicic.

Septa deeply concave; siphuncle large; siphonal bead occupying fully two thirds of diameter of shell.

Stones River and Black River beds of Minnesota, Cincinnati region and Tennessee; Trenton of New York, Minnesota and Tennessee.

151. **A. tenuifilum** Hall. (Fig. 1351.) Ordovicic.

Siphuncle very large; septa crowded conspicuously, double, with large interspaces; concavity much less than in preceding.

Black River of New York.

152. **A. remotiseptum** Hall. Ordovicic.

Large, cylindrical, gradually tapering; septa moderately concave; widely separated (by half the diameter of tube); siphuncle excentric, moderately swelling between septa.

Lowville and Trenton of New York; Trenton of Minnesota.

153. **A. inops** Dawson. Carbonic.

Small, rapidly tapering; septa rather close, gently concave; siphuncle large, nearly one half diameter of tube.

Carbonic limestone, Pictou and Brookfield of Nova Scotia.

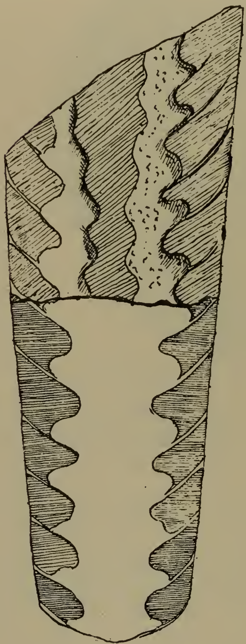

FIG. 1350. *Actinoceras bigsbyi*, longitudinal section. (After Clarke, Pal. Minn.)

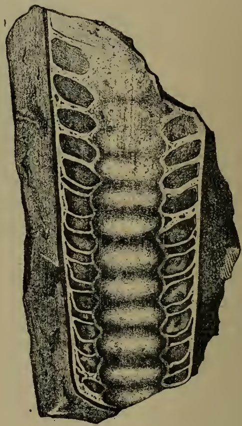

FIG. 1351. *Actinoceras* (*Ormoceras*) *tenuifilum*, $\times \frac{2}{3}$. (After Hall, Pal. N. Y., I.)

LX. CYRTACTINOCERAS Hyatt.

Cyrtoceracones with depressed section, rather closely arranged septa, and a moderately nummulitic siphuncle, filled in the middle stages with rosettes of organic deposits, and located near the convex side of the conch, but shrinking and approaching the center in old age.

154. **C. boycii** (Whitfield). (Fig. 1352.) Ordovicic.

Rather stout, rapidly enlarging, and strongly convex, of depressed, elliptical section, shallow cameræ and highly nummuloidal, siphuncle centren.

Chazy of the Lake Champlain region.

155. **C. champlainense** Ruedemann. Ordovicic.

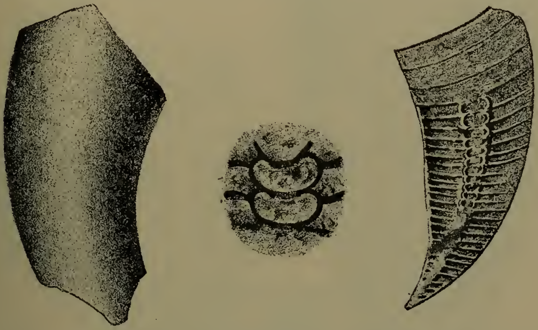

Fig. 1352. *Cyrtactinoceras boycii*, with section and enlargement of part of siphuncle. (After Ruedemann.)

Rapidly enlarging, much less curved than preceding; siphuncle smaller.

Chazy of the Lake Champlain region.

LXI. Gonioceras Hall.

Orthoceracones, extremely depressed dorsoventrally, with projecting lateral flanges, into which the septa are extended; siphuncle ventral, strongly nummuloidal; septa with strong ventral and dorsal lobes. Ordovicic.

156. **G. anceps** Hall. (Fig. 1353.) Ordovicic.

Large, rapidly expanding; transverse diameters as 1:4 or 1:5; septa crowded, deeply lobed.

Stones River of Minnesota and Tennessee; Black River of New York and Canada.

157. **G. occidentale** Hall. (Fig. 1354.) Ordovicic.

More rapidly expanding than the preceding; siphuncle large, septa less crowded, and strongly curved downwards in lateral expansions.

Trenton of Illinois and Wisconsin.

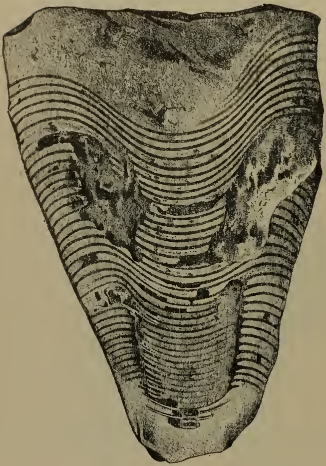

FIG. 1353. *Gonioceras anceps*, longitudinal section showing small part of siphuncle, × ½. (After Hall, Pal. N. Y., I.)

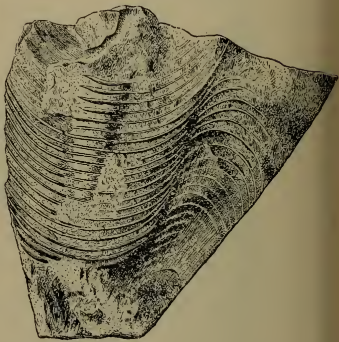

FIG. 1354. *Gonioceras occidentale*, × ⅔. (After Clarke, Pal. Minn.)

LXII. MÆLONOCERAS Hyatt.

Slender, very gradually enlarging, and regularly curved cyrtoceracones of subcircular or ovate section, with moderate living chamber, and more or less nummuloidal siphuncle, which is situated near the ventral surface. Sutures with ventral and dorsal saddles and slight lateral lobes. Shell with concentric striæ, or annulations, curved back on venter. Ordovicic–Siluric.

158. **M. neleus** Hall. (Fig. 1355.) Ordovicic.

Slender, strongly curved, very gradually expanding, slightly flattened on concave side; septa close but not regular; suture with broad, ventral saddle; siphuncle subventran, comparatively large, moderately nummuloidal; surface with rather strong concentric striæ or annulations, curved backwards on the venter.

Stones River of Minnesota and Wisconsin.

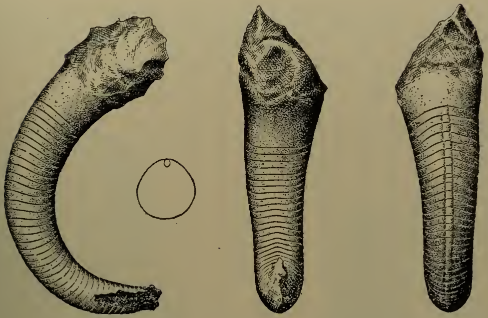

Fig. 1355. *Mælonoceras neleus*, × ⅔. (After Clarke, Pal. Minn.)

159. **M. arcticameratum** Hall. (Fig. 1356.) Siluric.

Slender, regularly and moderately curved and gradually and regularly expanding to the living chamber, which may contract very slightly towards the aperture; section transversely oval to circular;

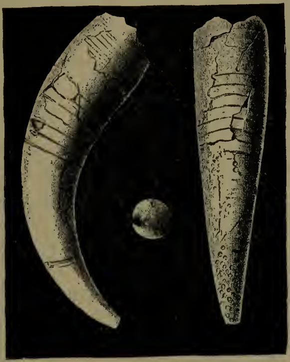

Fig. 1356. *Mælonoceras arcticameratum*, × ⅔. (After Clarke and Ruedemann.)

septa slightly convex; siphuncle small, ventral; surface with concentric striæ, recurving ventrally.

In the Guelph of Canada, New York and Wisconsin.

LXIII. Cyclostomiceras Hyatt.

Slender but short endo- or exo-gastric cyrtoceracones (rarely orthoceracones), of circular or slightly compressed, transversely oval section; living chamber comparatively long, slightly contracted towards the aperture in the gerontic stages, but aperture open; siphuncle more or less nummuloidal without organic deposits. Ordovicic–Devonic.

160. **C. cassinense** (Whitfield). (Fig. 1357.) Ordovicic.

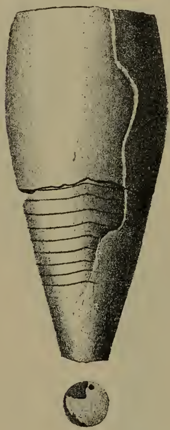

FIG. 1357. *Cyclostomiceras cassinense*, dorsal and septal views, × ⅔. (After Ruedemann, Bull. 90, N. Y. State Mus.)

FIG. 1358. *Cyclostomiceras orodes*, showing shell. (After Whiteaves, Pal. Foss., III.)

Very gently curved, rapidly expanding; aperture slightly contracted; living chamber half the length of the shell; apertural margin straight with shallow, wide hyponomic sinus; siphuncle large, propiodorsan, slightly nummuloidal.

Beekmantownian (Fort Cassin) beds of Lake Champlain region.

161. **C. orodes** (Billings). (Figs. 1358–60.) Siluric.

Very gently curved cyrtoceracones, rapidly expanding, with ventral, scarcely nummuloidal siphuncle; surface smooth; apertural contraction moderate.

Guelph of Canada and New York; Upper Monroe of Canada.

162. **C.(?) brevicorne** (Hall). (Fig. 1361.) Siluric.

Small, rapidly expanding, strongly curved; septa shallow, siphun-

FIG. 1359. *Cyclostomiceras orodes*, showing cameræ. (After Whiteaves, Pal. Foss., III.)

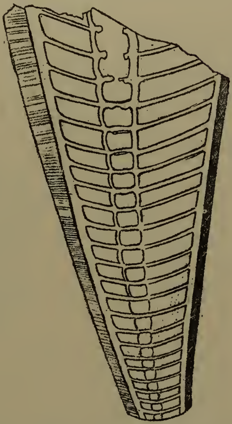

FIG. 1360. *Cyclostomiceras orodes*, section. (After Whiteaves, Pal. Foss., III.)

cle ventral, small; section oval, more broadly curving on ventral than on dorsal side.

Racine and Guelph of Wisconsin; Guelph of New York.

FIG. 1361. *Cyclostomiceras brevicorne*, × ⅔. (After Hall, 20th Mus. Rep.)

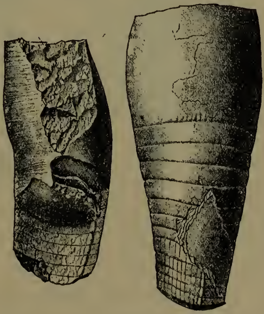

FIG. 1362. *Cyclostomiceras cretaceum*, × ⅔. (After Whitfield.)

163. **C. cretaceum** Whitfield. (Fig. 1362.) Devonic.

Moderately and somewhat irregularly expanding, slightly curving and of oval section; ventral surface more arcuate than dorsal; siphuncle small, near the venter, slightly nummuloidal; septa close, deeply concave; living chamber comparatively short; lip with broad, shallow sinuosity on each side.

Onondaga (Columbus) limestone of Ohio.

164. **C. metula** Hall. (Fig. 1363.) Devonic.

Differs from the preceding in the regular curvature, regular expansion, more slender form; sutures slightly lobed on dorsal and with faint forward sweep on ventral side; aperture very gently contracted.

Onondaga of New York and Ontario.

LXIV. Oncoceras Hall.

Differs from the preceding in being laterally compressed, with the living chamber more flattened laterally, and the aperture elongated and often subtrigonal, but typically open. Ordovicic–Siluric.

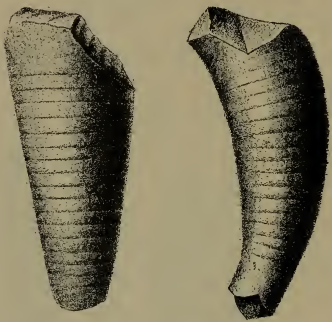

Fig. 1363. *Cyclostomiceras metula.* (After Hall, Pal. N. Y., V.)

Fig. 1364. *Oncoceras pristinum,* sectional view. (After Ruedemann, Bull. 90, N. Y. State Mus.)

165. **O. pristinum** Ruedemann. (Fig. 1364.) Ordovicic.

Small, breviconic cyrtoceracones, exogastric, and slightly curved; dorsoventral and lateral diameters as 9:7; dorsum more rounded;

living chamber slightly contracted; siphuncle slightly nummuloidal; surface smooth.

Chazy of Lake Champlain region.

166. **O. lycus** (Hall). (Fig. 1365.) Ordovicic.

Larger, more arcuate, and more compressed than preceding; living chamber very slightly contracting, somewhat abrupt just

FIG. 1365. *Oncoceras lycus*, body chamber and a few cameræ are preserved. (After Clarke, Pal. Minn.)

below slightly flaring lip; venter subacute; lip with dorsal and ventral sinus.

Stones River beds of Wisconsin and Minnesota.

167. **O. carveri** Clarke. (Fig. 1366.) Ordovicic.

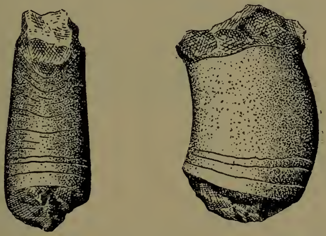

FIG. 1366. *Oncoceras carveri*, living chamber and a few cameræ. (After Clarke, Pal. Minn.)

More strongly compressed than preceding; dorsoventral and lateral diameters as 3:2.

Stones River beds of Minnesota and Illinois.

168. **O. pandion** (Hall). (Fig. 1367.) Ordovicic.

Strongly arched venter and less curved dorsum, the latter broad, the former narrow; suture with broad ventral saddle.

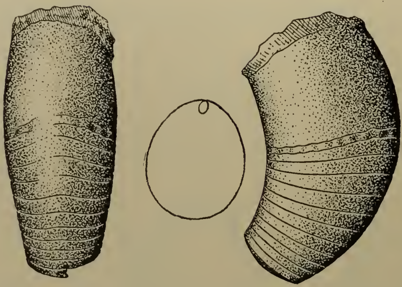

FIG. 1367. *Oncoceras pandion*, ventral and lateral views, and section. (After Clarke, Pal. Minn.)

Stones River of Wisconsin and Minnesota.

169. **O. exiguum** (Billings). (Fig. 1368.) Ordovicic.

Small, short, slender; aperture somewhat abruptly constricted. Living chamber long, cameræ high.

Trenton of Minnesota and Canada.

170. **O. orcas** (Hall). (Fig. 1369.) Siluric.

FIG. 1368. *Oncoceras exiguum*. (After Clarke, Pal. Minn.)

FIG. 1369. *Oncoceras orcas*, with shell partly removed, $\times \frac{4}{9}$. (After Hall, 20th Mus. Rep.)

With very long, gradually contracting living chamber.

Niagaran of Wisconsin.

LXV. Oöceras Hyatt.

Cyrtoceracones of elongate form, more or less compressed dorso-ventrally; septa rise rapidly on ventral side, and sometimes bend sharply towards the aperture, thus forming a funnel, ridge or shoulder on the convex side. Siphuncle large, nummuloidal in adult, tubular in young, often with actiniform deposits; funnel in typical forms of hook-like section and confined to dorsal side of tube. Ordovicic–Siluric.

171. **O. seelyi** Ruedemann. Ordovicic.

Small, breviconic, rapidly enlarging; section slightly compressed, oval; cameræ shallow; septa flat; siphuncle large; septal necks only on dorsal side.

Chazy of Lake Champlain region.

172. **O.(?) lativentrum** Ruedemann. (Fig. 1370.) Ordovicic.

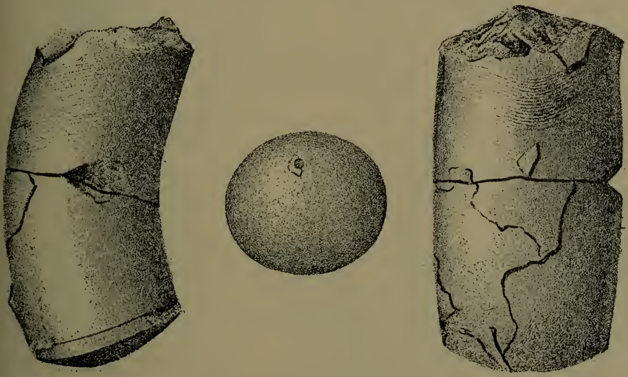

FIG. 1370. *Oöceras* (?) *lativentrum*, lateral and ventral view of living chamber with one camera; septal view showing portion of siphuncle. (After Ruedemann.)

Slender, strongly curved, large; living chamber about one third length of shell; section depressed, elliptical; siphuncle small, propioventran.

Chazy of Lake Champlain region.

LXVI. Clinoceras Mascke.

Differs from the preceding in its slender, gently arcuate form, and broad constriction below the aperture, which is not contracted. Ordovicic–Devonic.

173. **C. mumiæforme** (Whitfield). (Fig. 1371.) Ordovicic.

Slender, of circular section, gradually expanding and gently

Fig. 1371. *Clinoceras mumiæforme*, fragment showing siphuncle reduced. (After Clarke, Pal. Minn.)

Fig. 1372. *Poterioceras apertum.* (After Clarke, Pal. Minn.)

arcuate; constriction below the aperture broad and gentle; siphuncle excentric, distinctly nummuloidal.

Stones River beds of Minnesota and the Cincinnati region.

LXVII. Poterioceras McCoy.

Breviconic orthoceracones and cyrtoceracones, chiefly characterized by the short and stout form and contracted subtrigonal aperture. Ordovicic–Carbonic.

174. **P. apertum** Whiteaves. (Fig. 1372.) Ordovicic.

Short, compressed; venter somewhat narrower than the dorsum; body chamber long, gradually contracted.

Trenton of Minnesota and Canada.

175. **P. sauridens** Clarke and Ruedemann. (Fig. 1373.) Siluric. Small, fusiform, tapering abruptly and very slightly curved;

FIG. 1373. *Poterioceras sauridens*, two views of inner mold of living chamber, and a nearly complete internal mold. (After Clarke and Ruedemann, Guelph Fauna.)

living chamber rather short and strongly contracted, but bending out again at aperture, which has shallow hyponomic sinus and broad, low dorsal saddle.

Guelph of New York; Upper Monroe of Michigan.

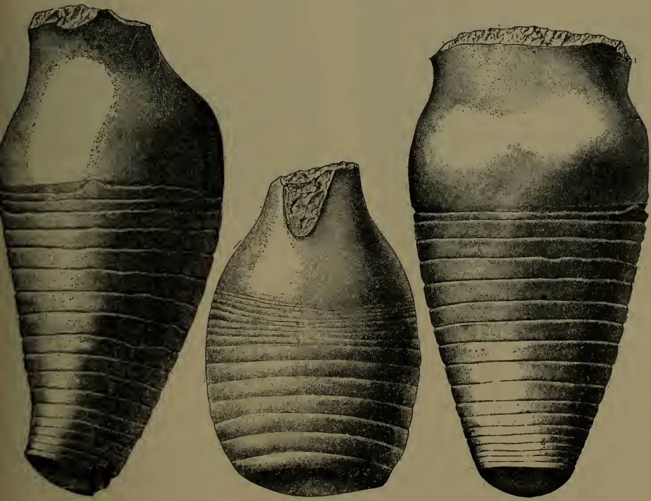

FIG. 1374. *a*, *b*, *Poterioceras hyatti*, × ½; *c* (center), *P. amphora*, × ½. (After Whitfield.)

176. **P. hyatti** Whitfield. (Fig. 1374, *a, b.*) Devonic.

Very large, quite strongly curved in young, rapidly expanding; living chamber strongly constricted below the aperture.

Columbus limestone of Ohio.

177. **P. amphora** Whitfield. (Fig. 1374, *c.*) Devonic.

Short; aperture very strongly contracted; last septa closely crowded.

Columbus of Ohio (closely related forms occur in the Traverse limestones of Michigan).

178. **P. eximium** Hall. (Fig. 1375.) Devonic.

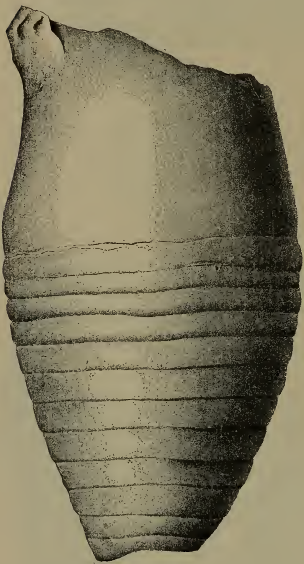

FIG. 1375. *Poterioceras eximium*, × ½. (After Hall, Pal. N. Y., V.)

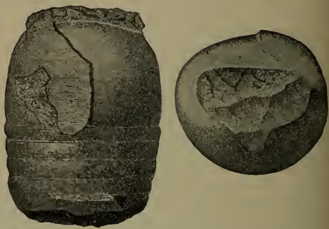

FIG. 1376. *Poterioceras oviforme*, × ⅔. (After Hyatt.)

Large, gibbous, straight, and exogastric, with subcircular or very broadly oval section; tube rapidly enlarging to living chamber which is regularly contracted to aperture; siphuncle nummuloidal.

Onondaga of New York and Ohio.

179. **P. oviforme** Hall. (Fig. 1376.) Devonic.

Small, short and thick, ovoid, with broadly oval to subcircular section; sides of adult portion nearly parallel; final portion of living chamber only contracted into a trilobate aperture; surface with lamellose growth lines; siphuncle near the ventral side.

Agoniatite limestone (Marcellus) of New York.

180. **P. lunatum** Hall. (Fig. 1377.) Devonic.

FIG. 1377. *Poterioceras lunatum*, two portions of same shell, × ⅔. (After Grabau, copied from Hall.)

Large, regularly arcuate, exogastric; section broadly oval; regularly enlarging in earlier portion, but with sides nearly parallel in adult; aperture slightly contracted; siphuncle moniliform; surface with growth lines and faint longitudinal striæ.

Hamilton of New York.

181. **P. turbiniforme** (M. and W.). Devonic.

Small, rapidly expanding, slightly asymmetrical, and of nearly circular section; living chamber very short, two or three times as wide as long, rounding to aperture which is transverse, with rounded ends and deep rounded ventral sinus. Siphuncle marginal.

Hamilton (Sellersburg) beds of Indiana and Kentucky.

182. **P. minum** (Beecher). Devonic.

Less abruptly expanding than preceding; living chamber longer; form pear-shaped; aperture small, trilobate.

Hamilton (Sellersburg) beds of Falls of Ohio region.

183. **P. raphanus** Hall. Devonic.

Small, slender, gradually tapering; living chamber short, abruptly sloping to contracted aperture, which is equal to transverse diameter of living chamber, and has a small semicircular hyponomic sinus; siphuncle submarginal, nummuloidal.

Hamilton of New York, and Sellersburg beds of Falls of Ohio region (?).

184. **P. tumidum** Hall. Devonic.

Gradually expanding to living chamber which is inflated and rapidly narrows to aperture.

Chemung of New York.

LXVIII. Trimeroceras Hyatt.

Breviconic orthoceracones like preceding but with apertures contracted into narrow, slit-like openings arranged in form of a T-shaped cross, the stem of which forms the hyponomic sinus and the arms the brachial sinuses. Siluric.

185. **T. gilberti** Kindle. Siluric.

Large (body chamber of type: height, 83 mm.; basal diameter 89 × 65 mm.), rapidly tapering, of conical form; upper side of body chamber rather flat, parallel to plane of the basal edge.

Niagaran of northern Indiana.

LXIX. Hexameroceras Hyatt.

Like the preceding but with six lateral sinuses in addition to the hyponomic sinus; no median sinus present. Siluric.

Fig. 1378. *Hexameroceras herzeri*, × ⅔. (Pal. Ohio.)

186. **H. herzeri** Hall and Whitfield. (Fig. 1378.) Siluric.

Small, somewhat compressed laterally; aperture rapidly contracting; brachial sinuses elevated.

Niagaran of Ohio.

187. **H. cacabiforme** Newell. Siluric.

Of medium size, straight; transverse section subcircular; living chamber short, less than three fourths greatest diameter; septal edges crenulated; lateral lobes of aperture strong, elevated, more regularly curved and more distinct than in *H. herzeri;* hyponomic sinus longer, more slender, widening at the margin.

Niagaran of northern Indiana.

LXX. Septameroceras Hyatt.

Like the preceding but with addition of a median sinus. Siluric.

188. **S. septoris** (Hall). (Fig. 1379.) Siluric.

Fig. 1379. *Septameroceras septoris*, side and apertural view of living chamber. (After Hall, 20th Mus. Rep.)

Aperture gradually contracting; apertural view ovate; brachial and median sinuses all distinct, rounded at the ends.

Niagaran of Wisconsin.

LXXI. Phragmoceras Sowerby.

Laterally compressed, endogastric cyrtoceracones and gyroceracones, of oval section with narrowly rounded venter; siphuncle

Fig. 1380. *Phragmoceras nestor*, apertural view. (After Hall, 20th Rep. N. Y. State Mus.)

Fig. 1381. *Phragmoceras nestor*, × ⅔. (After Hall, 20th Rep. N. Y. State Mus.)

generally large, internal; gerontic aperture strongly contracted laterally, leaving a long, hyponomic area. Siluric.

189. **P. nestor** Hall. (Figs. 1380, 1381.) Siluric.

Of moderate size, and ovoid section; living chamber ventricose, nearly as high as long; aperture laterally contracted to long narrow slit, which widens to broad aperture ventrally, and a smaller one dorsally, without pronounced prolongation; siphuncle submarginal.

Niagaran of Wisconsin.

190. **P. parvum** Hall and Whitfield. (Fig. 1382.) Siluric.

FIG. 1382. *Phragmoceras parvum.* (Pal. Ohio.)

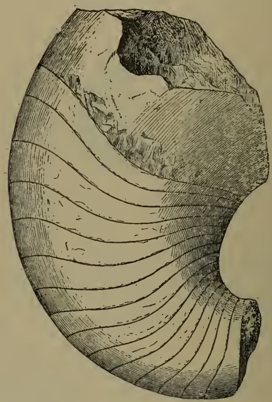

FIG. 1383. *Phragmoceras angustum,* × ½. (After Kindle, 28th Ind.)

Small, strongly curved, rapidly expanding, transversely broadly ovate below, but more flattened above; hyponomic slit prolonged ventrally into a tube-like projection; siphuncle minute.

Guelph of Ontario, New York and Ohio; Niagaran of northern Indiana.

191. **P. angustum** Newell. (Fig. 1383.) Siluric.

Large, strongly curved, moderately compressed, less rapidly expanding than either of preceding; sutures sinuous, with broad lateral lobe.

Niagaran of northern Indiana.

192. **P. ellipticum** Hall and Whitfield. (Fig. 1384.) Siluric.
Large, slightly curved; section narrowly elliptical, very little wider on inner side; ventral and dorsal height of living chamber

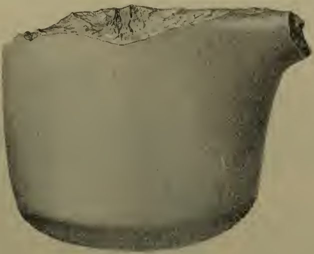

FIG. 1384. *Phragmoceras ellipticum*, × ½. (Pal. Ohio.)

nearly the same; hyponomic sinus extended into a tube.
Guelph of Ohio.

Order AMMONOIDEA.

CLIMENIDA (*Gastrocampyli*).

LXXII. ACANTHOCLYMENIA Hyatt.

Costate whorls rather rapidly enlarging, moderately involute, suture with broad and high ventrolateral saddle and shallower lateral lobe; siphuncle dorsan, *i. e.*, on interior of coil. Devonic.

193. **A. neapolitana** (Clarke). Devonic.
Young with distant ribs, adult with fine, sharply forward arching striæ. (Type of genus.)
Naples shales (Portage) of New York.

LXXIII. PLATYCLYMENIA Hyatt.

Discoidal with costated whorls of subquadrangular section; sutures with rounded lobes and saddles; siphuncle tubular, internal, with comparatively short funnels. Devonic.

194. **P. americana** Raymond. (Fig. 1385.) Devonic.
Shell with numerous whorls, closely coiled but not involute; surface marked by rather distant ribs which do not cross the venter; suture simple; whorl section depressed; differs from the associated *P. polypleura* Raymond in having fewer ribs, and from

the only other known American Clymenia, *Acanthoclymenia neapolitana* (Clarke), in its more simple suture and the presence of ribs.

Common in the upper part of the Three Forks shale at the top of the Upper Devonic, at Three Forks, Montana.

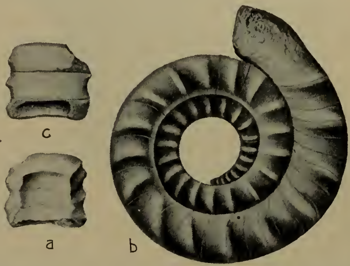

FIG. 1385. *Platyclymenia americana*; *b*, $\times \frac{4}{3}$; *a* and *c*, opposite sides of fragment, $\times$ 2. (After Raymond.)

BACTRITIDA (*Bactritidæ*).

LXXIV. BACTRITES Sandberger.

Straight shelled like *Orthoceras*, with simple sutures except for sutural (ventral) lobe. Devonic.

195. **B. clavus** Hall. (Fig. 1386.) Devonic.

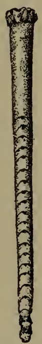

FIG. 1386. *Bactrites clavus*, $\times$ 2/3. (After Hall.)

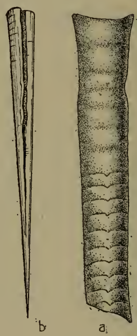

FIG. 1387. *a*, *Bactrites gracilior*, a fragment; *b*, *B. aciculum*. (After Clarke and after Hall.)

Small, slender, scarcely tapering; septa somewhat oblique.
Marcellus of New York.

196. **B. arkonensis** Whiteaves. Devonic.
Small, gently tapering, of circular section; septa concave; similar to, but smaller than, preceding.
Hamilton of Ontario.

197. **B. gracilior** Clarke. (Fig. 1387, *a*.) Devonic.
Large, of subcircular section, nearly cylindrical; adult with obscure, low, transversely oblique wrinkles; living chamber often with constrictions.
Naples shales and limestones of New York and Michigan.

198. **B. aciculum** (Hall). (Fig. 1387, *b*.) Devonic.
Slender, rapidly tapering to point, commonly compressed; length three inches or over, with aperture 7 mm. in compressed specimens.
Naples shales and limestones of New York.

Agoniatitida (*Agoniatitidæ*).

LXXV. Agoniatites Meek.

Round whorled in young, becoming flattened ventrally in later stages and laterally compressed, more or less close coiled; aperture with deep, hyponomic sinus; adult sutures comparatively simple with broad lateral and deep ventral lobes separated by narrow saddles. Devonic.

199. **A. expansus** (Vanuxem). (Fig. 1388.) Devonic.
Large (a foot or more in diameter); half grown shell with ribs and flat venter bounded by lateral carinæ; adult venter scarcely flattened, with rounded lateral angles; sides flat.
Agoniatite limestone of Marcellus in New York, Maryland, etc.

LXXVI. Tornoceras Hyatt.

Similar to preceding, but whorls compressed and annular lobes present. Devonic.

200. **T. uniangulare** (Conrad). (Fig. 1389, *d, e*.) Devonic.
Umbilicus closed; venter rounded; surface smooth except for growth lines.

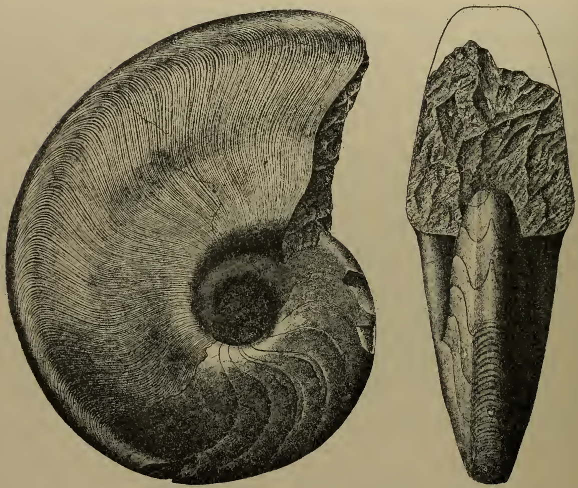

FIG. 1388. *Agoniatites expansus*, × ½. (After Hall, Pal. N. Y., V.)

Hamilton of New York; also represented by varieties in the Naples Fauna.

MANTICOCERATIDA (*Primordialidæ, pars.*).

LXXVII. MANTICOCERAS Hyatt.

Compressed goniatites, with rounded venter, and often strongly involute whorls; suture with broad, lateral saddle, sharp lobes, and a high, medially divided, ventral saddle. Devonic.

201. **M. intumescens** Beyrich. (Fig. 1389, *a, b.*) Devonic.

Of medium size; whorls embracing one half or more; umbilical angles rounded; venter strongly rounded, sides flat.

Naples shales of New York, Iowa, Michigan, and Hay River, Canada.

202. **M. rhynchostoma** Clarke. (Fig. 1390, *b, d.*) Devonic.

Very large; sides somewhat less flattened than in preceding, umbilical angle somewhat more abrupt.

Naples shales of New York.

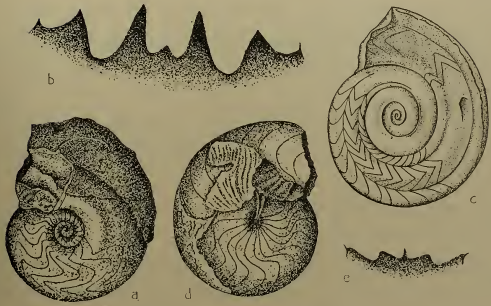

FIG. 1389. *a*, *b*, *Manticoceras intumescens* (*a* × ⅔); *c*, *Probeloceras lutheri*, × ⅔; *d*, *Tornoceras uniangulare*, × ⅔; *e*, suture of same. (After Hall.)

203. **M. sororium** Clarke. (Fig. 1390, *c*.) Devonic.
Small; young broader, adult narrower than preceding; sides flat;

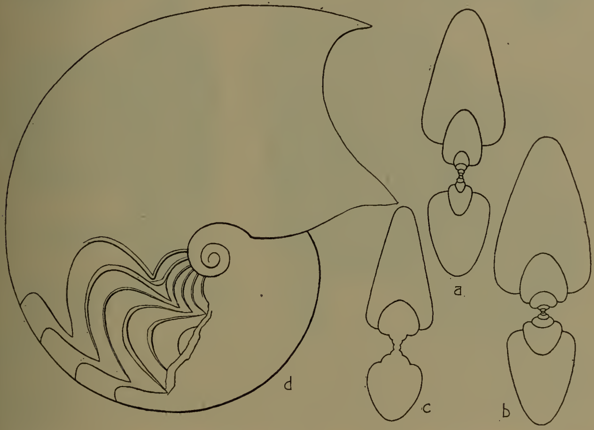

FIG. 1390. *a*, *Manticoceras intumescens*, section; *b*, *d*, *M. rhynchostoma*, × ½; *c*, *M. sororium*, section, × ½. (After Clarke.)

young ornamented by varices, which become obsolete in adult. Naples shales of New York.

LXXVIII. Probeloceras Clarke.

Less involute than preceding; suture of young manticoceran, becoming sharply angular in adult. Devonic.

204. **P. lutheri** Clarke. (Fig. 1389, *c*.) Devonic.

Very slightly involute; septa crowded and nearly parallel; median saddle acute, and two lateral lobes acute; surface with fine lines, gently curving forward.

Naples shales of New York.

Aganidida.

LXXIX. Parodiceras Hyatt.

Goniatites similar to preceding, but more involute; sides less flattened, semilunar in section; lateral lobes and saddles rounded, nearly equal; ventral saddle deeply divided; annular lobes sometimes present. Devonic.

205. **P. discoideum** (Hall). (Fig. 1391.) Devonic.

Fig 1391. *Parodiceras discoideum.*

Completely involute; surface with striæ of growth only. (Type of genus.)

Marcellus (Agoniatite limestone) and Hamilton of New York.

LXXX. Aganides deMontfort.

(*Brancoceras* Hyatt, not Steinmann.)

Closely involute, with sides somewhat convex; umbilicus minute or closed, and without angular shoulders; ventral lobe without saddle, otherwise similar to *Muensteroceras*. Mississippic.

206. **A. rotatorius** deKoninck. (Fig. 1392, *i–k*.) Mississippic.

Sides sloping gently to rounded venter; umbilicus almost closed, not showing inner whorls; ventral lobe tongue-shaped, lateral lobes narrow and pointed.

Kinderhook of Indiana (Rockford Goniatite bed); Waverly of Ohio; also in Europe in same horizon.

LXXXI. MUENSTEROCERAS Hyatt.

Evolute, compressed or discoidal goniatites, with highly arched whorls and moderately wide umbilicus. Sutures with angular, superior, lateral lobe, and acute second lateral lobe outside of

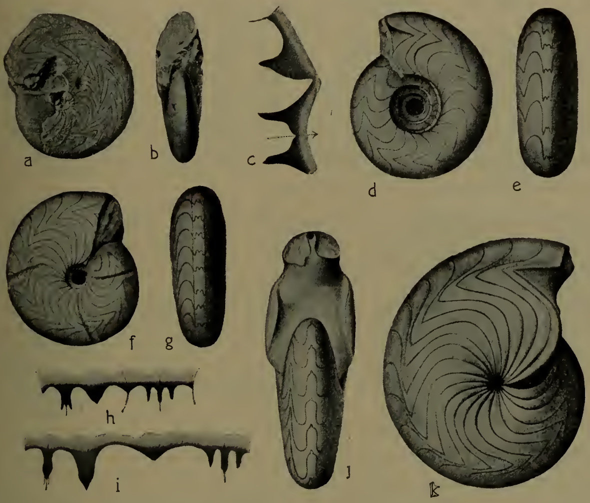

FIG. 1392. *a–c*, *Gonioloboceras welleri*, shell ⅔, and suture enlarged; *d*, *e*, *Muensteroceras oweni*, shell × ⅔; *f–h*, *M. parallelum*, shell × ⅔, and suture enlarged; *i–k*, *Aganides rotatorius*, shell × ⅔, and suture enlarged. (All after J. P. Smith.)

umbilicus; ventral lobe narrow, with small, notched saddle; surface smooth. Mississippic.

207. **M. oweni** (Hall). (Fig. 1392, *d, e*.) Mississippic.

Laterally flattened; height and width of whorl about same; embracing to one half the depth of whorl; umbilicus rather large, with angular shoulders of all whorls exposed; septa close; generally three to four wide shallow constrictions on internal mold.

Goniatite limestone (Kinderhook) of Indiana, and Marshall group of Michigan.

208. **M. parallelum** (Hall). (Fig. 1392, *f–h.*) Mississippic.

More compressed laterally than preceding; whorls higher, umbilicus smaller, septa closer.

Kinderhook of Indiana (Rockford Goniatite bed), and Michigan (Marshall group).

LXXXII. Gonioloboceras Hyatt.

In general form like the preceding, but with extremely angular lobes; sides flattened. Mississippic–Carbonic.

209. **G. goniolobus** Meek. Carbonic.

Of moderate size; sides gently convex; umbilicus small; lobes and superior lateral saddle deep and sharply angular or pointed; ventral saddle with small angular notch. (Type of genus.)

Coal Measures(?) of New Mexico.

210. **G. welleri** Smith. (Fig. 1392, *a–c.*) Carbonic.

Smaller than preceding, with flatter sides, more compressed laterally and with narrow venter, angular and slightly furrowed; ventral saddle with tongue-shaped extension instead of notch.

Coal Measures of Illinois and Texas.

LXXXIII. Dimorphoceras Hyatt.

Compressed, smooth, involute goniatites, with narrow umbilicus; surface with curved growth lines only; suture has ventral lobe divided by a deep, notched, siphonal saddle, with additional narrow saddle in the lobes thus formed, making a pair of narrow, ventral lobes on each side of the abdomen; a deep, pointed, lateral lobe in middle and another on umbilical shoulder; anti-siphonal lobe tongue-shaped, flanked by pointed laterals. Carbonic.

211. **D. texanum** Smith. (Fig. 1393, *p–r.*) Carbonic.

Greatest breadth at umbilical shoulder; venter narrow, flattened, angular and slightly furrowed at maturity, rounded in youth.

Upper Coal Measures (Cisco) of Texas.

Glyphioceratida.

LXXXIV. Goniatites de Haan.

Involute, globose shells with minute or closed umbilicus; sutures with mostly sharp lobes and saddles, a narrow, notched, siphonal saddle, and a narrower, siphonal lobe. Mississippic.

212. **G. crenistria** Phillips. (Fig. 1393, *f–h*.) Mississippic.

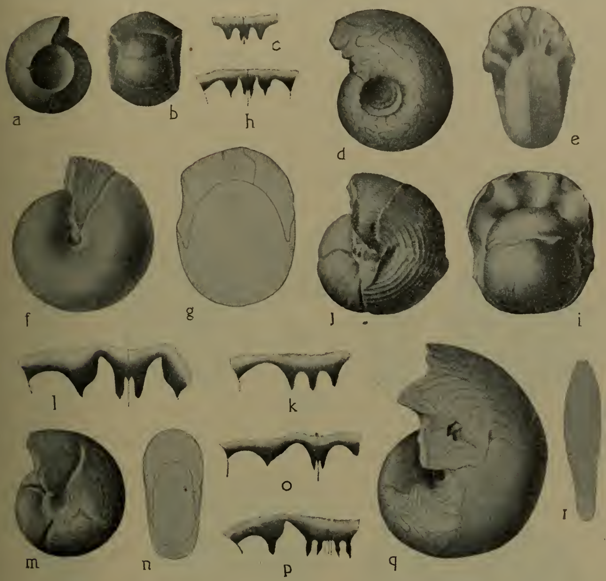

Fig. 1393. *a–c*, *Gastrioceras subcavum*, shell × ⅔, and suture; *d*, *e*, *Schistoceras hildrethi*, × ⅔; *f–h*, *Goniatites crenistria*, shell × ⅔, and suture; *i–l*, *G. striatus*, shell × ⅔, and suture internal and external; *m–o*, *G. subcircularis*, shell ⅔; *o*, suture enlarged; *p–r*, *Dimorphoceras texanum*, suture and shell × ⅔. (All after J. P. Smith.)

Whorls semilunar in section; umbilicus very narrow; four or five constrictions to a volution; surface with distinct cross striæ, with fine, sharp crenulations, which show only towards maturity; incipient nodes formed by bundling of striæ at umbilicus.

St. Louis-Chester of Texas (Bend), and Arkansas (Spring Creek and Fayetteville); also common in Europe.

213. **G. striatus** Sowerby. (Fig. 1393, *i–l.*) Mississippic.

With strong and sharp, revolving striæ, and sharply incised sinuous cross striæ.

St. Louis-Chester of Arkansas (Fayetteville shales); Bend of Texas.

214. **G. subcircularis** Miller. (Fig. 1393, *m–o.*) Mississippic.

More compressed than preceding, with larger umbilicus, and coarser spirals without crenulations; four deeply incised constrictions to the whorl, bending sharply forward on the venter.

St. Louis of Kentucky; Fayetteville shale of Arkansas.

LXXXV. GLYPHIOCERAS Hyatt (emend. Haug).

Goniatites of moderate involution, open umbilicus, rather broad and low whorls of semilunar or trapezoidal section and fine lateral

FIG. 1394. *a–c*, *Glyphioceras calyx*, shell about × 7, and suture much enlarged; *d–f*, *Gastrioceras branneri*, shell × 2/3, and suture enlarged; *g*, *h*, *G. carbonarium*, shell × 2/3, and suture enlarged. (All after J. P. Smith.)

or umbilical ribs; siphuncles small and funnels generally diplochoanitic; lobes and saddles rounded. Mississippic.

215. **G. calyx** Phillips. (Fig. 1394, *a–c.*) Mississippic.

Small (6 mm. or less), with wide, open umbilicus, and about three faint constrictions to a whorl; surface ornamented with fine, smooth cross striæ; suture with incipient ventral saddle.

St. Louis–Chester (Fayetteville shale) of Arkansas; Visé of western Europe.

LXXXVI. Gastrioceras Hyatt.

Evolute goniatites, with open umbilicus, trapezoidal or semilunar cross section, and usually ribs or tubercles on the sides; suture with nine lobes, only a single pair visible on the sides. Devonic–Carbonic.

216. **G. branneri** Smith. (Fig. 1394, *d–f.*) Mississippic.

Discoidal; comparatively narrow; umbilicus very large; whorls increasing very slightly; ribs strong on umbilical margin.

Chester of Arkansas.

217. **G. carbonarium** von Buch. (Fig. 1394, *g, h.*) Carbonic.

More involute than preceding, with smaller umbilicus, sharply angulated umbilical shoulder, and stronger ribs extending half way to venter.

Middle Coal Measures of England, Belgium and Germany, and a similar horizon in Coal Measures of Arkansas.

218. **G. entogonum** Gabb. (Fig. 1395, *a, b.*) Mississippic.

Smaller and broader than the preceding with conspicuous longitudinal striæ.

Chester of Texas, etc.

219. **G. globulosum** M. and W. (Fig. 1395, *c–e.*) Carbonic.

Very globose; whorls much wider than high; umbilicus about one third diameter of shell; angle of umbilicus 45°; lobes narrowly pointed; surface smooth.

Cisco of Texas; Upper Coal Measures of Illinois; Middle Coal Measures of Arkansas.

220. **G. listeri** Martin. (Fig. 1395, *f–h.*) Carbonic.

Of moderate width, with sharp, short umbilical ribs, and large umbilicus. Differs from *G. carbonarium* chiefly in its greater proportional width of whorls, the stronger umbilical ribs and broader lateral lobes.

Middle Coal Measures of Arkansas, and England, Belgium and Germany.

221. **G. noliense** Cox. (Fig. 1395, *i*.) Carbonic.

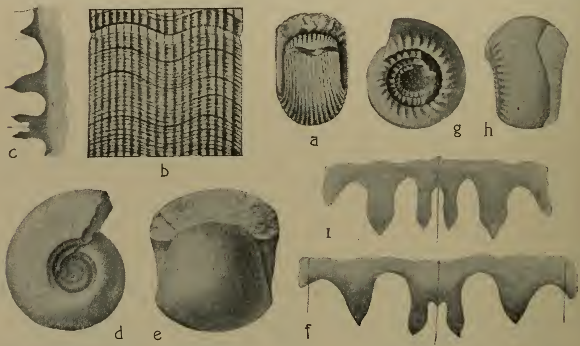

FIG. 1395. *a*, *b*, *Gastrioceras entogonum*, × ⅔, and surface enlarged; *c–e*, *G. globulosum*, suture and shell × ⅔; *f–h*, *G. listeri*, suture enlarged and shell × ⅔ *i*, *G. noliense*, suture enlarged. (After J. P. Smith.)

Like *G. carbonarium* but shell smooth, and siphonal saddle mucronate instead of notched.

Des Moines formation of Iowa; Middle Coal Measures of Kentucky.

222. **G. subcavum** Miller and Gurley. (Fig. 1393, *a–c*.) Carbonic.

Small and broad like *G. globulosum*, but with sharp umbilical angle and deep umbilicus, and no umbilical ribs.

Upper Coal Measures of Illinois and Texas.

LXXXVII. SCHISTOCERAS Hyatt.

Similar in general form to species of *Gastrioceras*, but generally less transverse, with moderate umbilicus; the suture has a large bottle-shaped saddle, the only distinction between it and that of *Prolecanites* (see beyond). The two arms of the ventral lobe are widely separated, and three pairs of lateral lobes and a small umbilical lobe with two pairs of dorsal lobes occur. The lobes are hastate, saddles club-shaped, the annular lobe deep and acute. Carbonic.

223. **S. hildrethi** Morton. (Fig. 1393, *d, e.*) Carbonic.

Whorls subglobose, helmet-shaped, embracing to umbilical shoulder of preceding whorls; umbilicus deep, nearly one third of total diameter; shoulder abrupt and noded or ribbed.

Upper Coal Measures of Ohio; Cisco of Texas.

LXXXVIII. Paralegoceras Hyatt.

Differs from *Gastrioceras* in its higher, transversely compressed whorls, narrower umbilicus, less pronounced sculpture, and long and narrow lobes and saddles, the former being eleven pairs in all. Mississippic–Permic.

224. **P. iowense** M. and W. (Fig. 1396.) Mississippic–Carbonic.

Fig. 1396. *Paralegoceras iowense*, shell × ⅔, and suture enlarged. (After Smith.)

Large, nearly flat on sides, with rounded venter and with shallow umbilicus about one half the width of last whorls.

Bend formation of Texas; Middle Coal Measures of Iowa.

Popanoceratida.

LXXXIX. Popanoceras Hyatt.

Involute, slightly compressed goniatites, with almost closed umbilicus and little sculpture; saddles rounded and entire; external lobes four or more in number on each side, serrated, either bifid or trifid. Carbonic–Permic and Triassic. (*Parapopanoceras.*)

225. **P. parkeri** (Heilprin). (Fig. 1397, *a*.) Carbonic.

Subglobose, involute; abdomen rounded; sides somewhat flattened; whorls high, and deeply embracing; lobes digitate; saddles entire.

Coal Measures (Strawn formation) of Texas.

226. **P. (Parapopanoceras) haugi** Hyatt and Smith. Triassic.

Umbilicus rather wide, one fourth diameter of shell; umbilical shoulders abrupt; venter high, arched, helmet-shaped; surface smooth; lobes digitate, serrations running high on sides of saddles, which are rounded on top.

Middle Triassic of Inyo County, California.

XC. Shumardites Smith.

Subglobose, rather evolute goniatites, with highly arched whorls, helmet-shaped, and deeply embracing; venter broadly rounded,

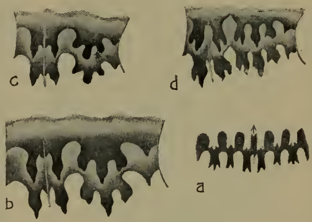

Fig. 1397. *a*, *Popanoceras parkeri*, suture; *b–d*, *Schumardites simondsi*, sutures at different stages. (After J. P. Smith.)

sloping in a gentle curve to the abrupt umbilical shoulders; umbilicus broad and deep; surface smooth except for obscure constrictions and traces of ribs on umbilical border; septa with numerous, rounded, constricted saddles and partly bifid, somewhat ammonitic lobes; siphonal saddle bottle-shaped; young form gastrioceran. Carbonic.

227. **S. simondsi** Smith. (Fig. 1397, *b–d*.) Carbonic.

Whorls twice as wide as high; general form much as in Fig. 1393, *d* (*Schistoceras hildrethi*), but umbilical angle more rounded. (Type of genus.)

Cisco formation (Missourian) of Texas.

XCI. Waagenoceras Gemmellaro.

Compact, smooth, round whorled, with moderately narrow umbilicus and complex, ammonitic sutures, of numerous, phylloid lobes and saddles, all digitate. A true Palæozoic ammonite.

Permic of Texas and Sicily.

228. **W. cumminsi** White. (Fig. 1400, *d, e.*) Permic.

Subglobose, somewhat compressed laterally; deep and narrow umbilicus showing only small part of inner whorls; cross section helmet-shaped; surface with lines of growth and occasional fine spirals; siphonal saddle narrow; three lateral and three auxiliary lobes besides the divided ventral one, all complicated as shown in figure.

Wichita of Texas.

229. **W. hilli** Smith. (Fig. 1400, *f.*) Permic.

More compressed laterally than preceding, with narrower umbilicus and higher whorls, which are, however, less deeply embracing; five sinuous constrictions on last whorl, which bend sharply backward on abdomen; septa more complex than in preceding, as shown in figure.

Double mountain beds of Texas.

Prolecanitida.

XCII. Prodromites Smith and Weller.

Laterally compressed, discoidal and involute, with deeply embracing whorls, narrow umbilicus, high, hollow abdominal keel and complex ceratitic sutures, with numerous rounded saddles and notched lobes; ventral lobe long and undivided. Mississippic.

230. **P. gorbyi** (Miller). (Fig. 1398, *a, b.*) Mississippic.

Narrowly compressed, with very narrow umbilicus and narrow abdomen, which, when the high, hollow keel is broken away, is flat, with angular sides.

Kinderhook (Chouteau limestone) of Missouri; Oölitic limestone of Burlington Iowa, and Rockford Goniatite bed of Indiana.

XCIII. Prolecanites Mojsisovics.

Evolute, compressed goniatites, with wide umbilicus, slightly embracing whorls, and lanceolate septa; external lobe undivided, the two or three lateral lobes pointed and tongue-shaped; saddles spatulate and rounded; antisiphonal lobe long and pointed, flanked by a pair of short, rounded lobes. Mississippic–Carbonic.

231. **P. greenii** (Miller). (Fig. 1398, *f, g.*) Mississippic.

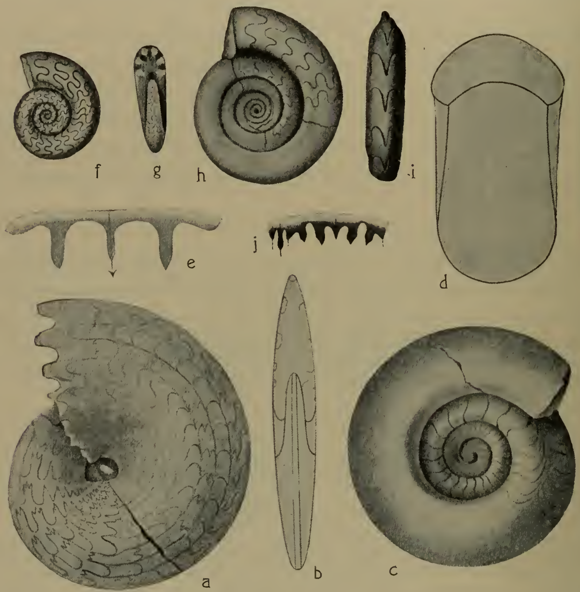

FIG. 1398. *a, b, Prodromites gorbyi*, × ⅔; *c, d, Prolecanites compactus*, × ⅔; *e*, suture enlarged; *f, g, P. greeni*, × ⅔; *h–j, P. lyoni*, shell × ⅔, and suture enlarged. (All after J. P. Smith.)

Small, discoidal, evolute, slightly embracing; whorls elliptical in section, with narrow, rounded venter; septa close and lanceolate, with short, pointed, tongue-shaped or dart-shaped ventral lobe, flanked by two similar laterals; saddles rounded and club-shaped. Kinderhook of Indiana.

232. **P. lyoni** (M. and W.). (Fig. 1398, *h–j.*) Mississippic.

Like the preceding but larger, with more whorls which increase less rapidly, with pointed ventral lobe and slightly mucronate lateral lobes and rounded saddles.

Rockford Goniatite bed (Kinderhook) of Indiana; Waverly of Ohio.

233. **P. marshallensis** Winchell. Mississippic.

Like the preceding but somewhat more involute; section of whorl elliptical; differs in having additional pair of lobes outside of the umbilical border, and in the greater length of the ventral lobe.

Marshall group of Michigan, and Waverly of Ohio.

234. **P.(?) compactus** M. and W. (Fig. 1398, *c–e*.) Carbonic.

Whorls broad, slightly arched and with rounded umbilical shoulder; sutures with narrow, tongue-shaped ventral, and two similar lateral lobes, and broad, rounded saddles.

Middle Coal Measures of Illinois.

XCIV. Pronorites Mojsisovics.

Discoidal, with high, narrow whorls, nearly parallel sides, very involute, and with narrow umbilicus; siphonal lobe three-pointed; first lateral lobe divided into two or three parts by secondary sinuses; three to six auxiliary lateral lobes, all slightly pointed; saddles all rounded. Mississippic-Carbonic.

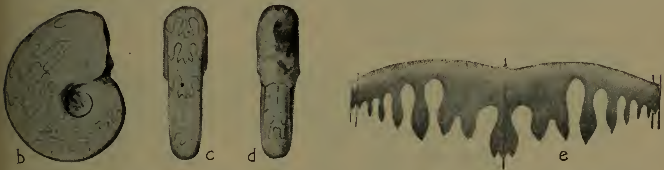

FIG. 1399. *b–d*, *Pronorites cyclolobus* var. *arkansasensis*, × ⅔; *e*, suture of same enlarged. (After J. P. Smith.)

235. **P. cyclolobus** Phillips, variety **arkansasensis** Smith. (Fig. 1399.) Mississippic.

With narrower umbilicus than the species, and a greater number of lateral lobes; saddles constricted.

Chester of Arkansas. The species is widely distributed in equivalent beds of Europe.

XCV. Medlicottia Waagen.

Discoidal, highly involute shells, with a narrow, grooved venter and smooth surface; suture ammonitic, with numerous narrow lobes and saddles, the latter rounded and entire or with lateral incisions, the lobes divided; siphonal lobe deep, bounded by high, much notched, external saddles.

Permic of India, Ural Mountains, Sicily and Texas.

236. **M. copei** White. (Fig. 1400, *a–c*.) Permic.

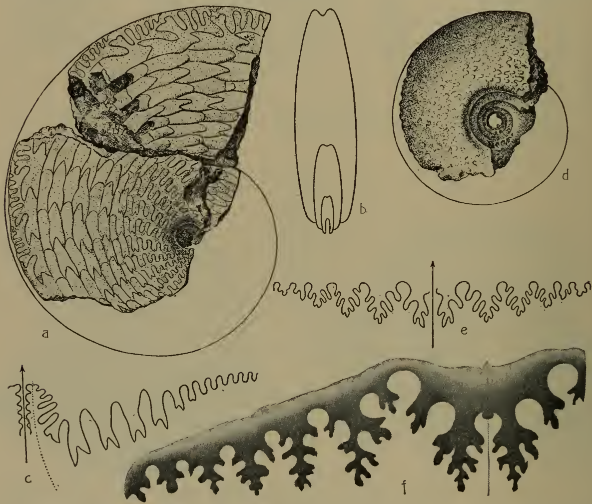

Fig. 1400. *a–c*, *Medlicottia copei*; *d*, *e*, *Waagenoceras cumminsi*; *f*, *W. hilli*, suture. (After J. P. Smith.) (All × ⅔, except sutures.)

Siphonal lobe narrow, with numerous notches; external saddles much notched, the others simple; ventral furrows bounded by angular and slightly beaded keels.

Wichita formation of northern Texas.

Nannitida.

XCVI. Nannites Mojsisovics.

Subglobose, rather involute shells, with highly arched, helmet-shaped whorls, open, deep umbilicus with steep umbilical shoulders and rounded sides; surface with constrictions or varices only; septa goniatitic, the external lobe divided by a siphonal notch, a lateral, and an auxiliary, all rounded; antisiphonal lobe undivided, flanked by two pairs of laterals. Triassic.

237. **N. dieneri** Hyatt and Smith. (Fig. 1401, *a–c*.) Triassic.
Small; whorls slightly wider than high, each indented more than half the height of the preceding whorl; surface with numerous (10 or more) varices and constrictions.
Lower Triassic Meekoceras beds of Inyo Range, California.

XCVII. Parananites Hyatt and Smith.

Like *Nannites* but with ceratitic sutures. Triassic.

238. **P. aspenensis** Hyatt and Smith. (Fig. 1401, *d–f*.) Triassic.
Highly arched whorls with flattened sides and rather broadly

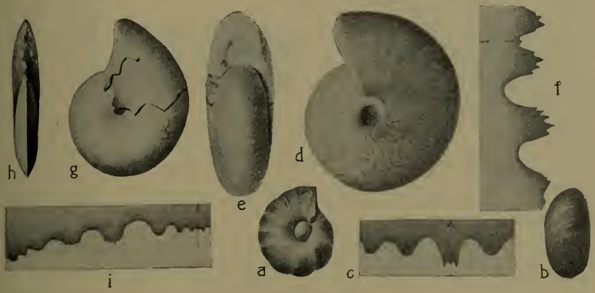

Fig. 1401. *a–c*, *Nannites dieneri*, × ⅔, and suture enlarged; *d–f*, *Parananannites aspenensis*, two views × ⅔, and suture enlarged; *g–i*, *Aspenites acutus*, × ⅔, and suture enlarged. (After Hyatt and Smith.)

rounded venter; umbilicus narrow; height of whorls half diameter of shell; surface with very weak folds and occasional constrictions; saddles rounded, lobes sharply notched. (Type of genus.)
Lower Triassic Meekoceras beds of Idaho.

Pinacoceratida.

XCVIII. Aspenites Hyatt and Smith.

Compressed, involute, deeply embracing, discoidal shells, with flattened sides; acute venter surmounted by a keel and closed umbilicus; surface with fine, radial folds; suture ceratitic, with short, rounded and notched lateral lobes, except the adventitious lobes near the venter and the auxiliaries which are goniatitic. Triassic.

239. **A. acutus** Hyatt and Smith. (Fig. 1401, *g–i.*) Triassic.

Height of last whorl nearly three fifths total diameter; radial folds visible near the umbilicus.

Meekoceras beds (Lower Triassic) of Idaho and Inyo Range of California.

XCIX. Sageceras Mojsisovics.

Discoidal, involute, laterally compressed, with narrow umbilicus, thin and deeply embracing whorls, rapidly increasing in size; venter narrow, furrowed and bounded by sharp ridges; surface with lines of growth and fine spirals; saddles numerous, long, narrow and tongue-shaped; lobes bifid, increase in size gradual and regular. Triassic.

240. **S. gabbi** Mojsisovics. (Fig. 1402, *a–c.*) Triassic.

Very flat, with narrow, channeled venter, and abruptly rounded umbilical shoulders.

Middle Triassic of Nevada.

C. Pseudosageceras Diener.

Like the preceding but with more complex septa, the lobes partly trifid; umbilicus closed. Triassic.

241. **P. intermontanum** Hyatt and Smith. (Fig. 1402, *d–f.*) Triassic.

Venter very narrow, with small furrow, bearing when perfect, a central keel; saddles entire, lobes mostly bifid with lateral notches but with the fifth deeply trifid.

Lower Triassic, Meekoceras beds of Idaho, and California, also Columbites bed of Idaho.

Ceratitoidea.

CI. Paralecanites Diener.

Evolute, slightly embracing shells, with low whorls, and goniatitic sutures; surface almost without sculpture; ventral lobe divided, a superior and second lateral but no auxiliary lobe. Permic–Triassic.

242. **P. arnoldi** Hyatt and Smith. (Fig. 1402, *g–j*.) Triassic.
Whorls subquadratic in section, slightly higher than wide, slowly increasing in size, scarcely indented by inner whorl; suture shows second lateral lobe just above umbilical shoulder, as well as internal lateral.

Meekoceras beds (Lower Triassic) of Aspen ridge, Idaho.

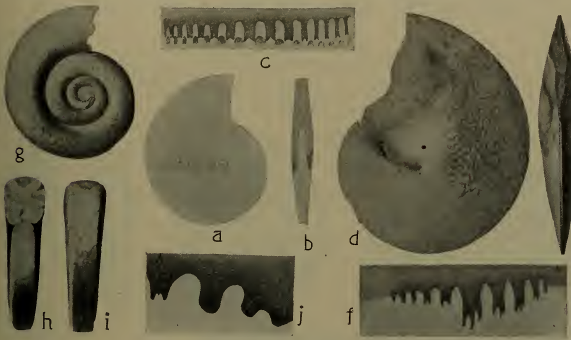

FIG. 1402. *a–c*, *Sageceras gabbi*, × ½, and suture enlarged; *d–f*, *Pseudosageceras in ermontanum*, × ½, and suture; *g–j*, *Paralecanites arnoldi*, × ½, and suture enlarged; showing divided ventral, two lateral and one internal lobe. (After Hyatt and Smith.)

CII. MEEKOCERAS Hyatt.

Compressed, discoidal, involute or evolute, with flattened sides; narrow venter, flattened or rounded but without keel or furrow; surface smooth or with fold-like ribs; sutures ceratitic, with rounded entire saddles, and serrated lobes; external lobe short and divided by siphonal saddle; the two lateral lobes are longer and there is an auxiliary series in most species, consisting of a single ceratitic or goniatitic lobe, or a series of denticulations; antisiphonal lobe divided, flanked by a single lateral. Triassic.

243. **M. gracilistriatum** (White). (Fig. 1403, *a–c*.) Triassic.
Deeply embracing; outer whorl concealing one fourth of inner; umbilical shoulder abruptly rounded; venter broad and flat, with sharp lateral angles; surface with low folds. (Type of genus.)

Lower Triassic (Meekoceras beds) of Idaho and California.

244. **M. (Prionolobus) jacksoni** Hyatt and Smith. (Fig. 1403, *d–f.*) Triassic.

Venter rounded; umbilicus moderately large; surface smooth; a long, straight row of denticulations in place of fourth lateral lobe.

Lower Triassic (Columbites bed) of Idaho and California (?).

245. **M. (Beyrichites) rotelliforme** Meek. (Fig. 1403, *g–i.*) Triassic.

With small, deep umbilicus, abrupt almost rectangular umbilical shoulder; whorls widest near umbilicus, rapidly sloping to the

FIG. 1403. *a–c*, *Meekoceras gracilistriatum*, two views of a typical specimen and ventral view of another × ½; *d–f*, *M.* (*Prionolobus*) *jacksoni*, views of two specimens × ½, and suture; *g–i*, *M.* (*Beyrichites*) *rotelliforme*, two views × ½, and suture enlarged; *j*, *k*, *M.* (*Koninckites*) *mushbachanum*, lateral view × ½, and suture; *l–n*, *M.* (*Gyronites*) *aplanatum*, two views, and suture × ½. (After Hyatt and Smith.)

sharply rounded venter; surface with numerous close-set ribs, widening to venter; saddles slightly indented.

Middle Triassic of West Humboldt Range, Nevada.

246. **M. (Koninckites) mushbachanum** White. (Fig. 1403, *j, k.*) Triassic.

Sides flat; umbilical angle abrupt; umbilicus moderate, venter abruptly and narrowly rounded; surface with faint, low folds spreading from umbilical margin; septa with rounded, entire saddles; lobes strongly serrate; siphonal saddle broad.

Lower Triassic of southeastern Idaho, and Inyo County of California.

247. **M. (Gyronites) aplanatum** White. (Fig. 1403, *l–n.*) Triassic.

Sides flat; whorls subquadrangular, higher than wide; venter flat with angular margins; umbilicus large; umbilical shoulder abrupt; surface with low, indistinct and broad folds; suture with rounded, entire saddles and partly serrate, partly entire lobes.

Meekoceras beds (Lower Triassic) of southeastern Idaho, and Inyo Range, California.

CIII. Eutomoceras Hyatt.

Differs from *Meekoceras* in having a sharp, solid, ventral keel without marginal furrows; dichotomous ribs branch from tubercles at umbilical shoulders and carry other tubercles at irregular intervals; suture with divided ventral and two principal lateral lobes, and several smaller auxiliaries, all serrated; saddles entire, rounded. Triassic.

248. **E. laubei** Meek. Triassic.

Ribs in bundles of twos or threes on umbilical tubercle; height of adult body whorl one half total diameter of shell. (Type of genus.)

Middle Triassic, West Humboldt Range, Nevada.

CIV. Longobardites Mojsisovics.

Involute, discoidal, with closed umbilicus and acute venter; surface smooth except for growth lines; suture with rounded saddles and serrate lobes, the third of which from venter is largest. Triassic.

249. **L. nevadanus** Hyatt and Smith. (Fig. 1404, *a–c.*) Triassic.

Height of body whorl more than half the diameter of shell; all lobes goniatitic in early adolescent stage; auxiliary lobes mostly remain so in adult.

Middle Triassic of Nevada.

CV. Celtites Mojsisovics.

Evolute, slightly embracing, ceratitoid shells, with low whorls increasing very slowly in height, and of quadratic section; sides flattened; ventral shoulders abruptly rounded, venter flattened; surface with simple ribs becoming obsolete at shoulder; suture goniatitic or slightly serrated. Triassic.

250. **C. halli** Mojsisovics. (Fig. 1404, *d–f*.)

Outer whorl concealing about one third of preceding one; ribs

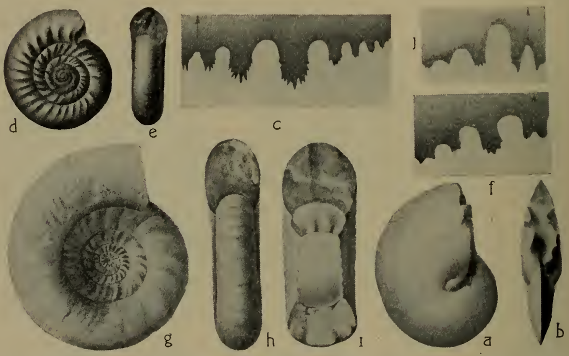

Fig. 1404. *a–c*, *Longobardites nevadanus*, two views × ⅔, and suture enlarged; *d–f*, *Celtites halli*, two views × ⅔, and suture enlarged; *g–j*, *Columbites parisianus*, two views of adult × ⅔, *i*, inner whorls, and *j*, suture, enlarged. (See p. 160.) (After Hyatt and Smith.)

becoming obsolete at point of involution; suture with a divided ventral, and two small laterals; first lateral serrated.

Middle Triassic of West Humboldt Range, Nevada.

CVI. Tirolites Mojsisovics.

Evolute ceratites, robust, laterally compressed, and with flattened or gently rounded venter, and square abdominal shoulders against which the simple ribs end in spines; suture with divided, external lobe and serrated first lateral. In *Metatirolites,* a distinct auxiliary lobe occurs on the umbilical shoulder. Triassic.

251. **T. (Metatirolites) foliaceus** Dittmar. (Fig. 1405, *h–j*.) Triassic.

Venter broadly rounded, with sharply forward arching growth lines; ventral borders marked by strong tubercles.

Upper Triassic of Shasta County, California, and the Alps.

CVII. Ceratites deHaan.

Moderately involute; whorls not deeply embracing, increasing rather rapidly in diameter, thus causing umbilicus to widen; subquadratic in section, usually higher than wide, with square abdominal shoulders and flattened venter; surface with ribs, which begin with nodes near umbilicus, and end in nodes at ventral margin;

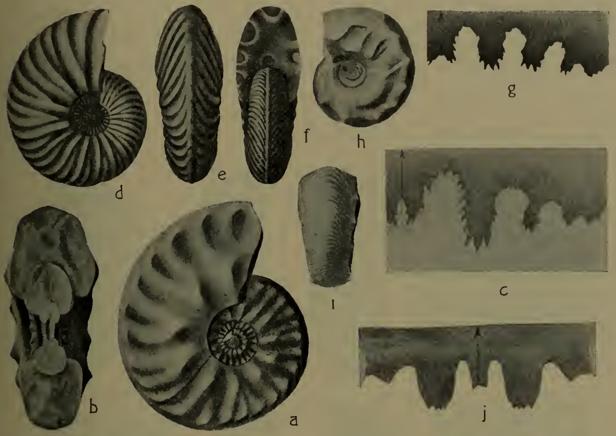

Fig. 1405. *a–c, Ceratites humboldtensis*, side view and section × ⅔, and suture; *d–g, C.* (*Gymnotoceras*) *blakei*, three views × ⅔, and suture; *h–j, Tirolites* (*Metatirolites*) *foliaceus*, two views × ⅔, and suture. (After Hyatt and Smith.)

suture with rounded, generally entire saddles, and serrated lobes, of which there are a divided external, two laterals and several small auxiliaries. Triassic.

252. **C. humboldtensis** Hyatt and Smith. (Fig. 1405, *a–c*.) Triassic.

Ribs curving, bifurcating; tubercles elongate; suture with slightly notched or wavy saddles and principal lobes serrated.

Middle Triassic of West Humboldt Range, Nevada, and Shasta County, California (?).

253. **C. (Gymnotoceras) blakei** (Gabb). (Fig. 1405, *d–g*.) Triassic.
Whorls deeply embracing; venter with median keel; surface with strong, dichotomous ribs dividing one third of distance from umbilicus and bending sharply forward, ending at ventral keel; sutures with slightly notched saddles.

Middle Triassic of West Humboldt Range, Nevada.

CVIII. Acrochordiceras Hyatt.

Moderately involute, with whorls robust, laterally compressed, higher than wide; moderately wide and deep umbilicus, with abrupt umbilical shoulders; surface with strong ribs bundled on umbilical knots, continuing across venter; sutures complex, ceratitic, with rounded saddles, but notched lobes, the lobes running high up on the side. Triassic.

254. **A. hyatti** Meek. (Fig. 1406, *a–c*.) Triassic.

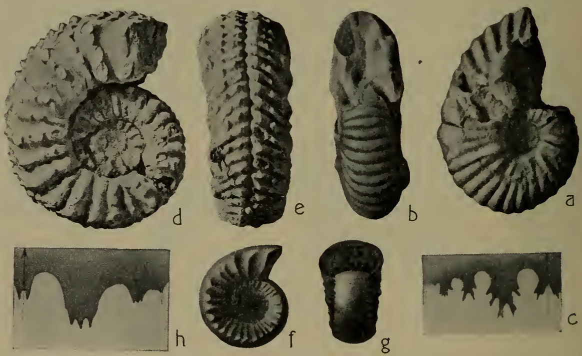

FIG. 1406. *a–c*, *Acrochordiceras hyatti*, × ⅔, and suture; *d–h*, *Clionites* (*Traskites*) *robustus*, adult (*d*, *e*) and young (*f*, *g*), × ⅔, and adult suture (*h*). (After Hyatt and Smith.)

Venter highly arched and broadly rounded; height of last whorl, one half diameter of shell. (Type of genus.)

Middle Triassic of Nevada.

CIX. CLIONITES Mojsisovics.

Slightly embracing, with subquadrangular whorls, of equal breadth and height; venter with central furrow; side with strong ribs bearing spinous nodes; sutures ceratitic with rounded saddles, entire or slightly serrated external lobe divided by low, siphonal saddle; strongly serrated lateral, and auxiliary lobe on umbilical shoulder; young like *Tirolites*. Triassic.

255. **C. fairbanksi** Hyatt and Smith. Triassic.

Ribs broad, very spinous in old age; broken into two rows of coarse nodes near ventral furrow; sides flat.

Upper Triassic of Shasta County, California.

256. **C. (Traskites) robustus** Hyatt and Smith. (Fig. 1406, *d–h.*) Triassic.

Broader and more robust than the preceding, with more strongly rounded venter; nodes finer, more spine-like; margined by strong spines.

Upper Triassic (Hosselkus limestone) of Shasta County, California.

CX. TRACHYCERAS Laube.

Compressed; moderately umbilicated; whorls deeply embracing, higher than wide; umbilical shoulders abrupt, narrow, furrowed; venter bounded by rows of tubercles (a single one on each side in *Protrachyceras*); surface with fine ribs radiating from umbilical tubercles; and ending in ventral rows of tubercles, having additional rows of tubercles on sides; suture ammonitic (ceratitic in *Anolcites*). Triassic.

257. **T. (Protrachyceras) lecontei** Hyatt and Smith. (Fig. 1407, *a–c.*) Triassic.

Umbilicus small; sides compressed, gently curving; whorls very high; ventral furrow with a single row of tubercles on each side; radiating striæ fine; spiral rows of nodes coarser than radial; sutures passing from goniatitic directly into ammonitic stage.

Upper Triassic (Karnic) of Shasta County, California.

258. **T. (Anolcites) meeki** Mojsisovics. (Fig. 1407, *d–f.*) Triassic.

Umbilicus wide and deep; ventral furrow deep; ribs strong and curving, spiral row of nodes weaker; suture ceratitic with entire rounded saddles.

Middle Triassic, West Humboldt Range, Nevada.

TROPITOIDEA.

CXI. COLUMBITES Hyatt and Smith.

Evolute, discoidal, with slightly embracing whorls, gradually increasing in size; body chamber long; surface with ribs, spirals and frequent varices; suture ceratitic, with divided ventral, a prin-

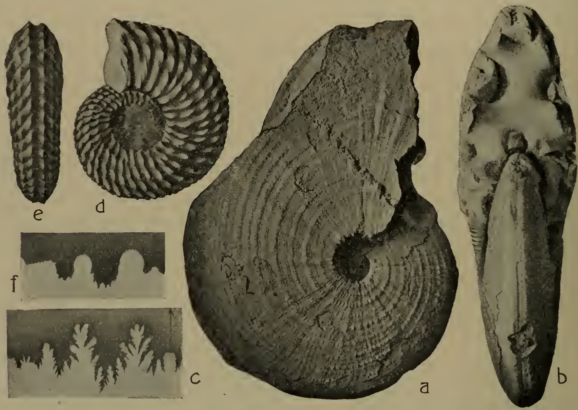

FIG. 1407. *a–c*, *Trachyceras* (*Protrachyceras*) *lecontei*, two views and suture × ½; *d–f*, *T.* (*Anolcites*) *meeki*, two views × ½, and suture (*f*). (After Hyatt and Smith.)

cipal lateral, and an auxiliary lobe. (This genus meets requirements for ancestor of *Tropites*.) Triassic.

259. **C. parisianus** Hyatt and Smith. (Fig. 1404, *g–j*.) Triassic.
Whorls very slightly indented by preceding whorl; sculpture weak at maturity, strong in young; saddles rounded and entire; first lateral lobe serrate. (Type of genus.)
Lower Triassic (above Meekoceras beds) of southeastern Idaho.

CXII. SAGENITES Mojsisovics.

Subglobose, somewhat compressed shells with rounded sides, arched venter, narrow umbilicus, and dichotomous ribs which cross the venter and are cancellated by spiral lines which often produce a series of short spines (*Trachysagenites* Moj.); sutures ammonitic; deeply digitate; distinguished from *Trachyceras* by the absence of interruption of the ornamentation of the venter.

260. **S. (Trachysagenites) herbrichi** Mojsisovics. (Fig. 1408.) Triassic.

Ornamentation has aspect of close-set, regular spiral rows of spines

Upper Triassic (Karnic) of California and the Alps.

FIG. 1408. *Sagenites* (*Trachysagenites*) *herbrichi*, two views × ½, and suture. (After Hyatt and Smith.)

CXIII. TROPITES Mojsisovics.

Moderately evolute, not deeply embracing, with deep, open umbilicus with steep walls; whorls usually broader than high, with angular, prominent, umbilical shoulders and arched venter; surface with strong umbilical nodes and spiral lines; septa ammonitic. Triassic.

261. **T. subbullatus** Hauer. (Fig. 1409, *a–c*.) Triassic.

Subglobose; section trapezoidal; venter with low, strong median keel.

Upper Karnic beds of California, and of Tyrolian Alps; probably also Himalayas.

CXIV. DISCOTROPITES Hyatt and Smith.

Involute, discoidal, laterally compressed; venter narrow, acute, with high keel, which is sometimes hollow; surface with dichotomous, sickle-shaped ribs which become obsolete at base of keel; umbilical nodes and spirals (sometimes with nodes) are present; sutures ammonitic; body chamber long; young like adult *Tropites*.

262. **D. sandlingerensis** Hauer. (Fig. 1409, *d, e.*) Triassic.

Ribs single or dichotomous; sides flat, outer whorl one half diameter of shell; keel high and hollow.

Upper Triassic of Shasta County, California, also common in Alps.

CXV. Paratropites Mojsisovics.

Less compressed than preceding, with rounded ventral shoulders and sunken keel. Triassic.

263. **P. sellai** Mojsisovics. (Fig. 1409, *f–h.*) Triassic.

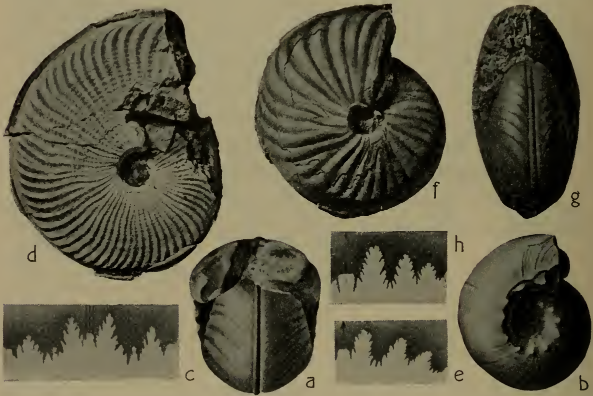

Fig. 1409. *a–c*, *Tropites subbuliatus*, × ⅔, and suture; *d*, *e*, *Discotropites sandlingerensis*, side views and suture × ⅔; *f–h*, *Paratropites sellai*, two views and suture × ⅔. (After Hyatt and Smith.)

Ribs begin in bundles, and curve abruptly forward over ventral margins, usually dichotomous; keel low, bounded by narrow grooves.

Upper Triassic (Karnic) of California (Hosselkus).

Arcestida.

CXVI. Arcestes Suess.

Globose or subglobose, involute and deeply embracing shells, with closed umbilicus; body chamber longer than last volution, often contracted and differing in shape from other whorls; whorls helmet-shaped with rounded venter, and smooth surface, except for periodic varices; sutures ammonitic with numerous similar lobes and saddles. Triassic.

264. **A. andersoni** Hyatt and Smith. (Fig. 1410, *a–c*.) Triassic.

Globose whorls deeply indented, umbilicus narrow, apparently closed in age; umbilical shoulders abruptly rounded; surface smooth but with about four constrictions.

Upper Triassic of West Humboldt Range, Nevada.

265. **A. (Proarcestes) pacificus** Hyatt and Smith. (Fig. 1410, *d*.) Triassic.

Umbilicus almost closed; general character like preceding but

FIG. 1410. *a–c*, *Arcestes andersoni*, × ½, and suture; *d*, *A.* (*Proarcestes*) *pacificus*, suture; *e*, *f*, *Ussuria waageni*, × ½, and suture. (After Hyatt and Smith.)

suture with broader saddles, less deeply digitate. Inner and outer whorls alike.

Upper Triassic of Shasta County, California.

CXVII. JOANNITES Mojsisovics.

Subglobose, laterally compressed shells, involute; inner coils completely covered by outer; umbilicus narrow and often closed by callus; surface smooth but with numerous varices; septa of *Arcestes* type, but saddles bifid and deeply digitate. Triassic.

266. **J. nevadanus** Hyatt and Smith. Triassic.

In general aspect like *Arcestes andersoni*, but more compressed laterally and venter more strongly arched; only about three sharp constrictions to the last volution; suture with eight lateral lobes on each side deeply digitate.

Middle Triassic of Nevada.

PHYLLOCERATIDA.

CXVIII. USSURIA Diener.

Compressed, involute, with narrow umbilicus, and narrowly rounded venter; surface smooth except for fine spiral striæ; sutures ammonitic, lobes and saddles digitate and highly specialized; external lobe divided by broad, digitate, siphonal saddle, each side deeply trifid with secondary indentations; principal lateral lobes two or three, wide, deep and strongly digitate; auxiliaries smaller. Triassic.

267. **U. waageni** Hyatt and Smith. (Fig. 1410, *e, f.*) Triassic.

Strongly compressed; umbilicus very narrow and almost closed; young passing through Dimorphoceran stage.

Meekoceras beds (Lower Triassic) of Aspen Ridge, Idaho.

CXIX. PHYLLOCERAS Suess.

Involute ammonites with umbilicus small or absent, laterally compressed with rounded venter; surface smooth or with obliquely forward extending lines or folds, which extend without break across the venter; varices or constrictions may occur; suture with numerous lobes or saddles, regularly increasing towards the venter;

FIG. 1411. *Phylloceras mazapilense, a,* section *b,* suture. (After Burkhardt.)

saddles ending in rounded, leaf-like pinnules; lobes numerous. Jurassic–Cretacic.

268. **P. apenninicum** Canavari. Jurassic.

Large, widening rather rapidly, with small umbilicus; surface with strong folds on inner side dividing into fine and uniform striæ on the outer portion; suture highly complicated; divisions fine; differs from *P. knoxvillense* in the more rapid widening towards the aperture, and in the coarse folds on umbilical half of the whorl.

Portlandian of the Mazapil district, Mexico, also Europe.

269. **P. mazapilense** Burckhardt. (Fig. 1411.) Jurassic.

Smaller than preceding; compressed whorls gradually widening with growth; costæ faint or obsolete; suture finely divided, saddles bifid.

Portlandian of the Mazapil region of Mexico, not rare.

270. **P. knoxvillense** Stanton. (Fig. 1412.) Comanchic.

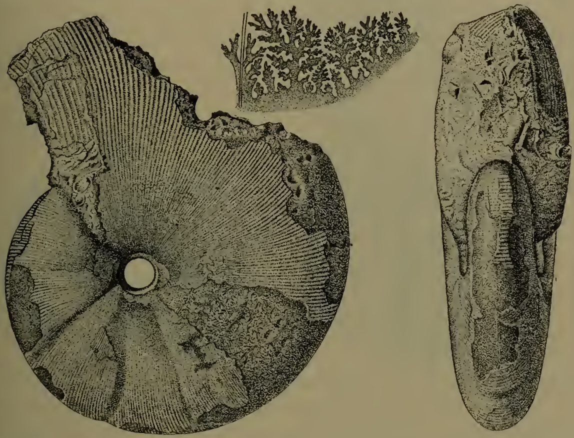

FIG. 1412. *Phylloceras knoxvillense*, shell × ⅔, and septum. This is inverted, and the finer divisions of the saddle are too narrow. (After Stanton.)

Large; in general form like the preceding, with small umbilicus; surface only with fine, forward curving striæ; the internal mold shows occasional sharp constrictions.

Knoxville of California, etc., and of Queen Charlotte Islands (Queen Charlotte formation).

271. **P. onoense** Stanton. Comanchic.

Like *P. knoxvillense* but more compressed, without constrictions and with finer surface sculpture.

Horsetown formation of Shasta County, California.

272. **P. ramosum** Meek. Cretacic.

Smaller and slightly more compressed than *P. knoxvillense;* umbilicus proportionally somewhat larger; constrictions absent; surface striæ more flexuous, curving strongly forward, near umbilicus; septa more complex and more finely divided than in *P. knoxvillense.*

Chico (Nanaimo group) of Vancouver and probably also in the United States.

Haploceratida.

CXX. Tetragonites Hyatt.

Smooth, discoidal ammonites, slightly involute; whorls of trapezoidal section; umbilicus large, sides abrupt; surface smooth with numerous constrictions or varices which arch backwards on the venter; suture much as in *Phylloceras.* Comanchic–Cretacic.

273. **T. timotheanus** Mayor. (Fig. 1413.) Comanchic–Cretacic.

Fig. 1413. *Tetragonites timotheanus* (After Whiteaves, Mes. Foss., I.)

Whorls nearly quadrangular in section, in younger portion becoming more rounded with age; umbilicus about one third diameter of shell; surface smooth but with periodic constrictions.

Queen Charlotte formation (Div. C.) of Queen Charlotte Islands; Nanaimo formation of Vancouver Island, also Europe (Gault and Albien), Trichinopoli and Oötatoor series, India.

CXXI. Gaudryceras Grossouvre.

Differs from *Tetragonites* in its more rounded section and more rapidly increasing whorls; constrictions (varices of shell) bending forward on venter; surface with very fine thread-like striations, parallel to the varices. Comanchic–Cretacic.

274. **G. sacya** Forbes. Comanchic.

Young similar to preceding; adult with well developed, broad ribs and narrower interspaces (diameter of shell up to six inches or over).

Upper Horsetown of California, abundant; Queen Charlotte formation of Queen Charlotte Islands, Japan, India, etc.

275. **G. denmanense** Whiteaves. (Fig. 1414.) Cretacic.

Umbilical margins of shell rounded rather sharply; umbilicus more than half the diameter of the entire shell; surface with about

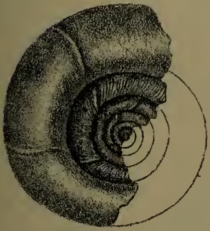

FIG 1414. *Gaudryceras denmanense*. (After Whiteaves, Mes. Foss., I.)

FIG. 1415. *Pseudophyllites indra*, × ½. (After Whiteaves, Mes. Foss., I.)

five low varices in a volution, and fine forward arching riblets which occasionally bifurcate, and also increased by intercalation.

Nanaimo group of Denman and Hornby Islands, Vancouver.

CXXII. PSEUDOPHYLLITES Kossman.

Differs from preceding in its strong involution, rapidly enlarging whorls, and absence of constrictions (varices). Cretacic.

276. **P. indra** (Forbes). (Fig. 1415.) Cretacic.

Large, with flattened sides and abrupt umbilicus; surface smooth, with faint, distinct, transverse furrows.

Nanaimo of Vancouver (Hornby Island), also India.

CXXIII. HAPLOCERAS Zittel.

Rather involute ammonites with narrow umbilicus; rounded venter; smooth or with sides marked by falcate growth lines which outline the ventral and lateral lappets; suture finely divided with two to four auxiliary lobes; and deeply incised saddles; long, straight, and bifid antisiphonal lobe, and blunt siphonal saddles. Jurassic–Cretacic.

277. **H. fialar** (Oppel). Jurassic.

Narrow, with nearly flat sides, rather large umbilicus for the genus, sides marked by a revolving groove slightly nearer the umbilical side of the center, and by faint falcate ribs above this groove.

Kimeridgean of Mexico and Europe.

278. **H. transatlanticum** Burckhardt. Jurassic.

Somewhat more rapidly widening than preceding, umbilicus smaller shell more involute; revolving groove absent, but in its

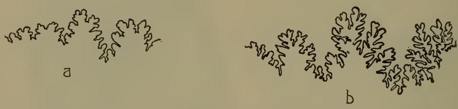

FIG. 1416. *a*, *Haploceras zacatecanum*, suture; *b*, *Eurynoticeras zitteli*, suture. (After Burckhardt.)

place the growth lines make a sudden recurvation; no ribs.

Kimeridgean of Santa Rosa, Mexico.

279. **H. zacatecanum** Burckhardt. (Fig. 1416, *a*.) Jurassic.

Differs from preceding in its somewhat narrower umbilicus and ribs of same strength as in *H. fialar,* but no groove; umbilical border subangular.

Occurs with the preceding.

280. **H. ordoñezi** Aguilera. Jurassic.

Larger than preceding with broadly rounded venter, abrupt but rounded umbilical shoulder and numerous narrow but distinct falcate ribs; no groove.

Kimeridgean of Sierra de la Zuluaga, Mexico.

281. **H. costatum** Burckhardt. Jurassic.

Ornamentation pronounced, the costæ stronger than is usual for the genus, sometimes increased by intercalation; umbilicus moderate.

Kimeridgean of Santa Rosa and Vereda del Quernado, Mexico.

CXXIV. Eurynoticeras Canavari.

Like *Haploceras* but with coarse folds mostly on venter and becoming less marked or obsolete on the sides; suture with strongly incised saddles, similar to, but more deeply incised than in the Jurassic *Haploceras*. Jurassic.

282. **E. zitteli** Burckhardt. (Fig. 1416, *b*). Jurassic.

Ribs rounded, bifurcating a short distance below the venter, strongly bent forward on the middle of the side and continuing, though faint, to the small umbilicus.

Portlandian of Mazapil district, Mexico.

CXXV. Puzozia Bayle.

Varying from slightly involute to forms with small umbilicus; section rounded or elongate, with rounded venter; surface ornamentation varying from fine lines to ribs, which have a sigmoid

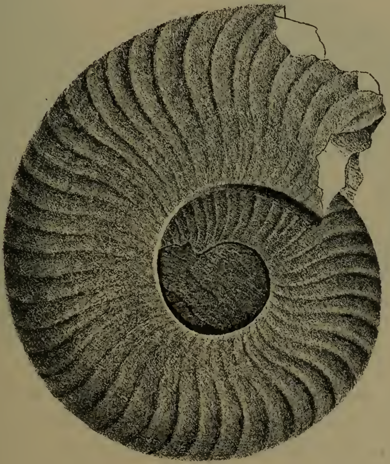

Fig. 1417. *Puzozia breweri*, × ⅔. (After Gabb.)

curve, bending forward across the venter; more or less frequent varices (or constrictions in mold) of the same outline also occur; suture highly complex, with blunt siphonal saddle and long, straight, trifid antisiphonal lobe. Comanchic–Cretacic.

283. **P. latidorsata** Michelin. Comanchic.

Like the next, but whorls more nearly circular in section, less involute and with larger umbilicus; strong, rounded and distant, sigmoid ribs, about 11 to 12 to the last volution, with finer striæ between.

Queen Charlotte formation of Queen Charlotte Islands, also in India and Europe.

284. **P. breweri** (Gabb). (Fig. 1417.) Comanchic.

Large, with large, open umbilicus, angular umbilical shoulder and strong, equal sigmoid ribs, which are fainter towards the umbilical margin.

Horsetown group of California; Queen Charlotte group of Queen Charlotte Islands.

285. **P. selwyniana** Whiteaves. (Fig. 1418.) Cretacic.

FIG. 1418. *Puzozia selwyniana.* (After Whiteaves, Mes. Foss., I.)

Umbilicus very small; surface with fine, flexuous striæ which arch forward forming a strong, beak-like process; on internal mold, periodic grooves of same form as the growth lines occur, about seven to the last volution.

Nanimo of Sucia and Denman Islands, Vancouver; a related species, *P. diphylloides,* occurs in the same horizon in India.

CXXVI. Desmoceras Zittel.

Differs from preceding genus in its compressed form, narrowly rounded venter, faint distant ribs, abrupt umbilical shoulder and less strongly incised suture. Comanchic–Cretacic.

286. **D. haydeni** (Gabb). (Fig. 1419.) Comanchic.

Fig. 1419. *Desmoceras haydeni,* × ⅓, and suture. (After Gabb.)

Smooth, strongly involute, sides flat, venter abruptly rounded; umbilical shoulder pronounced. (This may belong to a distinct genus, though in form it agrees with the typical species. The lack of ribs, however, and the more complex suture seem to separate it).

Horsetown of northern California, and Queen Charlotte formation of Queen Charlotte Islands.

CXXVII. Hauericeras Grossouvre.

Like *Puzzozia* but with a pronounced ventral keel; surface smooth. Cretacic.

287. **H. gardeni** (Baily). Cretacic.

Sides flattened, arching towards the sharply defined keel; height about twice the width; whorls embracing about one third, abrupt at the umbilical margin; surface with sigmoid lines of growth strongly curving forward to the venter.

Nanaimo group of Vancouver and in California, and also from India, Japan, South Africa, etc.

CXXVIII. Gabbioceras Hyatt.

Discoidal, umbilicate; the young whorls transverse, wider than high; smooth and angulated around the umbilical margin, the impressed zone very shallow and the venter flatly rounded; adult whorls rounded, somewhat higher than wide; adult suture with a long, narrow, and scarcely crenulated siphonal saddle and deeply incised lateral and dorsal saddles. Comanchic.

288. **G. batesi** (Gabb). (Fig. 1420.) Comanchic.

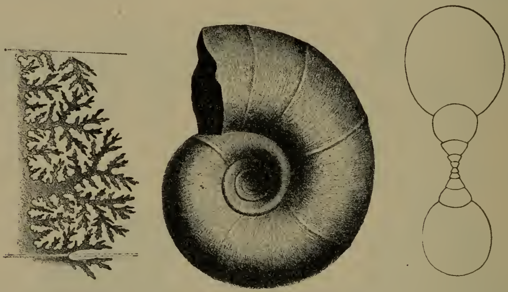

FIG. 1420. *Gabbioceras batesi*, with cross section, × ⅔; suture enlarged. (After Gabb.)

Adult whorls nearly circular; surface with few, narrow, distant costæ and numerous fine striæ.

Horsetown of California.

CXXIX. Pleuropachydiscus Hyatt.

Whorls more compressed laterally than preceding; abruptly inturned at the umbilicus; suture with narrow but not pointed siphonal saddle, and broad lateral saddles, much less deeply incised than in *Gabbioceras;* first lateral lobe longer than the ventral lobe. Comanchic–Cretacic.

289. **P. hoffmani** (Gabb). (Fig. 1421.) Comanchic–Cretacic.

With moderately large umbilicus, and numerous slightly sinuous growth lines, with periodic narrow grooves of the same form, from 6 to 9 in the last volution.

Horsetown of California; Nanaimo of Vancouver.

FIG. 1421. *Pleuropachydiscus hoffmani*, ⅓ natural size. (After Gabb.)

FIG. 1422. *Pleuropachydiscus hoffmani*, suture. (After Gabb.)

CXXX. PACHYDISCUS Zittel.

Ventricose, thick shelled, often gigantic (.5 to 1 meter) ammonites with rounded venter; with more or less well developed, strong, simple or bifurcating, sometimes noded ribs, generally obsolete on large individuals; constrictions faint only on younger stages; suture similar to *Desmoceras*, but less finely incised. Comanchic–Cretacic.

290. **P. brazoensis** (Shumard). Comanchic.

Large ($1\frac{3}{4}$ ft.); last whorl strongly rounded on venter, sides gently convex with 10 or 11 broad, slightly prominent, convex ribs, which become obsolete towards the venter and umbilicus; umbilicus deep, its width less than that of the last whorl; in the young the volutions are thicker at umbilical margin, the section being subtriangular; in adult the section is semielliptical, higher than wide.

Lower Washita of Colorado and Oklahoma; Kiamitia and basal Duck Creek and Lower Georgetown of Texas.

291. **P. otacodensis** (Stoliczka). (Figs. 1423, 1424.) Cretacic.

Whorls narrowing ventralwards; umbilicus moderate, sides abruptly inflected; ribs distant, narrow, obsolete towards umbilicus.

Nanaimo of Vancouver.

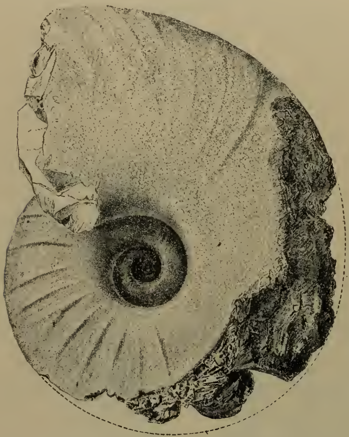

FIG. 1423. *Pachydiscus otacodensis*, × ½. (After Whiteaves, Mes. Foss., I.)

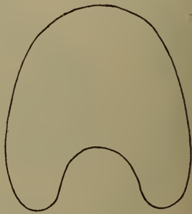

FIG. 1424. *Pachydiscus otacodensis*, section, × ½. (After Whiteaves.)

292. **P. suciaënsis** (Meek). (Figs. 1425, 1426.) Cretacic.

Similar to the preceding, but with broader and lower whorls, which are more deeply impressed and less abruptly inflected at the umbilicus; ribs sharp, alternating in length.

Nanaimo of Vancouver and northwestern United States.

293. **P. newberryanus** Meek. Cretacic.

Large, more compressed than *P. suciaënsis;* rather coarsely ribbed with an occasional large rib; in the young a row of umbilical nodes occur from which the ribs often bifurcate; lobes and saddles much less divided than in *P. suciaënsis;* siphonal lobe with three principal branches on each side, instead of four as in that species, these being again divided at their summits into two or three branches.

Nanaimo of Vancouver; Chico of California.

294. **P. complexus** Hall and Meek. Cretacic.

Rather small, subglobose, with broadly rounded venter and large

FIG. 1425. *Pachydiscus suciaënsis*, with cross section of body whorl, × ⅔, and suture natural size. (After Gabb.)

FIG. 1426. *Pachydiscus suciaënsis*, var., × $\frac{8}{15}$, with surface enlargement and septum. (After Gabb.)

umbilicus bounded by a row of small, transversely elongate nodes, which in large individuals bifurcate and form a series of distant, more or less obscure costæ, increased by intercalation and extending over the venter; septa less complex than preceding.

Ripleyan of New Jersey and Texas; Montanan of Nebraska, Dakota and Wyoming.

Scaphitidæ.

CXXXI. Scaphites Parkinson.

Phylogerontic ammonites with last whorl becoming more closely coiled, and often making one or more nearly rectangular turns; aperture generally somewhat contracted; surface marked by ribs, commonly bifurcating and extending across the venter, and frequently by two or more rows of tubercles; suture sometimes very simple, at other times with moderately incised saddles; young like *Pachydiscus*. Cretacic.

295. **S. warreni** Meek and Hayden. (Fig. 1427, *a, b*.) Cretacic.

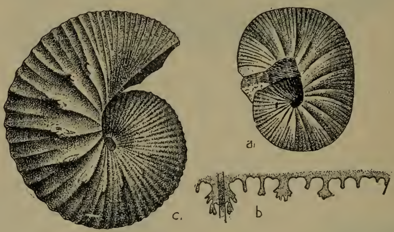

Fig. 1427. *a, Scaphites warreni*, × ⅔; *b*, septum enlarged; *c, Scaphites vermiformis*, × ⅔. (After Stanton.)

Small, last whorl partly free, recurved ribs simple, alternating coarse and fine; adult suture very simple.

Benton shales of South Dakota, Wyoming, Colorado and New Mexico.

296. **S. vermiformis** Meek and Hayden. (Fig. 1427, *c*.) Cretacic.

More nearly circular; ribs in last whorl bifurcating about the middle of the side; with node at bifurcation and intercalated ribs between the bifurcated pairs on the venter.

Fort Benton of the Upper Missouri region.

297. **S. nodosus** Owen, and var. **brevis** Meek. (Fig. 1428.) Cretacic. Large, with sides flattened; costæ bifurcating and increasing by

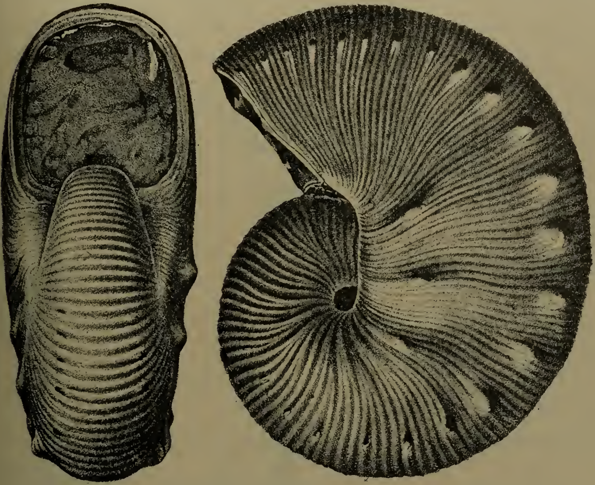

FIG. 1428. *Scaphites nodosus* var. *brevis*. (After Meek.)

intercalation, rounded, closely crowded; a strong node on every third to fifth rib near the ventral border of the last whorl; these

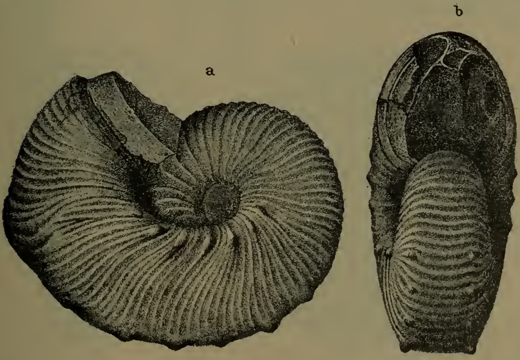

FIG. 1429. *Scaphites nodosus* var. *quadrangularis*. (After Meek.)

become strong and spread over several ribs in the first part of the loose-coiling whorl, but become smaller again towards the aperture; a second row of nodes more distant occurs near the small umbilicus; in the typical form the nodes of both rows continue over entire last whorl; in the variety the tubercles of the outer

FIG. 1430. *Scaphites nodosus* var. *quadrangularis*, × 3 +. (After Meek.)

row increase and diminish rapidly and do not cover the entire whorl, while the inner row has few nodes.

Widely distributed in the Montanan of western North America, and also in the Ripleyan of New Jersey.

298. **S. nodosus quadrangularis** (Meek). (Figs. 1429, 1430.) Cretacic.

Small, more nearly subquadrangular in section of whorl; venter flattened, nodes weak, and of but slight extent in each row.

Montanan of Dakota, Kansas, etc.

299. **S. hippocrepis** (DeKay). (Fig. 1431.) Cretacic.

Rapidly enlarging in last whorl, and as rapidly contracting to

FIG. 1431. *Scaphites hippocrepis*. (After Whitfield, Pal. N. J., 2.)

the aperture; ribs of adult bifurcating and trifurcating; nodes only on last half, those of inner row nearly obsolete.

Lower Ripleyan of New Jersey; common.

CXXXII. Baculites Lamarck.

Straight shells except for the minute apical portion which is enrolled, but generally lost; section varying from elliptical or oval to ovoid, generally sharper on posterior side; living chamber large, with anterior ventral prolongation, generally indicated by the smooth lines; suture comparatively simple; surface smooth. Cretacic.

300. **B. gracilis** Shumard. (Fig. 1432.) Cretacic.

Small, slender, scarcely tapering; broad ovate to subelliptical in

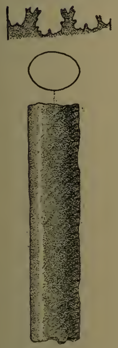

Fig. 1432. *Baculites gracilis*, ×⅔, with section and suture. (After Stanton.)

Fig. 1433. *Baculites chicoensis*, with section. (After Gabb.)

Fig. 1434. *Baculites chicoensis*, suture enlarged. (After Gabb.)

section; surface smooth or with numerous rounded, distinct costæ or undulations, strongest on siphonal side; saddles and lobes, six each, only slightly incised.

Coloradoan (chiefly Niobrara) of Utah, Colorado and Texas.

301. **B. chicoensis** Trask. (Figs. 1433, 1434.) Cretacic.

Slender, of subelliptical section, with slightly narrower venter;

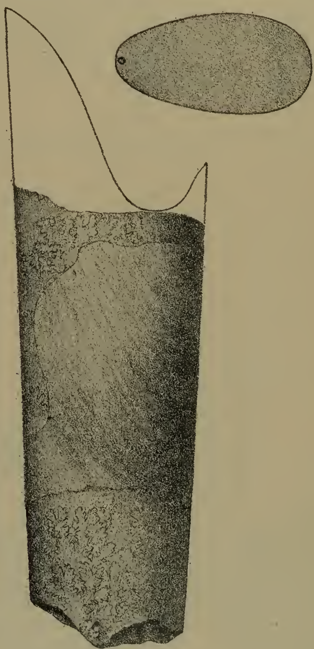

FIG. 1435. *Baculites compressus*, side view and cross section. (After Meek.)

ventral lappet proportionally longer and narrower than in preceding species; suture with narrow, bilobed saddles and broader lobes.

Nanaimo of Vancouver; Chico of California.

302. **B. anceps** Lamarck. Cretacic.

In form similar to *B. gracilis*, but with section more ovoid and surface with strong, curved ribs, which are prominent over half the side, and in the young converge forward on the broader side.

Coloradoan of Texas.

303. **B. compressus** Say. (Figs. 1435, 1436.) Cretacic.

FIG. 1436. *Baculites compressus*, suture enlarged. (After Meek.)

Large, regularly and rather rapidly tapering, compressed, ovate, with narrowly rounded venter; suture with strongly incised lobes and saddles.

Pierre of Upper Missouri and Dakota, and elsewhere; Ripleyan of New Jersey.

304. **B. ovatus** Say. (Figs. 1437, 1438.) Cretacic.

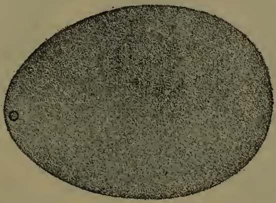

FIG. 1437. *Baculites ovatus*, cross section. (After Meek.)

Large, gradually tapering, more broadly ovate than preceding; suture somewhat less finely incised.

Ripleyan of New Jersey, Alabama, etc.; Pierre of Dakota, Montana, Colorado, etc.

FIG. 1438. *Baculites ovatus*, septum much magnified. (After Meek.)

CXXXIII. Lytoceras Suess.

Discoidal, widely umbilicated, scarcely, or but slightly, embracing; sections of whorls approaching circular; surface with lines of growth, fine distant ribs, and often with constrictions in the internal molds; suture complexly incised, consisting of siphonal and antisiphonal lobes and two lateral lobes; the antisiphonal narrow, with cruciform branches and ending in points; the siphonal lobe is shorter than the first lateral one and is divided by a narrow, pointed saddle. Jurassic–Cretacic.

305. **L. batesi** Trask. (Fig. 1439.) Comanchic.

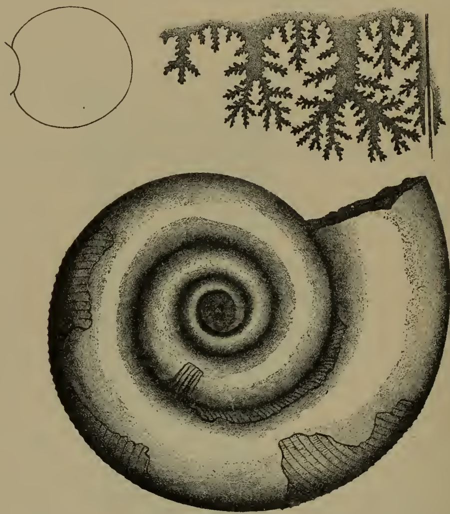

Fig. 1439. *Lytoceras batesi*, with cross section of last whorl, × ⅔, suture enlarged. (After Gabb.)

Very slightly embracing, nearly circular whorls; surface ornamented by fine, sharp, elevated ribs extending obliquely forward over the venter, and sometimes by fine, spiral lines; siphonal saddles smooth.

Knoxville beds of California, Oregon and Queen Charlotte Islands.

ARIETIDA.

CXXXIV. ÇORONICERAS Hyatt.

Flat, discoidal ammonites, with quadrangular whorls, slightly or scarcely at all embracing; venter flat with median keel bounded by two pronounced depressions; sides marked by strong ribs which bend forward at the venter and end abruptly at the margin of the ventral grooves, or end in tubercles before reaching the groove; suture with broad saddles moderately incised; siphonal saddle long and narrowing with slight incisions; second lateral saddle larger than first; antisiphonal lobe long and ending in two points. Young whorls stout and smooth, followed by tuberculated stage, in form subquadrangular. Jurassic (Lias).

306. **C. claytoni** Hyatt. Jurassic.

Ribs well defined, lyre-like, with similar tubercles on the angulations; channels deep, somewhat narrow and smooth; keel prominent.

Lower Lias of Nevada.

CXXXV. ARNIOCERAS Hyatt.

Very similar to preceding, differing mainly in the young. Discoidal, with quadragonal whorl; costæ prominent, thin, sharp, straight and smooth; geniculations abrupt, on the level with the venter; first three or four whorls smooth, followed by lateral folds, which later develop into costæ, and a median angular ridge, which later develops into a keel; section of young whorl ovoid, higher than wide. Jurassic.

307. **A. nevadanum** (Gabb). Jurassic.

Large, but slightly embracing; whorls slowly and regularly enlarging; costæ round, somewhat more distinctly separated than their width; curving slightly near venter, where they are united by a continuous ridge; ventral grooves wider than keel; section quadrate, the whorls higher than wide; superior lateral lobe bifurcate.

Lower Lias of Nevada.

308. **A. humboldti** Hyatt. Jurassic.

Costæ higher than in preceding; whorls much higher than wide.

Lias of Humboldt County, Nevada, and Inyo County, California.

CXXXVI. Oppelia Waagen.

Discoidal and highly involute ammonites, with living chamber rounded on venter, the earlier parts acute; sides with weak ribs; lobes asymmetrically divided. Jurassic–Comanchic.

309. **O.(?) fallax** Castillo and Aguilera. (Fig. 1440.) Jurassic.
Compressed, with small but deep umbilicus; greatest thickening of shell at umbilicus; surface smooth.
Malone formation of Texas, also Mexico.

CXXXVII. Œcotraustes Waagen.

Differs from the preceding in the distinct geniculation of the ribs, with a median depressed line connecting the angles. Jurassic.

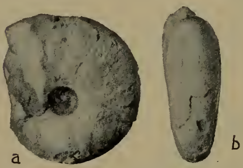

Fig. 1440. *Oppelia* (*?*) *fallax*, young shell, $\times \frac{2}{3}$. (After Cragin.)

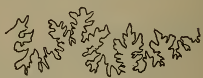

Fig. 1441. *Macrocephalites epigonus*, suture. (After Burckhardt.)

310. **O. denticulata** Hyatt. Jurassic.
Smooth and denticulated; suture with short abdominal lobe, large siphonal saddle, large first lateral lobes, with three long slender terminal lobes.
Mariposa slates of California.

Dactylioida.

CXXXVIII. Macrocephalites Sutner.

Strongly involute shells with rounded sides and venter, small umbilicus, and surface ornamented by numerous slightly flexuous, bifurcating ribs which pass across the venter; sutures very complex, with lobes and saddles about equal in breadth. Jurassic.

311. **M. epigonus** Burckhardt. (Fig. 1441.) Jurassic.
Height and width of whorls nearly equal; strongly involute, with narrow, deep umbilicus in the younger whorls; ribs rather coarse, but becoming obsolete towards the umbilicus.
Kimeridgean of Sierra Santa Rosa, Mexico.

CXXXIX. Cardioceras Neumayr and Uhlig.

Involute ammonites with angular venter and more or less triangular section, and moderate but deep umbilicus; a strong ventral keel corded by fine, multiple ribs, and more or less prominent, frequently bifurcating sigmoid ribs characterize the surface; suture with broad lobes and saddles, much incised; the siphonal saddle broad, the antisiphonal lobe singly pointed. Jurassic.

312. **C. cordiformis** M. and H. (Fig. 1442.) Jurassic.

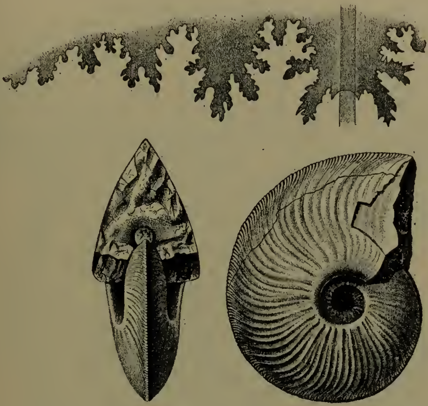

Fig. 1442. *Cardioceras cordiformis*, × ⅔, septum enlarged. (After Whitfield, Pal. Blk. Hills.)

Ventricose, with sides nearly flat and umbilical shoulder abrupt, less than 90°; ribs divide near umbilicus and again into numerous divisions near keel.

Upper Jurassic of Black Hills.

CXL. Perisphinctes Waagen.

Discoidal, scarcely involute, and widely umbilicated ammonites with rounded venter and mostly flattened sides; ribs strong, bifurcating and trifurcating near venter, which they cross uninterruptedly; intercalations may replace the bifurcations; suture finely incised; siphonal and first lateral lobe large; second lateral lobe small; inner parts of suture steeply inclined apicad, with a long pair of first dorsal saddles, usually two additional pairs of saddles, and two pairs of lobes. Jurassic–Cretacic.

313. **P. mclachlani** Burckhardt. Jurassic.

Ribs bifurcate, rarely one remains single; whorls slightly wider than high.

Kimeridgean of Mazapil, Mexico.

314. **P. nikitini** Michalski. Jurassic.

Transverse section of last whorls nearly circular; ribs similar to preceding, rather coarser and more irregular.

Portlandian of Mexico; Lower Volgien of Central Russia.

315. **P. mazapilensis** Castillo and Aguilera. Jurassic.

Higher than wide; sides flattened; costæ bifurcating and occasionally trifurcating, when the branches on opposite sides do not regularly correspond.

Upper Jurassic of San Luis Potosi, Zacatecas and Durango, Mexico.

316. **P. felixi** Castillo and Aguilera. (Fig. 1443.) Jurassic.

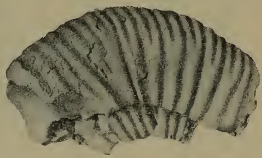

FIG. 1443. *Perisphinctes felixi*, fragment, × ⅔.

Height and breadth of whorls nearly equal, narrowing towards venter; involution from one half to one third; costæ heavy, bifurcating, more rarely trifurcating at about the middle, sometimes uniting at the umbilical margin, curving forward and making an obtuse angle at the median line.

Malone formation of Texas, Tithonian of San Luis Potosi, Mexico.

317. **P. virgulatiformis** Hyatt. Jurassic.

Strongly involute, embracing about one third; inner whorls discoidal, outer whorls broaden rapidly; bifurcation of costæ irregular.

Mariposa formation of California.

318. **P. colfaxi** Gabb. Jurassic.

Discoidal, scarcely embracing, increasing very slowly in diameter; sides somewhat compressed; in neanic stage every second alternate rib bifurcates, generally at about the middle of the side, but it may vary from near umbilicus to ventral border; sometimes several single costæ occur together.

Upper Jurassic (Goldbelt slates) of California.

319. **P. skidegatensis** Whiteaves. (Figs. 1444, 1445.) Comanchic.

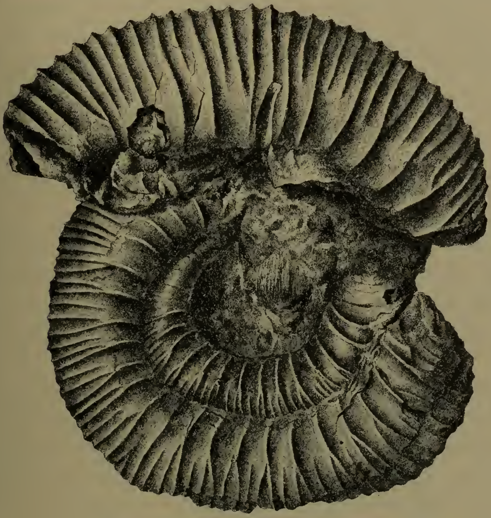

FIG. 1444. *Perisphinctes skidegatensis*, $\times \frac{1}{2}$. (After Whiteaves, Mes. Foss., I.)

Similar to the preceding, but with the single costæ not extending to the umbilicus.

Queen Charlotte formation of Queen Charlotte Islands, Canada.

CXLI. IDOCERAS Burckhardt.

Differs from *Perisphinctes* in having the costæ bending forward along the median ventral line, where they become faint or obsolete, a smooth band remaining; suture very simple, characterized by the predominance of the first lateral lobe. Jurassic.

320. **I. laxevolutum** (Fontannes). Jurassic.

Sides flattened; costæ bifurcating, rarely trifurcating, with intercalated single costæ; ventral interruption slight, the ends of the costæ sometimes overlapping, sometimes continuous.

Kimeridgian of Sierra de la Caja, Mexico; also Europe.

321. **I. baldarum** (Oppel). Jurassic.

Larger than preceding, more compressed laterally, ribs somewhat narrower, but in general character and in the ventral interruption much like the preceding.

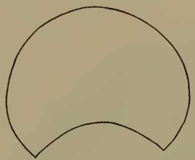

FIG. 1445. *Perisphinctes skidegatensis*, section, × ½. (After Whiteaves.)

FIG. 1446. *Aspidoceras acanthicum*, suture. (After Burckhardt.)

Kimeridgian of Santa Rosa, Mexico, and of Europe.

CXLII. ASPIDOCERAS Zittel.

Discoidal ammonites, with large umbilicus, and more or less flatly rounded venter; early whorls costate, later ones with two rows of tubercles at the ends of the costæ which do not extend across the venter; suture with broad lobes and saddles, not strongly incised. Upper Jurassic.

322. **A. acanthicum** (Oppel). (Fig. 1446.) Jurassic.

Large, with strongly rounded, smooth venter; costæ fine, numerous; umbilicus large, deep; a series of tubercles on the umbilical border; outer row of tubercles wanting on the last two whorls.

Kimeridgian of Mexico.

323. **A. bispinosum** (Quenstedt). Jurassic.

With two rows of spinous tubercles on the side, those of the umbilical row smaller and more crowded.

Kimeridgian of Sierra de la Caja, Mexico; White Jura of Suabia.

324. **A. avellanoides** Uhlig. Jurassic.

Small, subglobular; whorls broad, strongly embracing; umbilicus rather small, but deep; a row of small, crowded tubercles at umbilical margin, absent from outer margin; feeble undulations and irregular striations characterize the shell surface.

Kimeridgian of Sierra de Santa Rosa, Mexico; Spiti shales of Himalayas.

325. **A. alamitocense** Castillo and Aguilera. Jurassic.

Very large, the ribs obsolete or represented by faint wrinkles, outer row of tubercles about the middle of the body whorl.

Tithonian of San Luis Potosi, Mexico; Malone formation of Texas.

MORPHOCERATIDA.

CXLIII. OLCOSTEPHANUS Neumayr.

Differs from *Perisphinctes* in the higher whorls, and generally smaller umbilicus, ribs dividing near umbilical angulation and continuing as bundles across the rounded venter; they mostly lack the regularity and precision of those of *Perisphinctes;* suture strongly incised. Upper Jurassic–Cretacic.

326. **O. (Simbirskites) mutabilis** Stanton. (Fig. 1447.) Comanchic.

FIG. 1447. *Olcostephanus* (*Simbirskites*) *mutabilis*, × ⅔, with suture. (After Stanton.)

Comparatively small, with small umbilicus and much compressed whorls; costæ numerous, but irregular, generally dividing into two to four, rarely five branches at about the middle of the side, and curving forward at the venter.

Knoxville of California.

327. **O. loganianus** Whiteaves. (Fig. 1448.) Comanchic.

Whorls embracing about one half, or to the line of division of costæ, mostly broader than high; tubercles at point of division of ribs near the middle of the whorls; primary ribs bifurcate or trifurcate with intercalated demicostæ.

Queen Charlotte formation of Queen Charlotte Islands (Div. C).

FIG. 1448. *Olcostephanus loganianus*, × ⅔. (After Whiteaves, Mes. Foss., I.)

328. **O. traski** Gabb. (Figs. 1449, 1450.) Comanchic.

Differs from the preceding in having the costæ less definite and the divisions near the umbilical margin.

Horsetown of California, etc.

CXLIV. VIRGATITES Pavlow and Lampl.

Form of whorl as in *Olcostephanus*, but ribs like those of *Perisphinctes*, dividing on the side so as to cross the venter in triplicate or quadruplicate. Jurassic.

329. **V. mexicanus** Burckhardt. Jurassic.

Costæ sharp, bifurcating near the middle of the sides, with an occasional intercalated costa which dies away part way down or unites with the primary ones; on last whorl the primary costæ are

FIG. 1449. *Olcostephanus traski*, two thirds natural size. (After Gabb.)

widely separated by concave spaces, and the shorter ones do not all unite with them.

Portlandian of Canyon de San Matias, Santa Rosa, Mexico.

CXLV. AULACOSTEPHANUS Sutner and Pomp.

Similar to preceding, but division of costæ takes place at ventrolateral angles and they cross the venter only in the coronate young, when section is trapezoidal; venter of adult with smooth, median band; suture similar to the preceding; differs from *Idoceras* in characters of the young shell and in the suture. Jurassic.

330. **A. zacatecanum** Burckhardt. Jurassic.

Venter flatly rounded with broad, smooth space; ribs coarse, especially at the umbilicus becoming broad and distinct before trifurcating or quadrifurcating near ventral margin; in last part of last whorl they become obsolete; umbilicus large, deep.

Kimeridgian of Santa Rosa, Mexico.

CXLVI. HOPLITES Neumayr.

Discoidal, involute shells; costæ bifurcating on sides at umbilical shoulders, generally with tubercles at bifurcation and ends of branches, the latter separated by median, ventral channel; suture complex; lateral saddles narrow and deeply cut, the first often trifid; dorsal series with two pairs of complex zygous lobes and saddles, separated by complex, narrow, antisiphonal lobe. Jurassic–Cretacic.

331. **H. vancouverensis** (Meek). Cretacic.

Section of whorls triangular; umbilical angles abrupt; ventral nodes narrow, elongate, close; median depression moderate;

FIG. 1450. *Olcostephanus traski*, suture. (After Gabb.)

FIG. 1451. *Stoliczkaia remondii*, suture. (After Gabb.)

ribs faint, narrow, alternating, the longer tubercled near umbilicus.

Nanaimo group of Vancouver.

CXLVII. STOLICZKAIA Neumayr.

Like *Hoplites,* but the ribs enlarging outwards, and passing continuously across the rounded venter. Comanchic.

332. **S. texana** (Cragin). Comanchic.

Ribs simple or subnodose at ventral margin, less strongly widening than in preceding, and with broader interspaces; suture very simple.

Washita of Texas.

333. **S. dispar** (d'Orbigny). Comanchic.

Small tubercles on margin of venter; ribs unequally longer and shorter, nodular on venter of body whorl and dividing on sides; body chamber irregularly evolute.

Horsetown of California; Comanchic of Texas; Gault of India, etc.

334. **S. remondii** (Gabb). (Fig. 1451.) Comanchic.

The ribs become coarse towards the venter which they cross continuously; intercalated ribs do not reach umbilicus; saddles of suture broad.

Horsetown of California.

CXLVIII. SONNERATIA Bayle.

Differs from *Hoplites* in the strong ribs which begin with weak umbilical node and extend across the arched or carinated venter. Comanchic.

335. **S. acuto-carinata** (Shumard). Comanchic.

Strongly involute, sharply carinated; keel smooth, sharp; sides flat; 30–34 flexuous ribs on last whorl, alternating in length and widening to within short distance of dorsal border where they are again somewhat contracted; aperture elongate and cordate.

Fredericksburg of Texas, etc.; also South America.

336. **S. stantoni** Anderson. Comanchic.

Small (3.5 cm. ±); sides flattened and gently converging to rounded or subquadrate venter; umbilicus less than one third total diameter, funnelform; ribs begin with distinct umbilical tubercle, divide almost at once, gently sigmoid, and become more prominent and wider near outer margin where they bend distinctly forward.

Upper Horsetown of California, common.

ACANTHOCERATIDA.

CXLIX. LYTICOCERAS Hyatt.

Like *Hoplites* but the nodes weak or absent, venter flat without furrow, the ribs more or less fading; lateral lappets well developed. Comanchic.

337. **L. hyatti** (Stanton). (Fig. 1452.) Comanchic.

Sides flat; umbilicus large; ribs somewhat flexuous, mostly bifurcating, sometimes simple, continued faintly across the venter which is flat, except in last senile portion of whorl where ribs also become obsolete.

Knoxville of Oregon.

338. **L. angulatus** (Stanton). (Fig. 1453.) Comanchic.

Small; umbilical angle abrupt; sides flat; venter flat or slightly depressed; ribs scarcely crossing venter, often somewhat nodose at ventral margin.

Knoxville of California.

CL. ACANTHOCERAS Neumayr.

Ammonites with the young discoidal, non-tuberculate, and section rounded till late neanic stage; adult with straight, simple, or

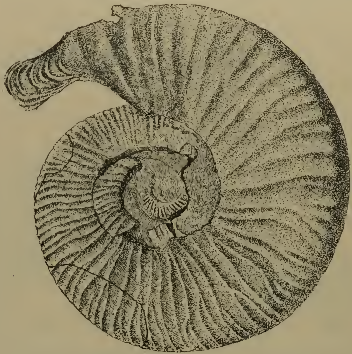

FIG. 1452. *Lyticoceras hyatti*, × ⅔. (After Stanton.)

bifurcating ribs, thickening outwards with lateral and marginal tubercles; venter with median row of tubercles; suture deeply cut; first lateral saddle broad and bifid; ventral lobe straight and deep, with truncated siphonal saddle. Comanchic–Cretacic.

FIG. 1453. *Lyticoceras angulatus*, × ⅔. (After Stanton.)

339. **A.(?) justinæ** Hill. Comanchic.

Discoidal, thin and flattened; umbilicus large; ribs numerous with intercalated shorter ones; venter oblately rounded.

Trinity beds of Texas.

MANTELLICERATIDA.

CLI. DOUVILLEICERAS Grossouvre.

Ammonites, with the young shell discoidal, and more or less sharply costate, with two or three rows of large tubercles on each side of the non-costate venter; costæ remain single or bifurcate, and in later stages cross the venter; the nodes may disappear in old age, but in typical forms are retained; median ventral furrow, if present, is weak and interrupted by the costæ; external saddle large, stronger and longer than the first lateral ones; lateral lobes pointed. Comanchic–Cretacic.

340. **D. spiniferum** Whiteaves. (Figs. 1454, 1455.) Comanchic.

Immature shells with sharp ribs bearing two or three rows of sharp nodes on either side of median ventral depression, and a

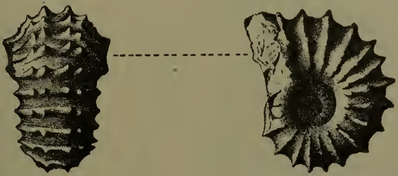

FIG. 1454. *Douvilleiceras spiniferum*, immature individual. (After Whiteaves, Mes. Foss., I.)

similar number of nodes on lateral and umbilical portion, the two sets being separated by broad depressions. Adult with spines weaker or obsolete, the ribs increasing mainly by intercalations of two shorter ones and becoming broader towards the venter.

Queen Charlotte formation of Queen Charlotte Islands; also Horsetown and Lower Chico of California; also (?) Eagle Ford formation of Texas.

This species has been regarded by some as identical with *D. mamillare* Schloth of the European Gault.

341. **D. stolitzkanum** Gabb. (Fig. 1456.) Comanchic.

Ribs alternating in size, covering the venter uninterruptedly; tubercles not well defined, mainly shown on the coarser ribs; they occur in three rows on each side of the slightly depressed venter and decrease towards the umbilicus, the larger ones are flattened in the direction of the costæ.

Shasta of California.

CLII. METOICOCERAS Hyatt.

Involute shells, laterally compressed and strongly costate; costæ sometimes extending across the more or less depressed or grooved

FIG. 1455. *Douvilleiceras spiniferum*, × $\frac{4}{9}$. (After Whiteaves, Mes. Foss., I.)

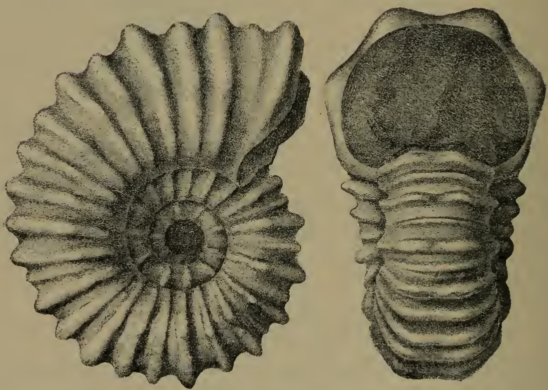

FIG. 1456. *Douvilleiceras stolitzkanum*, × ⅔. (After Gabb.)

venter, the margins of which are tuberculated. Sutures with a rather ragged appearance, the first lateral saddle bifid, the first lobe deeper and larger than the others. Young coronate, with large lateral tubercles. Cretacic.

342. **M. swallovi** (Shumard). (Fig. 1457, *a, b*.) Cretacic.

Umbilicus moderate; ribs frequently bifurcating near umbilicus;

FIG. 1457. *a, b, Metoicoceras swallovi*, × ½, and suture; *c–e, M. whitei*, two views and suture, × ½. (After Hyatt.)

ventral concavity frequently smooth, bordered by rounded nodes; suture rather simple, the first lateral saddle divided by shallow notch, with three notches on the outer and one on the inner (ventral) margin.

Coloradoan of Texas and Utah.

343. **M. whitei** Hyatt. (Fig. 1457, *c–e*.)

Larger, more compressed, umbilicus smaller, sides flatter, nodes less pronounced, more nearly a part of the ribs; secondary ribs extending only about half way to umbilicus; suture more complex, with deeper and more numerous incisions.

Coloradoan of Texas and Kanab Valley, Utah.

Ancyloceratida.

(A provisional group of phylogerontic genera.)

CLIII. Crioceras Leveille.

Loose coiled, spiral, gerontic ammonites, the coil in a single plane, the whorls not in contact; surface ornamented by ribs and two (typically) or three rows of nodes or spines on either side of median line of venter, which latter is smooth or costate. Comanchic–Cretacic.

344. **C. latum** Gabb. (Fig. 1458.) Comanchic.

Fig. 1458. *Crioceras latum*, $\times \frac{8}{15}$. (After Gabb.)

Principal ribs strong, rounded, and bearing spines in the young, and three rows of blunt nodes in the adult; between them are about three finer and lower ribs without tubercles or spines.

Knoxville and Lower Horsetown of California.

345. **C. percostatum** Gabb. Comanchic.

Large, with subquadrate whorls, very nearly in contact; surface with simple or dichotomous ribs, small and numerous in young, fewer and large on adult, with broad interspaces, crossing the venter.

Knoxville and Horsetown of California.

CLIV. Ancyloceras d'Orbigny.

Like *Crioceras* in the young stage, but generally continuing straight in the adult, with a final crook at the end. In typical forms three rows of tubercles occur on the principal costæ, but other species at present referred here, though belonging to a distinct genetic series, have only smooth costæ. Comanchic–Cretacic.

346. **A. remondii** Gabb. (Figs. 1459, 1460.) Comanchic.

Compressed, more than twice as high as wide; venter rounded,

Fig. 1459. *Ancyloceras remondii*, × ⅔. (After Gabb.)

Fig. 1460. *Ancyloceras remondii*, suture. (After Gabb.)

somewhat narrower than dorsum which is flat or even concave; ribs fine, numerous, often dichotomous, flexuous and often extending across the venter; rarely with ventral spines.

Horsetown of California, and Queen Charlotte Islands.

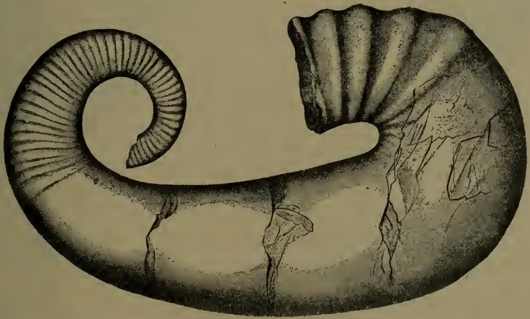

Fig. 1461. *Ancyloceras percostatum*, $\frac{1}{5}$ nat. size. (After Gabb.)

347. **A. percostatum** Gabb. (Fig. 1461.) Comanchic.

Very large (about 1½ ft. long), the early stages loosely coiled into a spiral, the straight portion rapidly enlarging; internal mold finely costate in the young, smooth in the subquadrate adult, but with a few coarse ribs in the final crook.

Horsetown of California.

CLV. HAMITES Parkinson.

Gerontic ammonoids which have lost the power of coiling, though curving two or three times through an angle of 180°; costæ are continuous all around, and tubercles are absent; suture with first lateral lobe divided in two, and saddles strongly bifid. Comanchic–Cretacic.

348. **H. fremonti** Marcou. (Fig. 1462.) Comanchic.

FIG. 1462. *Hamites fremonti*, × ⅔. (After Hill.)

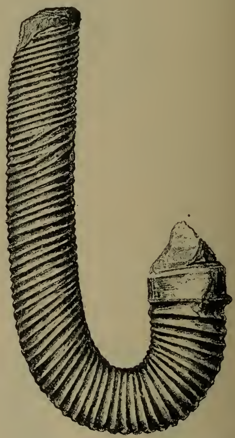

FIG. 1463. *Hamites obstrictus*. (After Whiteaves, Mes. Foss.)

Costæ rather coarse, with a suspicion of tuberculation on the ventral margin, becoming faint or obsolete towards the dorsum.

Washita of Oklahoma and Texas.

349. **H. obstrictus** Jimbo. (Fig. 1463.) Cretacic.

Smaller, with more numerous and crowded, sharper ribs, separated by wider concave interspaces and scarcely enlarging towards the venter.

Nanaimo of Sucia and Hornby Islands, British Columbia; also Japan.

CLVI. PTYCHOCERAS d'Orbigny.

Similar to *Hamites,* but the straight limbs in contact, or impressed upon one another, the ribs smooth or tuberculated; suture

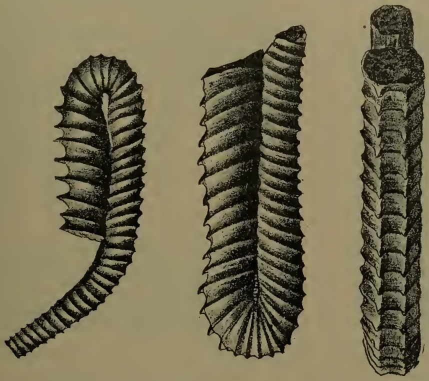

FIG. 1464. *a*, *Ptychoceras meekanum*, lateral view, and *b*, *c*, *P.* (*Oxybeloceras*) *crassum*, lateral and dorsal views. (After Whitfield.)

much simpler than that of *Hamites* and suggesting a closer relationship to *Baculites*. Comanchic-Cretacic.

350. **P. (Oxybeloceras) crassum** Whitfield. (Figs. 1464, *b, c*; 1466.) Cretacic.

Ribs distant, sharp, oblique, ending in spinous nodes on either side of a broad, concave, ventral groove; whorls slightly impressed.

Pierre of Black Hills.

351. **P. meekanum** Whitfield. (Figs. 1464, *a*; 1465.) Cretacic.

Of somewhat oblate, transverse section, smaller than preceding,

FIG. 1465. *a*, *Ptychoceras meekanum*, × 2.

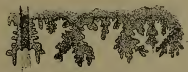

FIG. 1466. *Ptychoceras* (*Oxybeloceras*) *crassum*, × 2.

less robust; with less distant and less complicated septa; young portion often strongly bent, making an angle of 135° with middle part; venter gently concave, lined by nodes.

Pierre of Black Hills.

352. **P. glaber** Whiteaves. (*Hamites*(?) *glaber*.) Comanchic.

Section elliptical or ovate, siphonal edge slightly narrower than antisiphonal; surface smooth except for oblique constrictions at

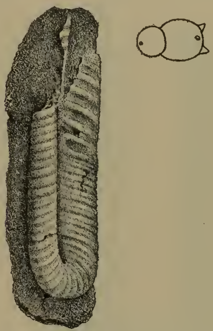

FIG. 1467. *Ptychoceras mortoni*, and cross section, × 2.

FIG. 1468. *Ptychoceras mortoni*, suture enlarged. (After Meek.)

distant intervals; septum with three nearly equal saddles on each side, and two divided lobes; siphonal lobe strong.

Queen Charlotte group of Queen Charlotte Islands, also India.

353. **P. mortoni.** (Figs. 1467, 1468.) Cretacic.

Small; outer limb impressed over inner; costæ thick and crowded, except in last portion; tubercles on ventral margin of larger limb.

Pierre of the Upper Missouri Country.

CLVII. HELICANCYCLUS Gabb. (=(?) *Lindigia* Karsten).

Whorls in contact in early part, and growing in a low, asymmetrical spiral. The ribs are marked by three rows of tubercles on either side of the venter, as in typical *Ancyloceras* to which it appears to be related. Gerontic stages of a loose ptychoceran form, with recurved crook. Cretacic.

354. **H. æquicostatus** Gabb. (*Lindigia* (?) *nodosum* Anderson.) (Fig. 1469.) Cretacic.

Ribs strong, oblique, separated by wide, concave spaces, with only growth lines; nodes strong, rounded; spire not rising above

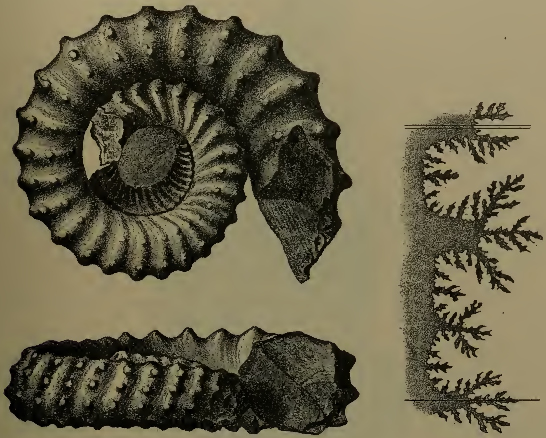

FIG. 1469. *Helicancyclus æquicostatus*, top and side views of spiral of a small individual and suture enlarged. (After Gabb.)

the plane of the outer whorl. Ptychoceran stage, with ribs straight, broader and similarly noded.

Chico of California.

CLVIII. HELICOCERAS d'Orbigny.

Ammonoids coiled in a loose, turrilitoid spiral (generally right-handed) ornamented by costæ and nodes; the earliest stages are generally ptychoceran, and the final stages have the retroversal bend of *Hamites*. Cretacic.

355. **H. stevensoni** (Whitfield). (Figs. 1470, 1471.) Cretacic.

Coiled whorls round, scarcely in contact, with regular, rounded ribs, every other one ornamented by a low node; a second row of nodes in the last whorl around the open umbilicus.

Pierre of the Black Hills.

356. **H. simplicostatum** (Whitfield). (Fig. 1472.) Cretacic.

Spiral much looser than in preceding; ribs more numerous, sharper and separated by concave interspaces; tuberculated in old

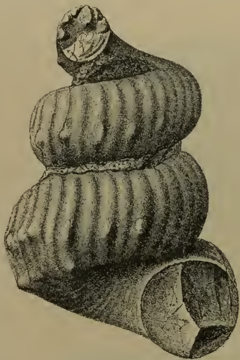

FIG. 1470. *Helicoceras stevensoni*, × ⅔. (After Whitfield, Pal. Blk. Hills.)

age; section circular except last part. (For a full description and illustration of this remarkable form and its ptychoceran stage,

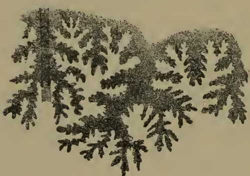

FIG. 1471. *Helicoceras stevensoni*, suture enlarged, × $\frac{4}{8}$. (After Whitfield, Pal. Blk. Hills.)

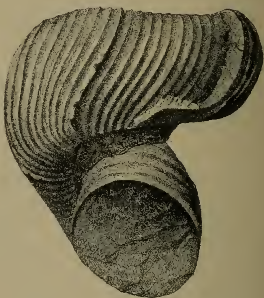

FIG. 1472. *Helicoceras simplicostatum*, × ⅔, fragment. (After Whitfield, Pal. Blk. Hills.)

see Whitfield, Bull. Am. Museum of Natural History, Vol. 16, pp. 68–72, pls. 23–27.)

Benton group of Black Hills, etc.

357. **H. (Bostrychoceras) elongatum** Whiteaves. (Fig. 1473.) Cretacic.

Sinistral (left-handed) or dextral coil of round whorls in con-

FIG. 1473. *Helicoceras elongatum.* (After Whiteaves, Mes. Foss., I.)

tact, with narrow umbilicus, sharp, simple ribs, and wide, concave interspaces but no nodes; last portion loose.

Nanaimo of Vancouver.

CLIX. EXITELOCERAS Hyatt.

Helicoceran shells of low spire, with costæ and two rows of tubercles, each costa being tuberculated; suture varying in complexity; gerontic stage probably with retroversal living chamber. Cretacic.

358. **E. jenneyi** (Whitfield). (Fig. 1474.) Cretacic.

Spiral coil low, ribbed, adult departing more strongly from spiral curve; costæ sharp, distant, with occasionally shorter ones intercalated; nodes in a continuous row on each side of depressed venter; suture complex.

Pierre group of the Black Hills.

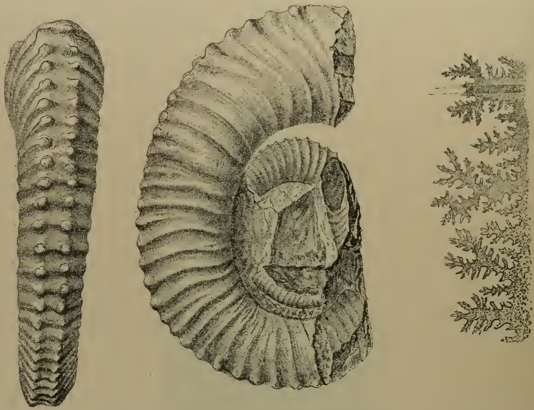

FIG. 1474. *Exiteloceras jenneyi*, $\times \frac{2}{3}$, and suture, $\times \frac{4}{3}$. (After Whitfield.)

359. **E. pariense** (White). (Fig. 1475.) Cretacic.

Very loose helicoid spire in young, with whorls separated by more or less than their diameter; costæ sharply rounded, oblique, more than their width apart; a row of tubercles on each side of

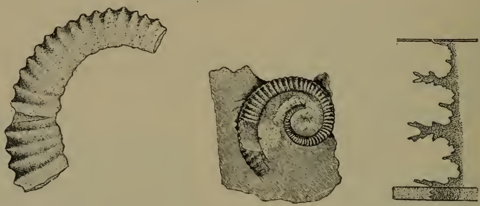

FIG. 1475. *Exiteloceras pariense*, entire shell, $\times$ 2/3, and fragment and suture enlarged. (After Stanton.)

siphuncle, one to a rib, subspinous when well preserved, but variable; lobes of sutures all smaller than saddles.

Coloradoan of Upper Kanab, Utah.

CLX. HETEROCERAS d'Orbigny.

A more or less composite group of phylogerontic ammonites, with helicoceran young, but loose, and generally irregularly coiled adult and old age; the final portion generally straight or with a final crook; ornamentation by costæ and often by nodes. Cretacic.

360. **H. (Didymoceras) newtoni** Whitfield. (Fig. 1476.) Cretacic.

Helicoceran portion low, with simple and bifurcating costæ, and

FIG. 1476. *Heteroceras* (*Didymoceras*) *newtoni*, helicoceran fragment, × $\frac{2}{3}$, and septum, × $\frac{4}{3}$.

two rows of tubercles, one just above the line of contact of the whorls.

Pierre of the Black Hills.

361. **H. (Didymoceras) tortum** (M. and H.). (Figs. 1477–1479.) Cretacic.

Large, volutions nearly doubling in diameter with each turn,

FIG. 1477. *Heteroceras* (*Didymoceras*) *tortum*, peripheral view of a fragment (type). (After Meek.)

disconnected, with umbilicus less than diameter of largest volution; surface with two rows of rather depressed nodes, passing around below middle of outer side, and smaller annular costæ sometimes bifurcating at nodes.

Pierre group, near Fort Pierre, Dakota.

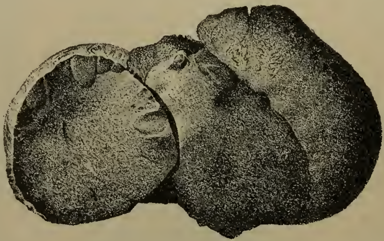

FIG. 1478. *Heteroceras* (*Didymoceras*) *tortum*, opposite view of specimen, Fig. 1477. (After Meek.)

362. **H. conradi** Morton. (Fig. 1480.) Cretacic.

Mostly U-shaped fragments; more or less subcircular in section, or compressed in one direction; ribs sharply angular; a double row of more or less strongly developed nodes, either lateral in

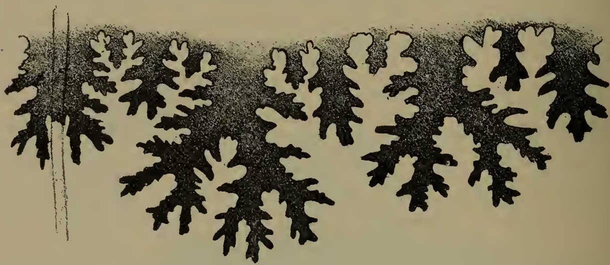

FIG. 1479. *Heteroceras* (*Didymoceras*) *tortum*, suture enlarged. (After Meek.)

position or upon outer side of U-shaped tube; ribs often obsolescent between nodes.

Ripleyan (Navesink) of New Jersey.

CLXI. ANISOCERAS Pictet.

Young shells helicoceran followed by long, straight (toxoceran) portion; costæ often bifurcating, simple or with two rows of tubercles; gerontic stage with retroversal crook. Cretacic.

FIG. 1480. *Heteroceras conradi*, terminal fragment. (After Whitfield, Pal. N. J., II.)

363. **A. subcompressum** (Forbes). (Fig. 1481.) Cretacic.

Oval in section with only the earliest whorls close coiled, the

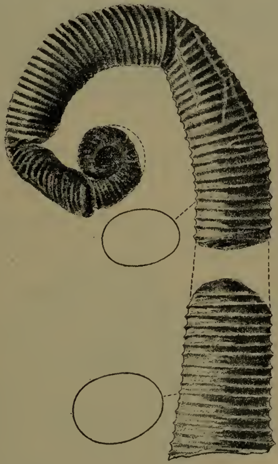

FIG. 1481. *Anisoceras subcompressum*, × ⅔, with outlines of cross sections. (After Whiteaves, Mes. Foss., I.)

later crioceran, and finally straight; costæ sharp, with wider concave interspaces, occasionally bifurcating.

Nanaimo of Vancouver.

364. **A. cooperi** Gabb. (Fig. 1482.) Cretacic.

Larger and coarser than preceding, ribs more irregular, fre-

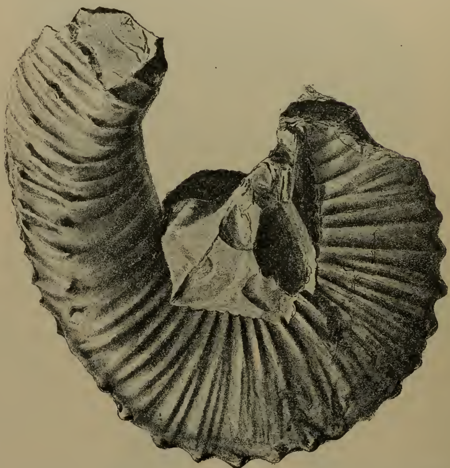

FIG. 1482. *Anisoceras cooperi*, fragments, × ⅔. (After Whiteaves, Mes. Foss., I.)

quently bifurcating or even trifurcating, with irregular rows of nodes.

Chico of California, and Nanaimo of Vancouver.

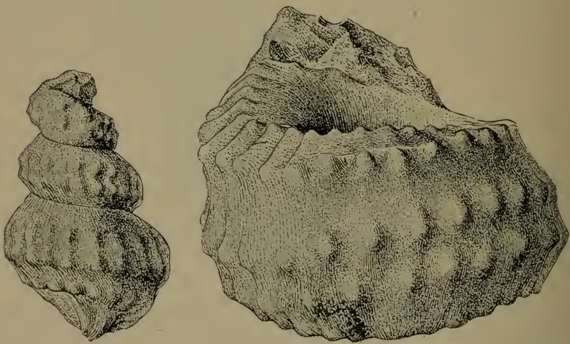

FIG. 1483. *Turrilites brazoënsis*, apical and adult whorls. (After Hill.)

CLXII. Turrilites Lamarck.

High-spired cones (turriliticones) with more or less angulated volutions, in contact throughout or with only slight loose coiling in old age; costæ and two rows of tubercles on each side of median line of whorls; the costæ often obsolete in old age and only three rows of nodes. Comanchic–Cretacic.

365. **T. brazoënsis** Roemer. (Fig. 1483.) Comanchic.

Costæ weak; nodes strong, whorls with two revolving noded angulations, with flat interspaces.

Washita of Texas, etc.

366. **T. carlottensis** Whiteaves. Comanchic.

Large, narrowly elongate, usually sinistral, with widely sepa-

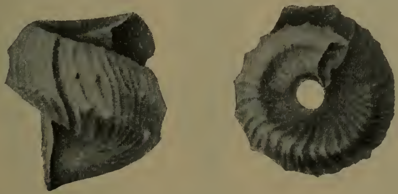

Fig. 1484. *Turrilites pauper*, lateral and summit view of a fragment. (After Whitfield, Pal. N. J., II.)

rated volutions, slightly compressed, of broadly subovate or almost circular section; ribs small, close set, numerous; tubercles at more or less distant intervals.

Queen Charlotte formation of Queen Charlotte Islands.

367. **T. pauper** Whitfield. (Figs. 1484, 1485.) Cretacic.

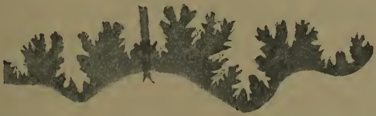

Fig. 1485. *Turrilites pauper*, septum, × 2. (After Whitfield, Pal. N. J., II.)

Similar to preceding, but costæ strong and sharp, and nodes small or nearly obsolete.

Ripleyan of New Jersey.

Placenticeratida.

CLXIII. Protengonoceras Hyatt.

Compressed shells, like *Engonoceras,* with venter deeply concave and bordered by sharp, smooth ridges; surface smooth, except in gerontic stages when folds appear; suture simple, ceratitic, with broad, flat saddles, and few marginals in the lobes. Comanchic–Cretacic.

368. **P. gabbi** (Böhm). (Fig. 1486.) Comanchic.

Smooth, sides gently arched, slightly concave near venter; ven-

Fig. 1486. *Protengonoceras gabbi : a*, ventral, *b*, section views, × ⅔, and *c*, suture. (After Hyatt.)

tral groove broad and deep; saddles low and broad; lobes with three or four short marginals.

Fredericksburg of Sonora, Mexico.

CLXIV. Engonoceras Neumayr.

Compressed shells, generally ornamented by nodose or fold-like costæ, which are often mere swellings; venter flat or concave; umbilicus small or absent; sutures very simple (through retardation), ceratitiform, with numerous saddles and narrow lobes which sometimes have numerous marginals or notches at the base; young like adult of *Protengonoceras*. Comanchic.

369. **E. gibbosum** Hyatt. (Fig. 1487, *d–f*.) Comanchic.

Venter flat, and rather broad, bordered by elongate, alternating nodes; a second row of obscure nodes occurs in the middle of the side and a third at the umbilical border; suture with more strongly incised lobes than in preceding.

Fredericksburg beds, Texas.

370. **E. stolleyi** (Böhm). (Fig. 1487, *i–k*.) Comanchic.

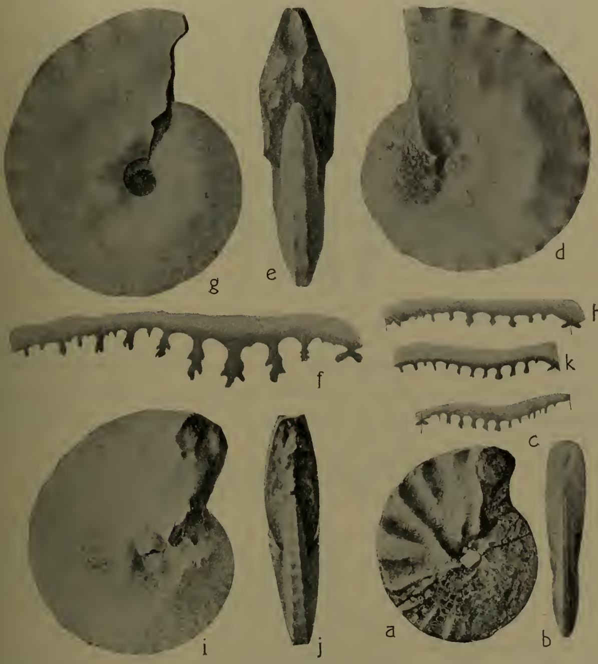

FIG. 1487. *a–c*, *Engonoceras serpentinum*, × ½, and suture; *d–f*, *E. gibbosum*, two views, × ½, and suture; *g*, *h*, *E. pierdenale*, side view, × ½, and suture; *i–k*, *E. stolleyi*, two views, × ½, and suture. (After Hyatt.)

Venter slightly concave, bordered by elongate, alternating nodes; lateral nodes very faint; young costate; suture very simple.

Fredericksburg (?) of Texas.

371. **E. pierdenale** (von Buch.). (*E. pedernalis* Böhm.) (Fig. 1487, *g, h*.) Comanchic.

Similar to *E. gibbosum*, but suture much simpler.

Fredericksburg of Texas.

372. **E. belviderense** (Cragin). Comanchic.
Sides and venter flat and smooth, with nodes on umbilical shoulders and alternating nodes on each side of the ventral flattening.
Champion shell bed and Kiowa shale, basal Washita, Kansas.

373. **E. serpentinum** (Cragin). (Fig. 1487, *a–c*.) Comanchic.
Smaller than preceding, with slightly concave venter bordered by two ridges, and coarse, alternating ribs instead of nodes, though the latter may appear in gerontic individuals; suture very simple.
Upper Washita (Denison) of Texas.

374. **E. hilli** Böhm. (Fig. 1488.) Cretacic.

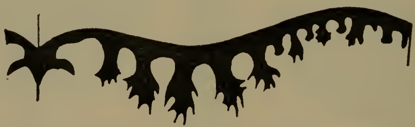

FIG. 1488. *Engonoceras hilli*, suture line. (After Lasswitz.)

Narrowly umbilicate; sides gently convex, converging to the flat venter, which is bounded on each side by a low ridge; surface smooth; suture more complicated than most species of the genus.
Austin chalk of Texas.

CLXV. METENGONOCERAS Hyatt.

Like *Engonoceras* but with grooved venter (*Protengonoceras* stage) only in the very young, the adult acute and rounded in the old-age stage; saddles numerous, phylliform; lobes narrow, with several marginals. Comanchic–Cretacic.

375. **M. dumblii** (Cragin). (Fig. 1489.) Cretacic.
Last portion of last whorl narrowly rounded, sides gently arching; marginal notches of lobes long and slender.
Eagle Ford shales (Coloradoan) of Texas.

CLXVI. SPHENODISCUS Meek.

Adult much like *Metengonoceras,* but young without the grooved venter, the rounded nepionic venter passing directly into an acute neanic, with flattened sides as in the adult; surface smooth or with costæ or tubercles. Cretacic.

FIG. 1489. *Metengonoceras dumblii*, two views and section, × ⅔, and suture enlarged. (After Hyatt.)

376. **S. pleurisepta** (Conrad). (Fig. 1490.) Cretacic.

Last portion of adult whorl rounded; sides with two rows of tubercles, the outer becoming obsolete in old age; first five saddles divided, the depth of the division decreasing; lobes broad, rounded,

FIG. 1490. *Sphenodiscus pleurisepta*, side and end view and sectional view, × ⅔, and suture enlarged. (After Hyatt.)

with six or more notches or marginals in the first three laterals which increase in size; remainder smaller, with smaller notches.

Eagle Ford beds of Texas and Mississippi.

377. **S. lobatus** (Tuomey). Cretacic.

Large, with small umbilicus, without umbilical shoulder, sides more strongly arched than in preceding; surface smooth or with obscure, fold-like costæ; lobes with numerous marginals.

Ripleyan of New Jersey, Alabama and Mississippi.

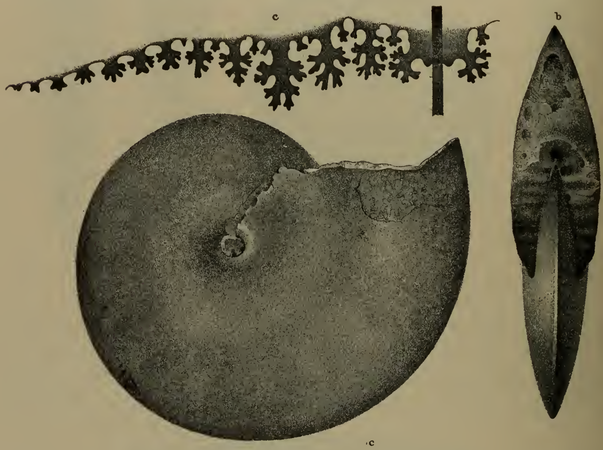

FIG. 1491. *Sphenodiscus lenticularis*, small specimen, with septum of a larger one, all × ⅔. (After Meek.)

378. **S. lenticularis** (Owen). (Fig. 1491.) Cretacic.

Similar to preceding, but venter more acute; saddles and lobes much more strongly incised, the former bifid, trifid and quadrifid.

Fox Hills of South Dakota, Wyoming and New Mexico.

CLXVII. PLACENTICERAS Meek.

Shell similar in form to *Engonoceras,* except in forms transitional to *Stantonoceras,* where the adult whorl becomes rounded. The venter of the young is flat, then concave and bordered by sharp ridges, and subsequently these become tuberculated, though in old age the venter may become smooth, flat, and even rounded; surface smooth or tuberculated; suture complex, of numerous more or less deeply incised lobes and saddles, the third lateral lobe the deepest, after which there is an abrupt decrease. Cretacic.

379. **P. planum** Hyatt. (Fig. 1492, *a.*) Cretacic.

Sides flat, shell broad at umbilicus, sloping to concave venter, rather abruptly rounded to umbilicus; venter bounded by rows of alternating, elongate tubercles; surface smooth or obscurely tubercled.

San Carlos beds, Upper Cretacic, Texas, and Presidio del Norte, Mexico.

380. **P. syrtale** (Morton). (Fig. 1492, *b–d.*)

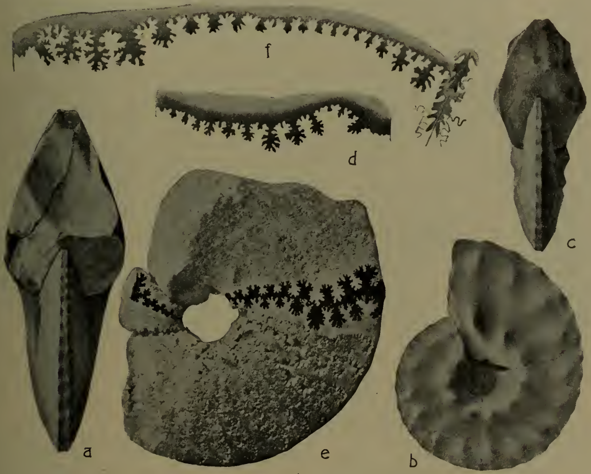

FIG. 1492. *a, Placenticeras planum*, × ½; *b–d, P. syrtale*, two views, × ½, and suture; *e, f, P. placenta*, a fragment, × ½, and suture enlarged. (All after Hyatt.)

Differs from preceding in having two rows of rounded tubercles on the sides, extended somewhat to suggest ribs, and the umbilical border less abruptly rounded.

Eutah of Alabama; Fort Worth limestone and Taylor marl of Texas.

381. **P. placenta** (Dekay). (Fig. 1492, *e, f.*) Cretacic.

Large, with flat venter, smooth sides or rarely tubercled, suture with numerous short lobes and saddles. (Type of the genus.)

Ripleyan of New Jersey and Alabama.

382. **P. whitfieldi** Hyatt. (Figs. 1493, 1494.) Cretacic.

Like preceding, but more involute, venter narrower throughout, and less completely rounded in old age; surface without tubercles; sutures more complicated in young, and more overlapping than in

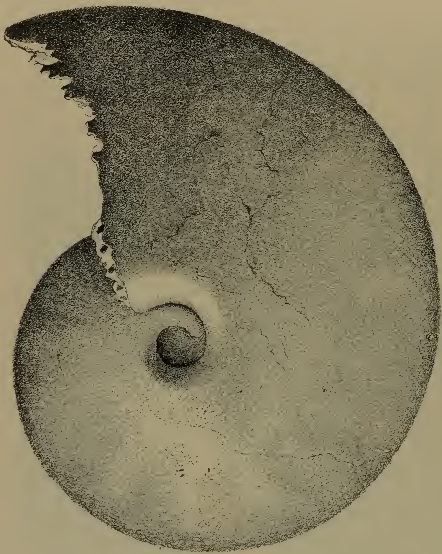

FIG. 1493. *Placenticeras whitfieldi*, a small specimen. (After Meek.)

FIG. 1494. *Placenticeras whitfieldi*, front view of specimen, Fig. 1493. (After Meek.)

P. placenta; saddles almost linear from development of lobes, which are very long and narrow.

Pierre of Nebraska, South Dakota and Colorado.

383. **P. intercalare** Meek. (Fig. 1495.) Cretacic.

With two rows of tubercles as in *P. syrtale,* but more compressed, tubercles smaller, less prominent, and more distant, not suggestive of ribs as in that species; venter narrow, concave, bordered by compressed tubercles in alternating position; suture with deeper and more numerous marginal incisions.

Pierre of Black Hills, etc.

384. **P. stantoni** Hyatt. (Fig. 1496.) Cretacic.

Like *P. whitfieldi*, but with stouter volutions and broader venter; intermediate in character between that species and *P. intercalare;* umbilical shoulder abrupt, with a row of sparse tubercles. In the

FIG. 1495. *Placenticeras intercalare*, and suture, × ¾. (After Meek.)

variety *bolli* Hyatt coarse, fold-like ribs occur at wide intervals, bifurcating occasionally; venter with elongate tubercles which correspond to the costæ when they are present.

Coloradoan of Upper Kanab Valley, Utah.

385. **P. pseudoplacenta** Hyatt. (Fig. 1497.) Cretacic.

Venter broad, flat or rounded in adult, but with *placenta* type of venter in neanic; suture simpler and more ragged than in *P. placenta.*

Coloradoan of Upper Utah; Huerfano Park of Colorado.

385*a*. Variety **occidentale** Hyatt. Cretacic.

Suture more like that of *P. whitfieldi,* but lobes and saddles more solid; a row of tubercles on the umbilical shoulder, and fine tubercles on the ventral borders.

Pierre of Upper Missouri; Bad Lands of South Dakota; Eagle Ford shales of Texas.

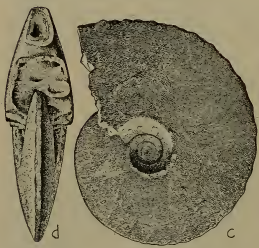

FIG. 1496. *Placenticeras stantoni*, × ½. (After Stanton.)

FIG. 1497. *Placenticeras* (*Stantonoceras ?*) *pseudoplacenta*: *a*, *b*, young "placenta" stage, × ⅔; *c*, section of adult, × ⅔; *d*, earliest whorls much enlarged. (After Hyatt and Smith.)

386. **P. spillmani** Hyatt. (Fig. 1498.) Cretacic.

Broader and stouter than the other species of *Placenticeras*, with rounded venter bearing low tubercles on either side; suture similar to *P. syrtale*.

Ripleyan of New Jersey and Mississippi.

FIG. 1498. *Placenticeras* (*Stantonoceras ?*) *spillmani*, a fragment, × ⅔, and suture. (After Hyatt.)

CLXVIII. Stantonoceras Johnson.

Like *Placenticeras* in the young and in septa, but adult with broad venter; generally strong tubercles, which sometimes become extended into costæ; the genus represents the terminal members of the evolutional line of *Placenticeras*.

387. **S. newberryi** (Hyatt). (Fig. 1499.) Cretacic.

Fig. 1499. *Stantonoceras newberryi*, two views and section, × ½, of the type. (After Hyatt.)

Placenticeras stage continued to beginning of adult; venter becomes broadly rounded; rounded tubercles near margin and near umbilicus, but becoming obsolete in adult and old age; obscure fold-like costæ occur.

Upper Cretacic of Presidio del Norte, Chihuahua, Mexico.

388. **S. guadaloupæ** (Roemer). (Fig. 1500.) Cretacic.

Venter broadly convex, bordered by a line of oblique, large tubercles; a second line of obliquely elongate tubercles on the side.

San Carlos of Texas; Pierre of New Mexico.

389. **S. pseudocostatum** D. W. Johnson. (Fig. 1501.) Cretacic.

Large, final whorl subquadrangular with nearly flat venter and flat sides marked by oblique costæ due to elongation of nodes; shell passes through *Placenticeras* stages and through stage in which it has characteristics of *S. guadaloupæ*. (Type of genus.)

Pierre of New Mexico.

FIG. 1500. *Stantonoceras guadaloupæ* (Roemer), side and end view, and section, × ½ ; also section of young stages (*d*). (After Hyatt.)

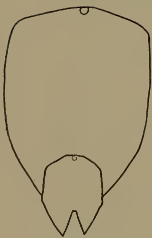

FIG. 1501. *Stantonoceras pseudocostatum*, section, × ½. (After D. W. Johnson.)

FIG. 1502. *Barroisiceras dentatocarinatum.* (After Roemer.)

Mammitida.

CLXIX. Barroisiceras Grossouvre.

Involute shells, laterally compressed, ribbed and tubercled, venter with sharp keel broken into tubercles by crowding of costæ; sometimes in later stages becoming a continuous keel; suture complex, with broad saddles and narrower lobes. Cretacic.

390. **B. dentatocarinatum** (Roemer). (Fig. 1502.) Cretacic.

A row of distant, rounded tubercles surrounds the umbilicus from which the primary costæ bifurcate or trifurcate, while additional costæ appear between the primary, from three to four in each interspace; each costa with a tubercle near venter; keel broken up into sharp, elongate tubercles by crossing of costæ.

Ripleyan of New Jersey; Austin limestone of Texas; Chico of California (= *? Schloenbachia siskiyouensis* Anderson).

CLXX. Schloenbachia Neumayr.

Involute, more or less widely umbilicated; laterally compressed ammonites, costated and with a comparatively broad venter bear-

Fig. 1503. *Schloenbachia leonensis*, × ⅔. (After Hill.)

ing a strong median keel; ribs curved sigmoidally, bending more or less strongly forward near venter. Comanchic–Cretacic.

391. **S. (Gauthiericeras) leonensis** (Conrad). (Fig. 1503.) Comanchic.

Section of final whorl subquadrangular, umbilicus large, ribs strong, marked by two rows of tubercles, one near umbilicus and a larger series near ventral border and becoming obsolete before reaching the strong, rounded keel.

Lower Washita of Texas, etc.

392. **S. inflata** (Sowerby). Comanchic.

Large, of regularly enlarging, very slightly embracing and coarsely costate whorls, the costæ in last whorl more than their width apart, with a coarse node at ventral margin and another just below; keel prominent, scarcely bounded by grooves.

Horsetown of California and British Columbia, and equivalent horizon in Europe, India, etc.

393. **S. belknappi** Marcou. (Fig. 1504.) Comanchic.

FIG. 1504. *Schloenbachia belknappi*, about one fourth natural size. (After Hill.)

Ribs increase by occasional bifurcation and intercalation; tubercles absent; in adult the ribs are flexuous, and become very broad before ending near the pronounced keel, where they have an alternating position.

Lower Washita of Texas.

394. **S. propinqua** Stoliczka. Comanchic.

From 40–44 ribs on a single whorl with tendency to bifurcation near umbilical margin; keel at first simple, later broken up into slight undulations; differs from *S. belknappi* in the larger umbilicus, more pronounced keel and tubercles near umbilicus.

Queen Charlotte formation (Horsetown) of Queen Charlotte Islands; Oötatoor beds of India.

395. **S. oregonensis** Anderson. Cretacic.

Differs from *S. propinqua* in its more numerous ribs which generally arise in pairs at the umbilicus, in the faint character of the umbilical row of tubercles, more flattened sides, less conspicuous keel, and more angular abdominal area.

Lower Chico of Oregon; abundant.

396. **S. chicoensis** Trask. Cretacic.

Shell with about 24 simple, distinct ribs, with double row of tubercles near outer margin of coil; ribs do not bifurcate but consist of two kinds, the smaller not extending to umbilicus; section of whorl oval.

Upper Chico of California.

397. **S. gabbi** Anderson. (Fig. 1505.) Cretacic.

FIG. 1505. *Schloenbachia gabbi* Anderson, with cross section and suture, × ⅔. (After Gabb.)

Ribs 40 or 50, broad, simple, with three or four rows of rounded tubercles; venter almost squarely truncate, or slightly depressed, broad; keel very low, sides nearly flat.

Upper Chico of California.

CLXXI. Mortoniceras Grossouvre.

Similar to *Schloenbachia* but with the keel strong and bounded by grooves, and the simple, curving ribs broken up into numerous nodules. In some adult or old-age individuals, the tubercles and costæ become obsolete, before the venter is reached. Cretacic.

398. **M. texanum** (Roemer). (Fig. 1506.) Cretacic.

Type of the genus; whorls scarcely impressed, with three rows of tubercles in addition to the marginal row of larger ones, and a fifth row of compressed tubercles bounding the ventral grooves;

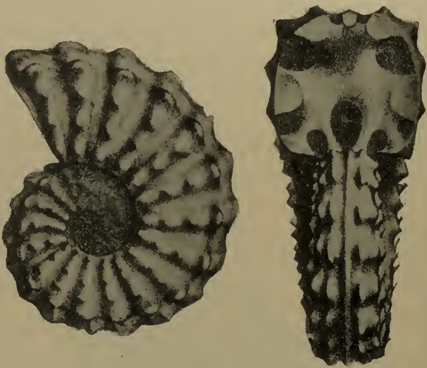

FIG. 1506. *Mortoniceras texanum.* (After Roemer.)

keel strong, narrow; in the adult the ribs become broader and the nodes fainter.

Austin limestone of Texas.

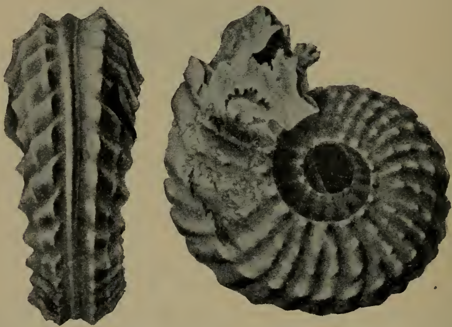

FIG. 1507. *Mortoniceras delawarense*, ventral and lateral views of an immature specimen.

399. **M. delawarense** Morton. (Figs. 1507, 1508.) Cretacic.

Ribs more numerous with intercalated secondary ones, which do not reach the umbilicus, or with two ribs starting from a single umbilical tubercle. The ribs and nodes become obsolete towards the venter in the old shells.

Ripleyan of New Jersey.

FIG. 1508. *Mortoniceras delawarense*, lateral view of adult, and septum, × ½. (After Whitfield, Pal. N. J., II.)

CLXXII. PRIONOTROPIS Meek.

Young similar to *Mortoniceras*, but ribs with tubercles only at their outer ends; in adult, the keel often becomes broken up into elongate, discontinuous node-like sections and the nodes become strong, blunt spines; sutures relatively simple, with few, broad, bifid saddles and lobes of similar width. Cretacic.

400. **P. woolgari** (Mantell). (Fig. 1509, *a–d.*) Cretacic.

Scarcely increasing in width, tubercles of adult coarse; keel broken up into corresponding sections; suture with deeply bifid first lateral, and obtuse siphonal saddles.

Benton of South Dakota, Missouri River region, Nebraska, Colorado, New Mexico; Eagle Ford shales of Texas; Turonian of Europe.

401. **P. hyatti** Stanton. (Fig. 1509, *e–g*.) Cretacic.

Small, the whorls more rapidly increasing in width, greatest transverse diameter near venter, ribs straight, simple, and ending in strong tubercle; suture with saddles much broader than lobes.

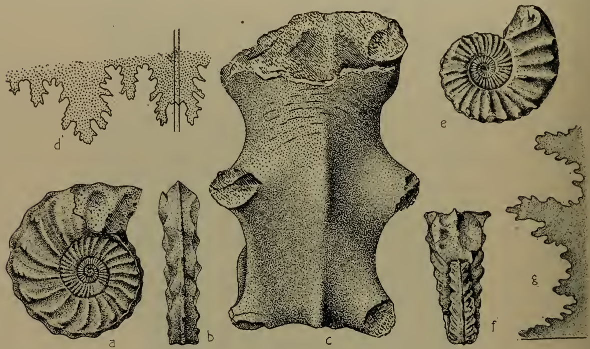

FIG. 1509. *a, b, Prionotropis woolgari*, small specimen, × ⅔ ; *c*, ventral view of large fragment of same, × ⅔ ; *d*, suture ; *e, f, P. hyatti*, an average specimen, × ⅔ ; *g*, septum enlarged. (After Stanton.)

Coloradoan (Pugnellus sandstone) of Colorado, and of Coalville, Utah.

CLXXIII. PRIONOCYCLUS Meek.

Similar to *Schloenbachia*, but whorls remaining narrowly compressed, the costæ bending forward and ending before the keel is reached; tubercles wanting or faint, and keel continuous; suture is similar to *Prionotropis*.

402. **S. wyomingensis** Meek. (Fig. 1510, *a–d*.) Cretacic.

Whorls increasing slightly in width, sides flat, venter flat, ribs sharp, with intercalated shorter ones.

Coloradoan of Wyoming, South Dakota, Utah and Colorado (below Niobrara).

403. **P. macombi** Meek. (Fig. 1510, *e–g*.) Cretacic.

Whorls scarcely increasing in width, ribs nearly obsolete, occurring as low, rounded folds with shorter ones between, each ending in a low, elongate node at ventral margin; venter smooth, gently sloping from sharp keel on either side.

Coloradoan of Colorado, and of New Mexico.

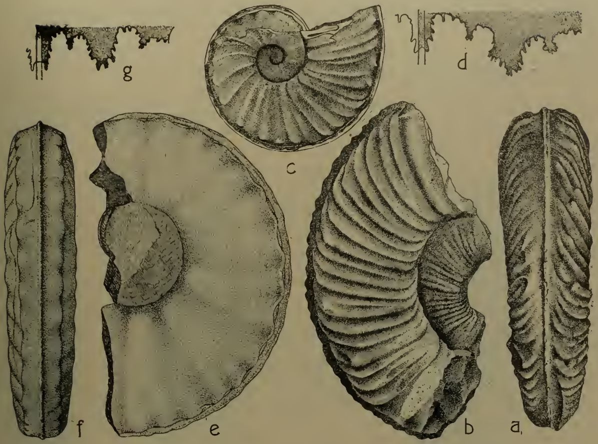

FIG. 1510. *a*, *b*, *Prionocyclus wyomingensis*, fragment of a large specimen, × ½ ; *c*, a small specimen, × ½ ; *d*, suture ; *e*, *f*, *P. macombi*, × ½ ; *g*, suture. (After Stanton.)

Subclass **DIBRANCHIATA** Owen.

Order BELEMNOIDEA.

BELEMNITIDA.

CLXXIV. ATRACTITES Guembel.

Belemnites with long phragmocone and short guard; septa simple, concave; siphuncle marginal, siphonal funnels marked; protoconch calcareous. Triassic–Jurassic.

404. **A. phillippi** Hyatt and Smith. (Fig. 1511.) Triassic.
Long and slender, circular in section; guard thick and massive, not extending far beyond the shell; absent in young shells.
Triassic of Shasta County, California.

CLXXV. BELEMNITES Lister.

Guard finger-like, cigar-shaped, subcylindrical or conoidal, sometimes short and thick, sometimes long and submucronate or obtusely rounded, frequently with ventral furrow of greater or less extent, and with dorsolateral grooves. Phragmocone generally inserted in guard, much shorter than it. Jurassic (Lower Lias)–Cretacic.

405. **B. (Megateuthis) densus.** (Fig. 1512.) Jurassic.

Guard large, up to four inches long below phragmocone, and nearly one inch in diameter; subcylindrical, ovate, or oval in sec-

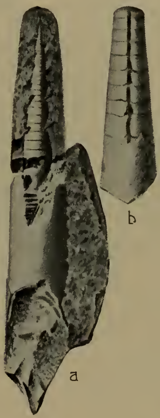

FIG. 1511. *Atractites philippi*, the phragmocone in part of guard (*a*), × ⅔, and separate (*b*), × ⅘. (After Hyatt and Smith.)

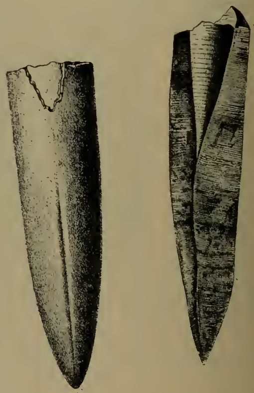

FIG. 1512. *Belemnites densus*, × ⅔. (After Whitfield, Pal. Black Hills.)

tion; sometimes obscurely subquadrangular; phragmocone short, rapidly expanding; apex subcentral in guard; septa numerous, regularly concave.

Jurassic of Dakota and Utah.

406. **B. (Belemnopsis) impressus** Gabb. (Fig. 1513, *a–c*.) Comanchic.

Large, robust, subcylindrical, tapering for about one fourth of its length to blunt point; ventral side with wide, deep furrow, deepest at about apex of phragmocone and fading to end of guard.

Very abundant in Upper Knoxville and basal Horsetown of California.

407. **B. (Belemnopsis) tehamaënsis** Stanton. (Fig. 1513, *d, e*.) Comanchic.

More slender and longer than preceding; apex more acute; section more nearly circular.

Knoxville of California, abundant.

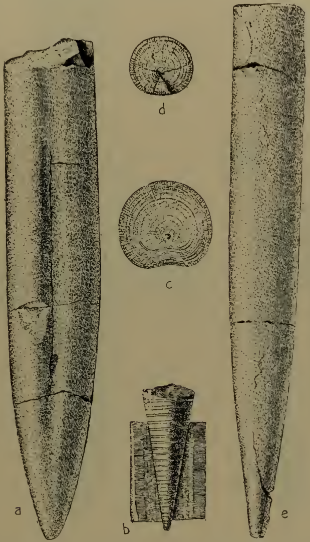

FIG. 1513. *a–c*, *Belemnites impressus*: *a*, ventral view of a somewhat slender individual; *b*, fragment with phragmocone in place; *c*, cross section just below phragmocone; *d*, *e*, *B. tehamaënsis*, cross section and side view of type. All × ⅔. (After Stanton.)

408. **B. skidegatensis** Whiteaves. (Fig. 1514.) Comanchic.

More slender than *B. densus*, with more nearly central axial line, faint apical groove, alveolar cavity about one half entire length of guard, apex of guard and phragmocone excentric.

Queen Charlotte formation of Queen Charlotte Islands, British Columbia.

CLXXVI. BELEMNITELLA d'Orbigny.

Guard cylindrical, with short, deep, ventral furrow falling short of the alveolar margin; phragmocone inserted in the guard which ends in a mucronate point. Cretacic.

409. **B. americana** (Morton). (Fig. 1515.) Cretacic.

Margin of alveolar cavity very thin, but that and mucronate point often destroyed; alveolar cavity about one third length of

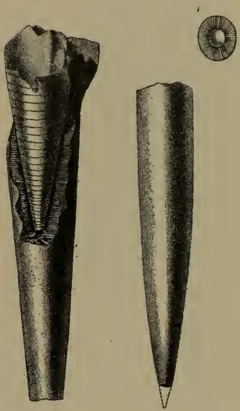

FIG. 1514. *Belemnites skidegatensis*, specimen showing phragmocone in place; and guard with cross section near apex of phragomocone, × ⅔. (After Whiteaves, Mes. Foss., I.)

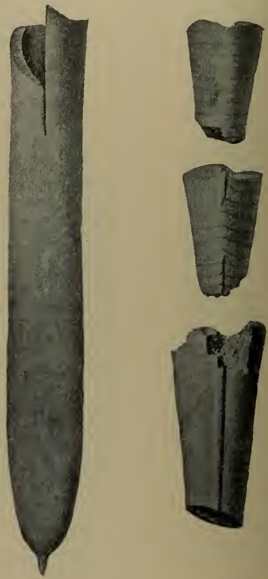

FIG. 1515. *Belemnitella americana*, guard, two views of phragmocone and filling of alveolar cavity. (After Whitfield, Pal. N. J., II.)

guard. This species is proportionally more elongate than the European *B. mucronatus*.

Ripleyan of New Jersey, Delaware, North Carolina, Alabama, Mississippi and Texas.

Order SEPIOIDEA.

(Cuttle fish.)

SEPIOPHORIDA.

CLXXVII. BELOSEPIA Voltz.

Posterior portion of proöstracum, or pen, ending in bent spine, and thickened anteriorly, where it is laterally expanded; a conical alveolus marks the position of the phragmocone. Eocenic.

410. **B. ungula** Gabb. (Fig. 1516.) Eocenic.

FIG. 1516. *Belosepia ungula*, three views. (After Cossmann.)

Conical expansion of proöstracum (mucro), much thickened at anterior end, which is strongly roughened; alveolar cavity profound.

Claibornian sands of Alabama.

Phylum VI. ANNULOSA.

Class **Annelida** MacLeay (*Vermes in part*).

The annelids or segmented worms have ciliate, elongate, bilateral bodies, divided externally into a number of rings representing a corresponding or smaller number of divisions of the internal parts. They are marine, fresh-water, or terrestrial animals, whose remains can seldom be preserved in the fossil state. It is only the tube-building suborder (Tubicola) and the free-swimming, predaceous suborder (Errantia) which leave any satisfactory remains. In the former the tube is either a calcareous secretion of the animal or it is composed of agglutinated sand and other foreign particles, being in each case wholly external. Presumably belonging to the latter division are the Conodonts, supposed to be the œsophageal jaws of the animals. Besides these two types of fossils, worm burrows are often preserved by sand or mud infiltration, producing a solid mold of the burrow in the strata.

Literature.

1879. **Hinde, G. J.** On Conodonts from the Chazy and Cincinnati Groups; and on Annelid Jaws from the Cambro-Silurian, Silurian, and Devonian Formations in Canada, etc. Quart. Jour. Geol. Soc., vol. 35, pp. 351, 370.

1886. **Clarke, J. M.** Annelid Teeth from the Lower Portion of the Hamilton Group, New York. 6th Ann. Rep. State Geol.

See also: Newberry, Pal. Ohio, vol. 2, 1875; Nicholson, Geol. Magazine, 1873; X., 1874; N. S., I.; Hall, J., Pal. N. Y., Vols. II. and V., Pt. II., Supplement; Emmons, E., Taconic System, 1844.

1906. **Sarle, C. J.** Arthrophycus and Dædalus of Burrow Origin, and Preliminary Note on the Nature of Taonurus. Proceedings Rochester Academy of Sciences, vol. 4, pp. 203–214.

1902. **Woodworth, J. B.** On the Sedentary Impression of the Animal whose Trail is known as Climactichnites. Bull. 69, N. Y. State Mus. Nat. History, pp. 959–966.

Order POLYCHÆTA.

Suborder Tubicola.

I. Serpula Linné.

Calcareous tubes, free or adherent, firm, irregularly contorted, sometimes spirally enrolled and frequently clustered together in large numbers. From the Jurassic onward, the usual condition is attached to other fossils. Siluric (?)–Recent.

1. **S. whitfieldi** Weller. Cretacic.

Tubes irregularly arcuate, slightly flexuous, gradually increasing in diameter; surface lamellose when exfoliated, in section concentrically lamellose.

Ripleyan (Navesink and Crosswicks) of New Jersey.

2. **S. dianthus** Verrill. Pleistocenic–Holocenic.

Singly adhering to shells, or growing in complex clusters, often making large masses; tubes contorted, averaging 3 mm. in diameter.

Abundant in Pleistocenic (Sankaty) beds of Nantucket, common in modern fauna along the Atlantic coast.

II. Spirorbis Daudin.

Minute, snail-like or spirally enrolled calcareous tubes, cemented by the flat under side; the spiral may be either dextral or sinistral and is usually ornamented externally with concentric striæ or annulations, sometimes with tubercles or spines; living species (marine) commonly adhering to sea weeds. Ordovicic–Recent.

3. **S. laxus** Hall. (Fig. 1517.) Siluric.

Fig. 1517. *Spirorbis laxus*, upper and lower side of a close coiled specimen; and two loosely coiled individuals. All greatly enlarged. (Pal. N. Y., III.)

Coiled, sometimes in a close low spiral, but more often with the last portion separated from the earliest whorls, or irregularly twisted instead of coiled; whorls round, with sharp annulations.

Manlius of New York; Lower Monroe (Raisin River) of Michigan, Ohio, Canada, etc.

4. **S. angulatus** Hall. Devonic.

Tube with two or more volutions, the outer robust; sides subangular; upper angular surface sometimes nodose; aperture round or oval, usually nearly at right angles to the plane of the spiral.

Hamilton of New York.

5. **S. arkonensis** Nicholson. (Fig. 1518, *b, c.*) Devonic.

Minute; sinistral or dextral, of two whorls, rounded and somewhat globular; last whorl elevated and large; aperture circular; surface with very fine, close-set, thread-like, transverse striæ.

On corals and brachiopods, Hamilton shales of Ontario and western New York.

6. **S. omphalodes** Goldfuss. (Fig. 1518, *a.*) Devonic.

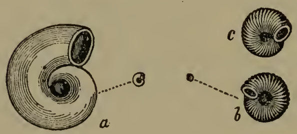

FIG. 1518. *a*, *Spirorbis omphalodes*, nat. size and enlarged; *b*, *c*, *S. arkonensis*, nat. size and enlarged, a sinistral and a dextral shell. (After Nicholson.)

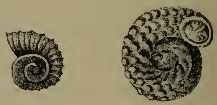

FIG. 1519. *a* (left),[1] *Spirorbis annulatus*; *b* (right), *S. nodulosus*. Both enlarged. (After Whitfield.)

Somewhat larger than preceding; surface smooth.

Hamilton of New York and Ontario; also Europe.

7. **S. annulatus** Hall. (Fig. 1519, *a.*) Mississippic.

Irregularly planospiral, with sharp annulations, with finer ones between.

St. Louis (Spergen) of Indiana and Illinois.

8. **S. nodulosus** Hall. (Fig. 1519, *b.*) Mississippic.

Volutions strongly deflected, subangular, with oblique ridges or striæ which become strongly nodose on umbilical side.

St. Louis of Indiana and Illinois.

9. **S. anthracosia** Whitfield. (Fig. 1520.) Carbonic.

Rather high-spired; volutions angular near suture and irregularly noded; surface only with coarse growth lines.

Coal Measures of Ohio, etc.

10. **S. rotula** Morton. Cretacic.

Large (9 mm. in diameter), discoid, bicarinate; coiling dextral or sinistral; aperture subcircular, but section of tube quadrangular.

Jerseyan (Vincentown) of New Jersey.

11. **S. calvertensis** Martin. (Fig. 1521.) Miocenic.

FIG. 1520. *Spirorbis anthracosia*, much enlarged. (After Whitfield.)

FIG. 1521. *Spirorbis calvertensis*, attached to shell, enlarged. (Maryland Survey.)

Small (diameter 1.3 mm.) tubes attached by flat under sides to molluscan shells; surface with indistinct, somewhat irregular annulations; coils somewhat sharply ridged on top.

Miocenic of Maryland (Calvert formation), etc.

III. CONCHICOLITES Nicholson.

Growing in clusters, attached to orthoceran and brachiopod shells, etc., by small, lower end. Tubes conical, slightly bent, thin-walled, made up of numerous short rings, each partly overlapping the preceding one; structure non-vesicular. Ordovicic.

12. **C. corrugatus** Nicholson. (Fig. 1522.) Ordovicic.

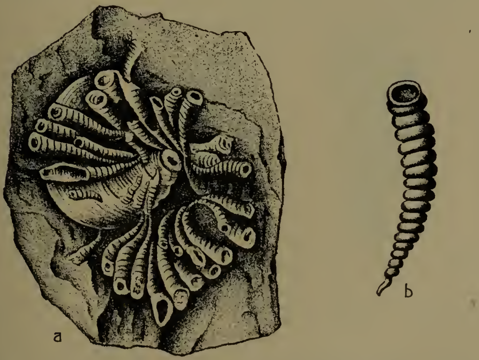

FIG. 1522. *Conchicolites corrugatus*, a group of individuals attached to shell and rock, × 1, and a single one enlarged. (After Hall and Clarke.)

Tubes irregularly annulated, often united; length one half inch or more; rings about 20; diameter at mouth one tenth inch.

Cincinnatian of Ohio.

13. **C. gregarius** Nicholson. Ordovicic.

Smaller than preceding, more closely crowded; diameter one twenty-fourth inch; attached to shells.

Cincinnatian of Ohio.

IV. CORNULITES Schlotheim.

Tube trumpet-shaped, gently tapering, flexuous, the small end usually bent; the tube closed at its lower end and either wholly or in part adhering to other objects; it at times attains a length of three or four inches; walls thick, cellular, composed of imbricating rings; surface ornamented with annulations and longitudinal striæ; interior presenting a succession of ring-like constrictions, giving to the internal mold a step-like appearance. Ordovicic–Devonic.

14. **C. proprius** Hall. Siluric.

Rapidly enlarging; adhering when young and strongly and sub-regularly annulated; adult (up to three inches in length) with irregular lamellose growth lines, and fine longitudinal striæ; structure of tube vesiculose.

Niagaran of Indiana, Tennessee, etc.

15. **C. bellistriatus** Hall. (Fig. 1523.) Siluric.

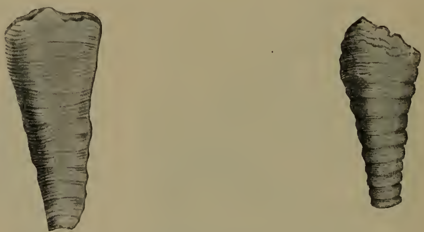

FIG. 1523. *Cornulites bellistriatus.* (After Hall.)

Wall thick; annulations scarcely marked at base, less strongly and irregularly marked in upper portion and more regular than in *C. proprius;* fine longitudinal striæ throughout; probably only a variety of the preceding.

Rochester (Niagaran) shale, New York.

16. **C. arcuatus** Conrad. (Fig. 1524.) Siluric.

Regularly tapering, sometimes more or less curved; internal mold shows a regularly increasing series of segments, abrupt and step-like towards apex, sloping towards aperture.

FIG. 1524. *Cornulites arcuatus*, two specimens, the larger × 2. (After Clarke and Ruedemann, Guelph Fauna.)

Lockport and Guelph of New York; Upper Monroe of Michigan and Ontario.

V. ORTONIA Nicholson.

Small, solitary, conical, calcareous tubes, more or less flexuous, thick-walled and cemented by the whole side to some foreign body; surface annulated, the rings overlapping as in *Conchicolites* of which it is sometimes considered a synonym; upper surface appar-

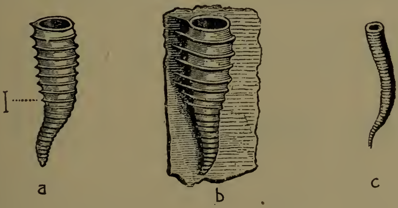

FIG. 1525. *a*, *b*, *Ortonia intermedia*, greatly enlarged; *c*, *O. minor*, enlarged. (After Nicholson.)

ently cellular. (May be the young of *Cornulites*.) Ordovicic–Carbonic.

17. **O. minor** Nicholson. (Fig. 1525, *c*.) Ordovicic.

Annulations sometimes faintly marked on side opposite to the attached side, about fifteen in 1/10 inch; curvature simple or S-shaped; length 1/10 to 3/20 inch; diameter at mouth 1/20 to 1/25 inch.

Cincinnati group of Ohio, common.

18. **O. intemedia** Nicholson. (Fig. 1525, *a, b*.) Devonic.

Straight or flexuous, sometimes bent at nearly right angles in the lower part (*Cornulites hamiltoniæ* Grabau); larger than preceding, more robust and with more distant annulations, which may be extended in wing-like prolongations for attachment.

On corals, brachiopods, etc., Hamilton shales, Thedford, Ontario, and western New York.

Suborder Errantia.

Annelid Jaws and Conodonts.

These microscopic teeth are of uncertain systematic position, especially the conodonts which were at first considered to be fish teeth, and have been regarded as pertaining to the lingual ribbon of molluscs, or to crustacea; they are translucent, of a shining, reddish horn color, and are composed of carbonate and phosphate of lime; they exhibit a great variety of form; the jaws and toothed plates have the character of the jaws of modern annelids. Some of the more important American types are here given:

A. Jaws.

VI. Arabellites Hinde.

Jaws of three kinds: (1) an extremely prominent anterior hook and a row of smaller teeth on a wide base; (2) sickle-shaped, and

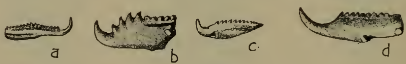

Fig. 1526. Annelid jaws from the Lorraine: *a*, *Œnonites serratus*, × 8; *b*, *Œ. rostratus*, × 10; *c*, *Œ. cuneatus*, × 10 +; *d*, *Arabellites hamatus*, × 14. (After Hinde.)

(3) quadrate jaws with straight upper edge of small teeth. Ordovicic–Devonic.

Examples: 19, **A. hamatus** Hinde Lorraine (Fig. 1526, *d*); 20,

A. cuspidatus Hinde Lorraine (Fig. 1527, *a*); 21, **A. gibbosus** Hinde Lorraine (Fig. 1527, *c*); 22, **A. lunatus** Hinde Lorraine

FIG. 1527. Annelid jaws from the Lorraine: *a*, *Arabellites cuspidatus*, × 5; *b*, *Lumbriconereites dactylodus*, × 4; *c*, *Arabellites gibbosus*, × 7. (After Hinde.)

(Fig. 1528, *d–f*); 23, **A. cristatus** Hinde Lorraine (Fig. 1528, *g*); 24, **A. elegans** Hinde Clinton (Fig. 1529, *b*); 25, **A. similis** Hinde

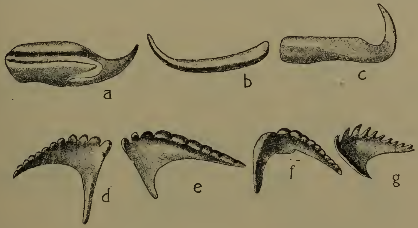

FIG. 1528. Annelid jaws from the Lorraine: *a*, *Glycerites sulcatus*, × 9; *b*, *Eunicites simplex*, × 9; *c*, *E. gracilis*, × 9; *d*, *Arabellites lunatus*, × 9; *e*, same, × 7; *f*, same, × 8; *g*, *Arabellites cristatus*, × 9. (After Hinde.)

Niagaran (Fig. 1529, *d*); 25*a*, **A. similis** var. **arcuatus** Hamilton (Fig. 1531, *a*).

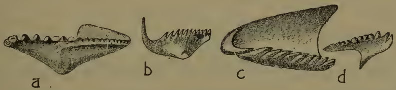

FIG. 1529. Annelid teeth from the Niagaran: *a*, *Lumbriconereites triangularis*, × 7; *b*, *Arabellites elegans*, × 9 +; *c*, *Lumbriconereites armatus*, × 7; *d*, *Arabellites similis*, × 7. (After Hinde.)

VII. EUNICITES Ehlers.

Minute, elongate, denticulate jaws with numerous teeth; subquadrate jaws with few teeth; simple, more or less curved, narrow hooks without denticles. Impressions of the worm itself have been obtained from the Lithographic shales (Jurassic). Ordovicic–Eocenic.

Examples: 26, **E. major** Hinde Lorraine (Fig. 1530, *a*); 27, **E. varians** Grinnell Lorraine (Fig. 1530, *b, c*); 28, **E. contortus** Hinde

Lorraine (Fig. 1530, *d*); 29, **E. simplex** Hinde Lorraine (Fig. 1528, *b*); 30, **E. gracilis** Hinde Lorraine (Fig. 1528, *c*); 31, **E. clintonensis** Hinde Clinton (Fig. 1532, *a*); 32, **E. tumidus** Hinde

FIG. 1530. Annelid jaws from the Lorraine: *a*, *Eunicites major*, × 2; *b*, *c*, *E. varians*, × 4; *d*, *E. contortus*, × 5 +. (After Hinde.)

Hamilton (Fig. 1531, *b*); 33, **E. palmatus** Hinde Hamilton (Fig. 1531, *c*); 34, **E. nanus** Hinde Hamilton (Fig. 1531, *d*).

VIII. LUMBRICONEREITES Ehlers.

Jaws like *Eunicites*, but with a well defined basal extension. Ordovicic–Siluric.

Examples: 35, **L. dactylodus** Hinde Lorraine (Fig. 1527, *b*);

FIG. 1531. Annelid jaws from the Hamilton group: *a*, *Arabellites similis* var. *arcuatus*, × 12; *b*, *Eunicites tumidus*, × 9; *c*, *E. palmatus*, × 10; *d*, *E. nanus*, × 10. (After Hinde.)

36, **L. triangularis** Hinde Clinton (Fig. 1529, *a*); 37, **L. armatus** Hinde Clinton (Fig. 1529, *c*); 38, **L. basalis** Hinde Clinton (Fig. 1532, *b*).

IX. ŒNONITES Hinde.

Jaws with more or less curved anterior hook, followed by a series of smaller teeth, like those of the modern genus *Œnone*. Ordovicic–Siluric.

Examples: 39, **O. serratus** Hinde Lorraine (Fig. 1526, *a*); 40,

FIG. 1532. Annelid jaws from the Clinton: *a*, *Eunicites clintonensis*, × 9; *b*, *Lumbriconereites basalis*, × 7; *c*, *Œnonites amplus*, × 9 +. (After Hinde.)

O. rostratus Hinde Lorraine (Fig. 1526, *b*); 41, **O. cuneatus** Hinde Lorraine (Fig. 1526, *c*); 42, **O. amplus** Hinde Clinton (Fig. 1532, *c*).

X. GLYCERITES Hinde.

Jaws consisting of a simple curved hook, with a wide base, without smaller teeth. Ordovicic.

Example: 43, **G. sulcatus** Hinde Lorraine (Fig. 1528, *a*).

B. Conodonts.

XI. POLYGNATHUS Hinde.

Minute, variously formed conodonts and minute, tuberculated plates. Devonic.

Examples: 44, **P. dubius** Hinde Genesee-Waverly, pectinate

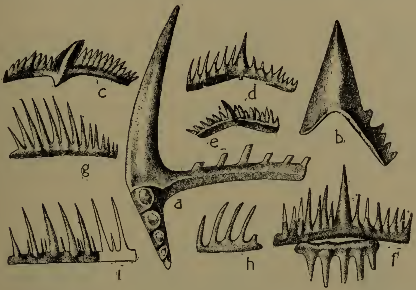

FIG. 1533. CONODONTS. *a*, *Prioniodus panderi*, × 14; *b*, *P.? alatus*, × 7; *c–i*, *Polygnathus dubius*, × 14; various forms of pectinate teeth found associated. (After Hinde.)

teeth (Fig. 1533, *c–i*), fimbriate teeth (Fig. 1534, *a*, *b*), crested teeth (Fig. 1534, *c–e*); 45, **P. coronatus** Hinde Genesee (Fig. 1535, *a*);

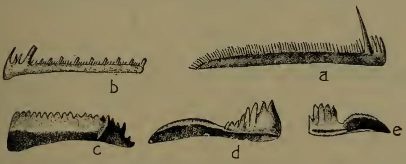

FIG. 1534. CONODONTS. *Polygnathus dubius*, × 14: *a*, *b*, fimbriate teeth; *c–e*, crested teeth. (These, and the pectinate teeth shown in Fig. 1533, *c–i*, were found associated. (After Hinde.)

46, **P. solidus** Hinde Genesee (Fig. 1535, *b*); 47, **P. crassus** H. Genesee (Fig. 1535, *c*); 48, **P. pennatus** Hinde Genesee (Fig. 1536, *a*); 49, **P. truncatus** Hinde Genesee (Fig. 1536, *c*; var. 1536, *b*); 50,

P. punctatus Hinde Genesee (Fig. 1536, *d*); 51, **P. tuberculatus** Hinde Genesee (Fig. 1536, *e, f*); 52, **P. cristatus** Hinde Genesee (Fig. 1536, *g*); 53, **P. palmatus** Hinde Genesee (Fig. 1536, *h*).

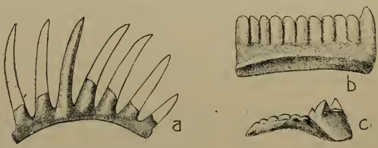

FIG. 1535. CONODONTS. *a*, *Polygnathus coronatus*, × 14; *b*, *P. solidus*, × 14; *c*, *P. crassus*, × 14. (After Hinde.)

XII. PRIONIODUS Pander.

Jaw with narrow basal portion, supporting numerous delicate denticles, and an elongated tapering tooth which extends below the basal portion. Ordovicic–Devonic.

Examples: 54, **P. radicans** Hinde Chazy (Fig. 1538, *a–c*); 55,

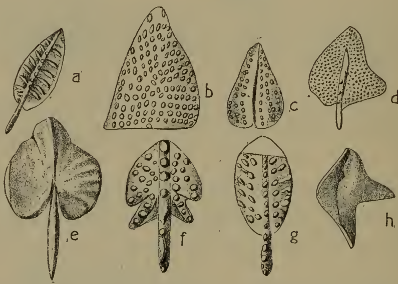

FIG. 1536. Plates associated with conodonts: *a*, *Polygnathus pennatus*; *b*, *P. truncatus*, var.; *c*, *P. truncatus*; *d*, *P. punctatus*; *e*, *f*, *P. tuberculatus*; *g*, *P. cristatus*; *h*, *P. palmatus*. All × 14. (After Hinde.)

P. elegans Pander Lorraine (Fig. 1538, *d*); 56, **P. abbreviatus** Hinde Genesee (Fig. 1537, *a*); 57, **P. clavatus** Hinde Genesee (Fig. 1537, *b*); 58, **P. erraticus** Hinde Genesee (Fig. 1537, *c*); 59, **P. armatus** Hinde Genesee (Fig. 1537, *f, g*); 60, **P. angulatus** Hinde Genesee (Fig. 1537, *h*); 61, **P. panderi** Hinde Genesee (Fig. 1533, *a*); 62, **P. alatus** Hinde Genesee (Fig. 1533, *b*).

XIII. Drepanodus Pander.

Single, straight or curved teeth of more or less circular or elliptical section.

Example: 63, **D. arcuatus** Pander Lorraine (Fig. 1537, *d, e*).

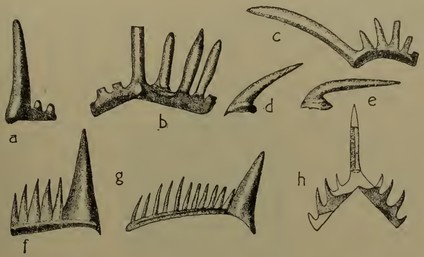

Fig. 1537. Conodonts. *a*, *Prioniodus abbreviatus*, × 14; *b*, *P. clavatus*, × 14; *c*, *P. erraticus*, × 14; *d*, *e*, *Drepanodus arcuatus*, × 7; *f*, *g*, *Prioniodus armatus*, × 14; *h*, *P. angulatus*, × 14. (After Hinde.)

Trails.

XIV. Nereites Murchison.

Long, convoluted trails, of two rows of equally oval or pointed crenulations. Cambric.

The following species have been described by Emmons from the

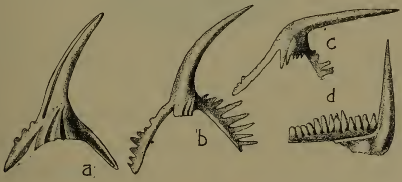

Fig. 1538. Conodonts. *a–c*, *Prioniodus radicans*: *a*, reverse showing groove; *b*, *c*, front views, × 7; *d*, *P. elegans*, × 14. (After Hinde.)

Taconic: 64, **N. deweyi**; 65, **N. gracilis**; 66, **N. jacksoni**; 67, **N. lanceolatus**; 68, **N. loomisi**; 69, **N. pugnus**; 70, **N. robustus**. (See Taconic system, p. 69.)

Worm Burrows (systematic position doubtful).

XV. SCOLITHUS Haldeman.

Tube free, cylindrical or subcylindrical, vermiform, never branched. Cambric–Ordovicic.

71. **S. linearis** Hall. (Fig. 1539.) Cambric.

Surface nearly smooth, sometimes apparently striated; form

FIG. 1539. *Scolithus linearis*, the pencil-like filling of the burrow. (After Walcott.)

rigidly straight; diameter one eight to one half inch; length from a few inches to several feet.

Upper Cambric of New York, Newfoundland, Vermont, Massachusetts, Pennsylvania, Tennessee, etc. Other species distinguished according to the size of the tube are: 72, **S. canadensis** Billings, and 73, **S. minutus** Wing; the first Upper Cambric, and the second Lower Ordovicic.

XVI. ARENICOLITES Salter.

Circular holes, generally in sandstone, occurring in pairs and resembling the burrows of the modern *Arenicola*. Cambric.

74. **A. woodi** Whitfield. Cambric.

Seldom as much as one eighth inch in diameter, generally less than one tenth, deflected at various angles near the surface of the layer and often oblique for some distance, then horizontal along the surface of the layer; natural openings surrounded by hillocks; older borings compressed by new ones so as to appear crescentic in section.

St. Croix formation of Wisconsin.

XVII. Scalarituba Weller.

Irregularly curving and twisting worm burrows, marked by transverse ridges at a distance of 1–2 mm. Mississippic.

75. **S. missouriensis** Weller. Mississippic.

Tubes 2–4 mm. in diameter, of subcylindrical form, never straight for more than a few centimeters.

Crowded in Vermicular or Northview sandstone of the Kinderhook of Missouri.

Of Doubtful Affinities.

XVIII. Arthrophycus Hall.

Trails or burrows in relief (solid mold of trail?), simple or apparently branching, rounded or subangular, with median groove, and close-set transverse grooves. Originally described as a plant, it was subsequently regarded as worm burrows, but may be the mold of a trail of some other (possibly terrestrial) animal. Siluric.

76. **A. alleghaniensis** (Harlan). (*A. harlani* Conrad.) Siluric.

Internal mold of the compound burrow (or trail) composed of numerous, strong, rounded, elongate and articulated branches which unite near the base; these branches are simple and approximately of the same dimensions throughout; diameter of branches one fourth of an inch to one inch.

Medina and Oneida of Ontario and New York; Tuscarora of Pennsylvania and Maryland; Clinch of Virginia, Tennessee, etc. (On the under side of sandstone layers.)

XIX. Dædalus Rouault.

(Including *Vexillum* Rouault.)

Vertical, flat, crimped or contorted plates often forming inverted spiral, and composed of sandstone. Interpreted as representing the successive packings of sand, in the making of successive burrows one above the other. The form is J-shaped. Ordovicic–Siluric.

77. **D. archimedes** (Ringueberg). Siluric.

Flat, turreted or spiral plates of sandstone standing vertically in the enclosing rock and often twelve to fourteen inches in depth, rarely more than four inches wide and one half inch thick; marked by J-shaped lines and ridges.

Medina sandstone of New York; Tuscarora of Pennsylvania, etc.

XX. Climactichnites Logan.

Trails marked by median and two marginal ridges, and by transverse, broad groove, or, in solid molds, by median groove and transverse, broad ridges, the transverse elements converging obliquely to the longitudinal ones. Cambric.

78. **C. wilsoni** Logan. Cambric.

Large, the width measuring from five to six and one half inches; transverse grooves about one inch, as measured from crest to crest of dividing ridge.

Potsdam sandstone of New York and Canada. Other species occur in the St. Croix of Wisconsin, etc.

This trail has been generally regarded as that of some crustacean. It may have been made by some unknown terrestrial or semiterrestrial animal. (See J. B. Woodworth's paper cited above.)

XXI. Taonurus Fisher-Ooster.

(*Spirophyton* Hall.)

Thin plates of ridged sand rock, nearly horizontal, U-shaped, suboval, or irregularly lobate, or more rarely forming low-inverted spirals, with the larger volutions downward; both faces of plates marked by U-shaped or otherwise curving, parallel lines. Originally regarded as a plant, also interpreted as mechanical markings by basally attached plants moved by wind; interpreted by Sarle as packings of successive burrows similar to *Dædalus*. Cambric–Tertiary.

79. **T. caudagalli** (Vanuxem). (Fig. 1540.) Devonic.

In form resembling a rough spiral suggesting the outline of a rooster's tail.

Oriskany sandstone and Esopus shale (Caudagalli grit) of New York and Pennsylvania.

80. **T. velum** (Vanuxem). (Fig. 1541.) Devonic.

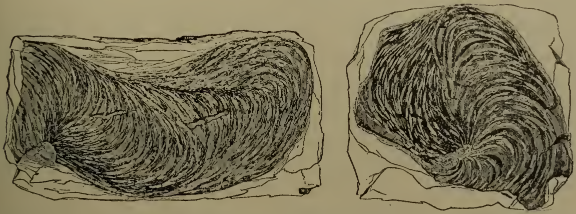

FIG. 1540. *Spirophyton caudagalli*, showing two types of these markings, × ¼. (After Vanuxem.)

Broadly ear-shaped, with the lines of structure U-shaped. Hamilton of New York, Pennsylvania, etc.

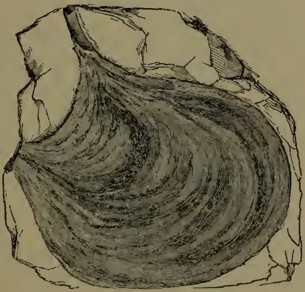

FIG. 1541. *Spirophyton velum*, × ½. (After Vanuxem.)

PHYLUM VII. ARTHROPODA.

Class **Crustacea** Lamarck.

Subclass TRILOBITA Burmeister.

Extinct marine Crustacea wholly confined to the Palæozoic rocks. Body covered with a shield (*dorsal shield or carapace*) longitudinally divided into three parts.

The anterior portion comprises the head-shield or *cephalon,* which is usually semicircular, with a straight posterior border. The central of the three lobes of the cephalon is the *glabella* which

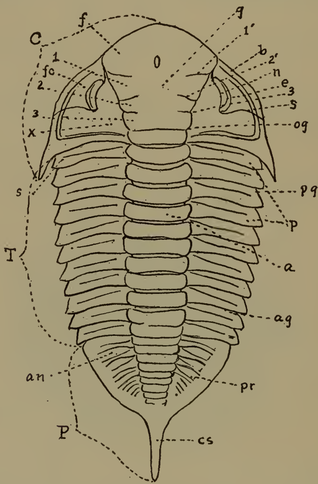

FIG. 1542. Diagram of a trilobite to show the parts. (After Clarke.) *C*, cephalon; *g*, glabella; *f*, frontal lobe; 1, 2, 3, first, second and third lateral lobes; 1′, 2′, 3′, first, second and third lateral furrows; *x*, fixed cheeks; *fc*, free cheeks; *s*, facial suture; *e*, eye; *n*, palpebral lobe; *og*, occipital groove (neck furrow) bounding the occipital ring (neck ring); *b*, border.

T, thorax: *a*, axis; *p*, pleuræ; *s*, first thoracic segment; *ag*, articulating groove; *pg*, pleural groove.

P, pygidium: *an*, annulation; *pr*, pleural rib; *cs*, caudal spine or telson.

is the most prominent part of the cephalon. It is of varying outline, bounded laterally by the *dorsal furrows,* and more or less divided by *transverse furrows* or pairs of furrows. The last (posterior) furrow is the *occipital furrow* and bounds anteriorly the *occipital ring* which is just in front of the first segment of the thorax. On either side of the glabella is a pair of *cheeks*, divided by the *facial suture* into *fixed cheeks* (those next to the glabella) and *free cheeks* (the outermost or movable portion). The latter are often prolonged into *genal spines*. The *compound eyes* are situated on the free cheeks and they are overshadowed by more or less prominent eyelids or *palpebral lobes*, which are lateral lobes from the fixed cheeks. The facial suture thus passes between the eyes and the palpebral lobes, and when, as is often the case, the free cheeks become separated after the moult or death of the animal, only the palpebral lobes remain on the central portion of the cephalon (*cranidium*) to indicate the former position of the eyes. The anterior end of this palpebral lobe is often bound to the glabella by the *ocular ridge*. The border of the cephalon is often distinctly marked and is spoken of as the *cephalic limb*. At the margin, it is folded down and back, making the *doublure*, which continues backwards, and often produces hollow or solid genal spines. To the anterior lower portion of the doublure is attached the lip or *hypostoma*, which is often found separate; this is homologous with the upper lip of other crustaceans.

The middle portion of the carapace, or *thorax*, consists of a varying number of divisions or *segments* articulated with each other, and commonly permitting the enrollment of the animal. Each segment of the thorax is divided by two *furrows* into a middle portion (*axis*) and two lateral divisions (*pleura*).

The posterior portion of the carapace, the abdomen or *pygidium*, consists of a single piece comprising a *central axis* and *lateral lobes*. The axis and the lobes commonly show *transverse furrows*, similar to the divisions of the thorax, and they are often so strongly marked that a line of division between thorax and pygidium is difficult to determine.

Probably all trilobites had jointed appendages, which included *antennæ, mouth parts, legs* and *gill fringes*, comparable in a general way to those of the lower orders of modern crustacea. These are shown in the restoration of *Triarthrus becki* (Fig. 1590).

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Artificial Key to the Genera.

A. Free cheeks on under side, usually not showing above. Compound eyes absent; simple ones (mere dots) may occur on each free cheek. Hypoparia............I.

I. Glabella prolonged beyond the anterior edge of the cephalon.........V. *Ampyx*.

I. Glabella not prolonged beyond the anterior edge of the cephalon..................1.

1. Small (cephalon or pygidium one fourth inch or less in length)...............a.

a. Segmentation of axis of pygidium well marked.............II. *Microdiscus*.

a. Axis of pygidium not segmented....................................I. *Agnostus*.

1. Moderately large. Cephalon with broad, pitted border.........................b.

b. Border continued backward and slightly tapering.............III. *Harpes*.

b. Border abruptly contracted at genal angles into true spines. IV. *Trinucleus*.

B. Free cheeks showing above, always bearing the genal angles. Compound eyes (never distinctly facetted) on the free cheeks, usually present. Opisthoparia..II.

II. Glabella of cephalon and axis of pygidium distinctly defined......................2.

2. Eyes absent. Glabella distinctly tapering anteriorly..... ....c.

c. Axis wide...11.

11. Axis twice the width of a lateral lobe..................IX. *Bathynotus*.

11. Axis slightly less than the width of a lateral lobe........VIII. *Atops*.

c. Axis narrow...22.

22. Lobe present in front of glabella....................VII. *Ctenocephalus*.

22. No lobe present in front of glabella....................VI. *Conocoryphe*.

2. Eyes present...d.

d. Glabella single (*i. e.*, without separated side lobes), prominently enlarging anteriorly...33.

33. Pygidium as long as cephalon or thorax....................................aa.

aa. Cephalon and pygidium with a flattened margin.
XLIX. *Griffithides.*

aa. Cephalon and pygidium without a flattened margin.
L. *Bronteus.*

33. Pygidium very short, plate-like ....XV. *Paradoxides.*

d. Glabella single, not prominently enlarging anteriorly.....................44.

44. Eyes long and narrow, extending from the margin of the anterior glabellar lobe (or the end of the ocular ridge) nearly to the posterior end or obliquely outward..bb.

bb. Sides of glabella somewhat irregular or narrowing anteriorly...†.

†. Glabella wider than long....................XVI. *Remopleurides.*

†. Glabella longer than wide...*.

*. Cephalon without genal spine........XIII. *Ellipsocephalus.*

*. Cephalon with genal spine......................................1″.

1″. Cephalon with strong, very narrow marginal rim.
{ XIV. *Protolenus.*
{ XIVA. *Bergeronia.*

1″. Marginal rim absent or not very narrow...............a″.

a″. Pygidium a long spine.......................X. *Olenellus.*

a″. Pygidium a small, unsegmented plate...............*1.*

1. Anterior three fourths of thoracic segments abruptly longer than posterior one fourth; without secondary cephalic spines.........XII. *Mesonaces.*

1. Anterior segments not differing from posterior; with secondary cephalic spines.......XI. *Holmia.*

a″. Pygidium comparatively broad..........................*2.*

2. Pygidium with posterolateral spines..............*a.*

a. Third or fourth pleural spine much extended.
XX. *Albertella.*

a. Pleural spines of equal length.
XXXII. *Crepicephalus.*

2. Pygidium without spines.............................*b.*

b. Glabella about three fourths the length of the cephalon or less..............XXI. *Ptychoparia.*

b. Glabella extending almost to anterior edge of cephalon..................XXXV. *Bathyuriscus.*

a″. Pygidium unknown. Pleura strongly angular dorsoventrally.........................XXIV. *Strenuella.*

bb. Sides of glabella straight or subparallel...............................††.

††. Pygidium very broad...**.

**. All annulations of pygidium terminating in short spines..*2″.*

2″. Outline of cephalon semicircular ...XVIII. *Olenoides.*

2″. Outline of cephalon subtriangular.....XVII. *Neolenus.*

**. Margin of pygidium entire.......................................3″.

3″. Cephalon and pygidium subequal, large.
XXXVIII. *Ogygopsis.*

3″. Cephalon and pygidium unequal.........................b″.

b″. Glabellar furrows present........XXI. *Ptychoparia.*

b″. Glabellar furrows obsolescent.
XXXVI. *Bathyurus.*

††. Pygidium narrow, its two or three spinose segments turned abruptly backward..............................XIX. *Zacanthoides.*

44. Eyes short.............. ....cc.

cc. Raised marginal rim anterior to glabella, bounded inwardly by a furrow. (This concave or flattened margin often bounds the entire cephalon and pygidium)..................................†††.

†††. Pleura strongly angular dorsoventrally...XXIV. *Strenuella.*

†††. Pleura not angular...***.

***. Glabella extending nearly to anterior border of cephalon. 4″.

4″. Genal spines absent....................XXVIII. *Peltura.*

4″. Genal spines present...c″.

c″. Genal spines set forward on the free cheeks........*3.*

3. Fixed cheeks wider posteriorly than anteriorly. XXX. *Sphærophthalmus.*

3. Fixed cheeks about equal in width anteriorly and posteriorly..................................*c.*

c. Pygidium large, ending in long spines. XXIX. *Ctenopyge.*

c. Pygidium small, ending in very short spines. XXXI. *Leptoplastus.*

c″. Genal spines set at the posterolateral end of the free cheeks...*4.*

4. Eyes set close to glabella..............................*d.*

d. Eyes opposite posterior part of glabella. XXXIII. *Dikellocephalus.*

d. Eyes opposite anterior part of glabella.....1).

1). Marginal fold prominent.

{ XXVII. *Parabolina.*
{ XXVIIA. *Parabolinella.*

1). Marginal fold not prominent. XXVI. *Chariocephalus.*

4. Eyes set far from glabella.......XXV. *Ptychaspis.*

***. Glabella about three fourths the length of the cephalon or less..5″.

5″. Pygidium with posterolateral spines...................d″.

d″. Pygidium broad, fan-like. XXXIII. *Dikellocephalus.*

d″. Pygidium small ....XXXII. *Crepicephalus.*

5″. Pygidium without spines...................................e″.

e″. Genal angles with spines........XXI. *Ptychoparia.*

e″. Genal angles pointed..........XXII. *Solenopleura.*

e″. Genal angles rounded........XXXVII. *Asaphiscus.*

cc. No raised marginal rim anterior to glabella.......................††††.

††††. Pygidium large..****.

****. Side lobes of pygidium segmented XXXIII. *Dikellocephalus.*

****. Side lobes of pygidium unsegmented.......XL. *Asaphus.*

††††. Pygidium comparatively small....................................5*.

5*. Glabella reaching nearly to the cephalon. XXXIV. *Triarthrus.*

5*. Glabella about one half the length of the cephalon. XXIII. *Agraulos.*

d. Glabella with a large central and one to three side lobes..........55.

55. Pleura grooved, also segments of pygidium ....dd.

dd. Cephalon large, about one third the length of the whole animal..5†.

5†. Pygidium short, axis usually less than 14 segments..........6*.

6*. Glabella extending practically to anterior edge of cephalon ....6″.

6″. Glabella with subparallel sides ....XLVI. *Proëtus.*

6″. Glabella with concave sides..........XLIX. *Griffithides*

6*. Glabella about three fourths the length of the cephalon. XLVII. *Cyphaspis.*

5†. Pygidium elongate, its axis usually with more than 14 segments..........XLVIII. *Phillipsia.*

dd. Cephalon broad, short, about one fourth the length of the whole animal..........LI–LVI. *Lichadidæ.*

55. Pleura ridged..........ee.

ee. Pygidium with spinose margin..........6†.

6†. Occipital ring with spines..........LVII. *Acidaspis.*

6†. Occipital ring smooth or with anterior tubules. LVIII. *Odontopleura.*

ee. Pygidium with spineless margin ....LIX. *Glaphurus.*

II. Glabella of cephalon and usually axis of pygidium not distinctly defined......3.

3. Body not trilobed except very slightly on cephalon..........XLIII. *Bumastus.*

3. Body distinctly trilobed..........e.

e. Axis broad, wider than pleura ....66.

66. Eyes placed anterior to the middle of the cephalon.....XLV. *Nileus.*

66. Eyes placed medially or posterior to middle..........XLI. *Isoteles.*

e. Axis comparatively narrow..........77.

77. Free cheeks long, terete. Axis of pygidium deeply defined. XLIV. *Thaleops.*

77. Free cheeks short, flat..........ff.

ff. Axis of pygidium inconspicuous ....XLII. *Illænus.*

ff. Axis of pygidium more or less conspicuous. XXXIX. *Asaphellus.*

C. Free cheeks showing above; genal angles borne by fixed cheeks. Compound eyes present. PROPARIA..........III.

III. Glabella narrowing anteriorly ....4.

4. Body indistinctly trilobed. Pygidium elongate, triangular. LXII. *Homalonotus.*

4. Body strongly trilobed. Pygidium comparatively short, semicircular. LXI. *Calymene*

4. Body unknown..........LXIV. *Pseudosphærexochus.*

III. Glabella ovoid or globular..........LXVI. *Sphærexochus.*

III. Glabella enlarging anteriorly (rarely subquadrate)..........5.

5. Glabellar furrows nearly or completely absent..........f

f. Eyes very large..........LXVII. *Phacops.*

f. Eyes small..........LX. *Encrinurus.*

5. Glabellar furrows conspicuous..........g.

g. Margin of cephalon bordered by a distinct rim..........LXV. *Pliomera.*

g. Margin of cephalon without rim..........88.

88. Pygidium triangular..LXIX. *Dalmanites.*
88. Pygidium semicircular..gg.
gg. Margin entire...............................LXVIII. *Pterygometopus.*
gg. Margin spinous..7†.
7†. Eyes large..LXX. *Cryphæus.*
7†. Eyes small ....LXIII. *Ceraurus.*

Order HYPOPARIA Beecher.

I. Agnostus Brongniart.

Small. Cephalon and pygidium subequal in form, size and markings. Free cheeks ventral. Eyes absent. Glabella not extending to anterior border of cephalon. Thorax of two segments, with grooved pleura. Cambric–Ordovicic.

1. **A. interstrictus** White. Cambric.

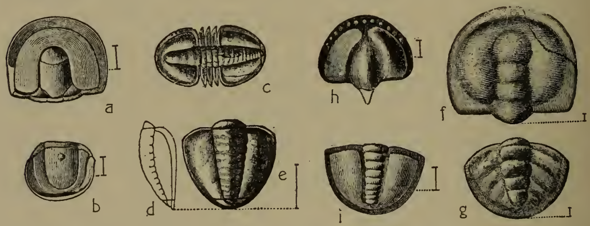

Fig. 1543. *a*, *b*, *Agnostus acadicus*, cephalon and pygidium (enlarged); *c–e*, *Microdiscus speciosus*, entire individual and pygidium enlarged; *f*, *g*, *M. lobatus*, cephalon and pygidium much enlarged; *h*, *i*, *M. pulchellus*, cephalon and pygidium. (After Walcott.)

Thorax narrower than cephalon or pygidium. Differs from *A. pisiformis* in the almost total absence of basal lobes in the glabella, in the presence of a slight folding back of the marginal rim at the antero-lateral angles of the pygidium, and in a less definite segmentation of the axis of the pygidium.

Middle Cambric of Utah and Nevada.

2. **A. acadicus** Hartt. (Fig. 1543, *a*, *b*.) Cambric.

Cephalon and pygidium very depressed-convex. Cheeks of same width throughout, most elevated next to the glabella. Surface smooth.

Middle Cambric (Acadian) of St. John group of New Brunswick.

3. **A. pisiformis** Linné. (Fig. 1544.) Cambric.

Glabella with a tubercle or posterior lobe anterior to middle and with the two basal lobes subtriangular.

Middle Cambric of St. John group of Nova Scotia.

4*a*. **A. trisectus** Salter var. **ponepunctus** Matthew. (Fig. 1545.) Cambric.

Reticulation of cephalon does not reach the glabella.

Upper Cambric (Bretonian) of Cape Breton.

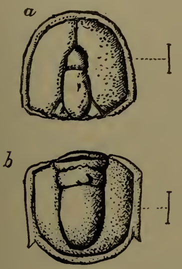

FIG. 1544. *Agnostus pisiformis*, var. *a*, cephalon; *b*, pygidium, ×4. (After Matthew.)

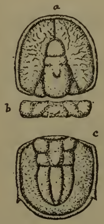

FIG. 1545. *Agnostus trisectus*, var. *ponepunctus*. *a*, cephalon; *b*, a single thoracic ring; *c*, pygidium, ×2. (After Matthew.)

4*b*. **A. trisectus** var. **germanus** Matthew. Cambric.

Differs from the preceding as follows: cephalon more strongly arched and smoother; pygidium without trisection of posterior lobe, though faint furrows may at times be traced.

Upper Cambric (Bretonian) of New Brunswick.

II. MICRODISCUS Emmons.

Similar to *Agnostus* but with three or four segments in the thorax, and with segmentation of the axis of the pygidium well marked. Cambric.

5. **M. speciosus** Ford. (Fig. 1543, *c–e*.) Cambric.

Cephalon bordered on each side by five or six tubercles. Glabella obscurely segmented; axis of pygidium more strongly segmented.

Lower Cambric of New York, Quebec and Newfoundland.

6. **M. lobatus** Hall. (Fig. 1543, *f, g*.) Cambric.

Glabella usually cylindroconical, and usually with no furrows except the occipital one, though at times there are two others well defined. Pygidium well segmented.

Lower Cambric of New York.

7. **M. pulchellus** Hartt. (*M. punctatus* of American authors.) (Fig. 1543, *h, i.*) Cambric.

Cephalon with crenulated border and basal spine.

Middle Cambric of St. John group of New Brunswick and Newfoundland.

III. Harpes Goldfuss.

Cephalon large, with a broad marginal expansion. Glabella short and prominent. Free cheeks ventral. Facial sutures marginal. Eye-spots paired and simple, and on the fixed, not the free, cheeks. Thorax of 25 to 29 segments; pleura long and grooved. Pygidium very small, of three or four segments. Ordovicic and Siluric.

8. **H. (Harpina) ottawaënsis** Billings. (Fig. 1546.) Ordovicic.

Marginal expansion of cephalon strongly punctate.

Trenton of New York, New Jersey, Minnesota, Quebec, etc.; Chazy of New York, etc.

IV. Trinucleus Lhwyd.

Cephalon very broad proportionately, with long genal spines and broad, regularly pitted border. Glabella inflated, pear-shaped,

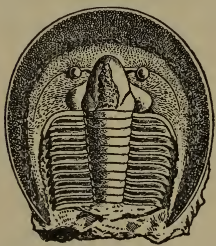

Fig. 1546. *Harpes ottawaënsis.* (After Billings.)

Fig. 1547. *Trinucleus concentricus.* *a*, cephalon showing occipital spine; *b*, entire individual, but without the median spine. (After Logan.)

smooth or with indistinct furrows. Eyes generally absent. Thorax of six segments which are nearly straight at their extremities; axis narrow. Pygidium with margin entire. Ordovicic.

9. **T. concentricus** (Eaton). (Fig. 1547.) Ordovicic.

Glabella finely granulated, produced posteriorly into a spine.

Trenton-Lorraine of Canada, New York, New Jersey, Oklahoma, Nevada, etc.

V. Ampyx Dalman.

Thorax and pygidium resembling *Trinucleus*. Cephalon subtriangular without pitted border. Glabella large, elongate, enlarging anteriorly to the end of the cephalon, beyond which it is often produced into a spine (rostrum). Genal angles spiniform. Ordovicic and Siluric.

(*a*) *Ampyx* restricted.—Glabella oval, terminating in a round spine. Thoracic segments six.

(*b*) *Lonchodomus* Angelin.—Glabella lanceolate, terminating in an elongate, prismatic spine.

10. **A. (Lonchodomus) normalis** Billings. Ordovicic.

Differs from *A. halli* in having the fixed cheeks extend to the base of the rostrum.

Upper Quebec group (Div. N and P, Chazy) of Newfoundland.

Fig. 1548. *Lonchodomus halli.* Top and side view of cephalon, ×2. (After Raymond.)

Fig. 1549. *Lonchodomus halli.* Top and end view of pygidium, × 3. (After Raymond.)

Fig. 1550. *Ampyx niagarensis*, cephalon. (After Van Ingen.)

11. **A. (Lonchodomus) halli** Billings. (Figs. 1548, 1549.) Ordovicic.

Glabella rather sharply carinated along its top, and extending half its length beyond the anterior margin of the fixed cheeks, beyond which it is prolonged as a prismatic spine with a furrow on each of its four sides. Pygidium very broadly triangular, its flat border abruptly bending downward at nearly a right angle.

Chazy of Vermont, New York and Quebec.

12. **A. niagarensis** Van Ingen. (Fig. 1550.) Siluric.

Glabella ovate.

Niagaran of Arkansas.

Order OPISTHOPARIA Beecher.

VI. CONOCORYPHE Corda.

Cephalon semicircular; genal angles produced into spines. Glabella lobed, not extending to frontal border, narrow in front and wide behind, and with three or four backwardly directed furrows and a well marked neck furrow. Fixed cheeks very large; free cheeks narrow. Thorax of 14 segments; pleura grooved. Pygidium small, with entire margin; axis with two to eight segments. Cambric.

13. **C. baileyi** Hartt. (Figs. 1551; 1552, *a*.) Cambric.

FIG. 1551. *Conocoryphe baileyi*, cephalon, × ⅔.

Anterior portion of cephalon finely striated vertically to the border.

St. John group (Acadian) of New Brunswick.

14. **C. elegans** Hartt. (Fig. 1552, *b*.) Cambric.

FIG. 1552. *a*, *Conocoryphe baileyi*, pygidium; *b*, *C. elegans*, cephalon; *c*, *Ctenocephalus matthewi*; *d*, *Olenellus iddingsi*, young. (After Walcott.)

Anterior fold bending inward toward glabella, forming a broad V-shaped elevation.

St. John group (Acadian) of New Brunswick.

VII. CTENOCEPHALUS Corda.

Like *Conocoryphe*, but with a lobe in front of the glabella; glabella less strongly defined, free cheeks larger, pygidium much smaller, and thoracic segments 15. Cambric.

15. **C. matthewi** Hartt. (Fig. 1552, *c*.) Cambric.

Marginal border of cephalon and lobe in front of glabella prominent.

St. John group (Acadian) of New Brunswick.

VIII. Atops Emmons.

Cephalon semicircular, its anterior and lateral edges turned upward. Glabella subquadrate. Free cheeks very narrow, the facial suture running nearly parallel to the sides of the glabella. Axis nearly as wide as the side lobes and ornamented with a medial row of spines; the lateral lobes with a median row of tubercles. Pygidium small.

Differs from *Conocoryphe* in having a more cylindrical and longer glabella, small pygidium and 17 free segments. Lower Cambric.

16. **A. trilineata** Emmons. (Fig. 1553.) Cambric.

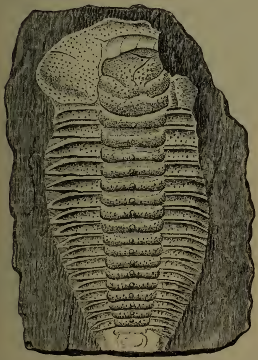

Fig. 1553. *Atops trilineata*. (After Emmons.)

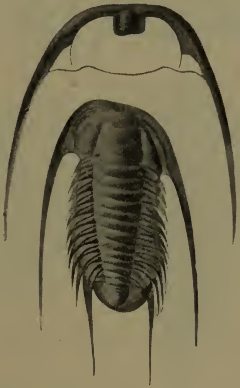

Fig. 1554. *Bathynotus holopyga*, entire individual, × ⅔, and hypostoma attached to doublure. (After Walcott).

Entire surface granular. (Type of genus.)

Lower Cambric of New York and Quebec.

IX. Bathynotus Hall.

Axis wide. Free cheeks united in front and extending backward in long genal spines. Thoracic segments 13. Lower Cambric.

17. **B. holopyga** Hall. (Fig. 1554.) Cambric.

Width of cephalon about twice its greatest length. Axis twice the width of the pleural segments. The lower pleural segments bend abruptly downward and end in spines; the last pair is much prolonged beyond the small, subcircular pygidium.

Lower Cambric (Georgian) of Vermont.

X. Olenellus Hall.

Glabella not enlarging anteriorly, marked with transverse furrows of which the basal ones at least extend entirely across. Eye lobes longer and nearer the glabella than in *Paradoxides,* with both

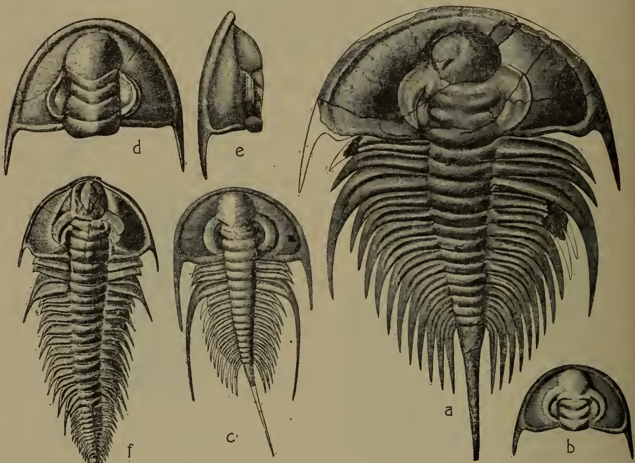

Fig. 1555. *a, b, Olenellus thompsoni,* complete individual, × ½, and young cephalon; *c–e, O. gilberti,* small individual, × ½, and two views of larger cephalon, × ½; *f, Mesonaces vermontana,* complete individual, × ½. (All after Walcott.)

ends practically reaching the glabella. Thorax with 14 segments, with third segment the largest. Pleural grooves shallower, broader and less oblique than in *Paradoxides.* Pygidium (?) a long, telson-like spine. Surface of test covered with inosculating striæ. Lower Cambric.

18. **O. thompsoni** Hall. (Fig. 1555, *a, b*.) Cambric.

Large, very slightly convex; spines of third thoracic segment of moderate length. (Type of genus.)

Georgian of Vermont, New Jersey, Pennsylvania, Quebec, Newfoundland, Labrador, etc.

19. **O. gilberti** Meek. (Fig. 1555, *c–e*.) Cambric.

This western species is very similar to *O. thompsoni,* but it shows great variations in different individuals in width of body, length of genal and third pleural spines, position of genal spines, size of eye lobes, etc. It is also moderately convex.

Lower Cambric (Georgian) of Utah, Nevada and British Columbia.

20. **O. iddingsi** Walcott. (Fig. 1552, *d*.) Cambric.

Outline of head subtriangular.

Lower Cambric (Georgian) of Nevada, etc.

XI. Holmia Matthew.

Cephalon semicircular; glabella with nearly parallel sides; a very long occipital spine present. A small secondary spine occurs on each side, just within the genal angle. Thorax of 18 segments, with a short spine upon each segment of the axis; pleura broad almost to the tip. Pygidium small, subquadrangular.

Lower Cambric of Atlantic provinces of America and Europe.

21. **H. bröggeri** Walcott. (Figs. 1556, *a*; 1556, *e*.) Cambric.

Posterior border of cephalon cut by a notch just within the genal spine.

Lower Cambric (Etcheminian) of Massachusetts and Newfoundland.

XII. Mesonaces Walcott.

Differs from *Olenellus* in that the anterior segments of the thorax are larger than the posterior, and in the plate-like pygidium. Anteriorly like *Olenellus;* posteriorly like *Paradoxides.* Lower Cambric.

22. **M. vermontana** Hall. (Fig. 1555, *f*.) Cambric.
Thorax of 26 segments. (Type of genus.)
Georgian of Vermont, Labrador and Newfoundland.

23. **M. asaphoides** (Emmons). (Fig. 1556, *b–d*.) Cambric.
Third thoracic segment only occasionally longer than the rest; segments 18, the anterior 13 larger than the posterior 5; on each of

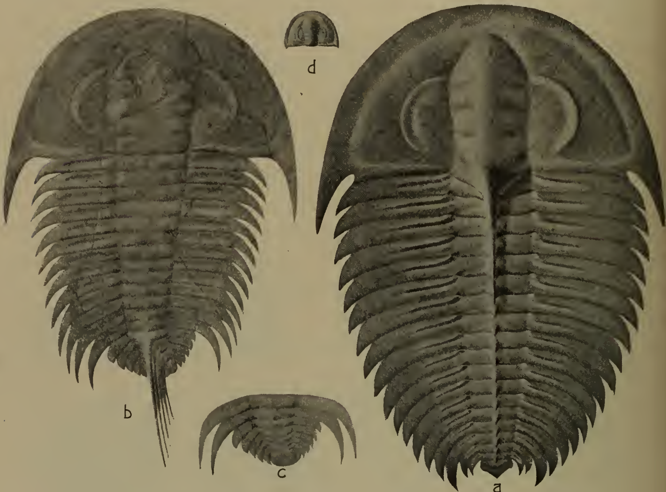

FIG. 1556. *a*, *Holmia bröggeri*, × ½ ; *b–d*, *Mesonaces asaphoides* : *b*, adult, × ½ ; *c*, pygidium, and last thoracic segment without the spines, × ½ ; *d*, young cephalon, × ½. (After Walcott.)

the 5 smaller posterior segments is a long spine projecting back over the transverse, plate-like pygidium. Form broader than in preceding.

Georgian of New York; Etcheminian of Massachusetts (?).

XIII. Ellipsocephalus Zenker.

Cephalon semicircular, depressed, without spines. Glabella smooth, obtusely angular in front. Free cheeks short, narrow; thoracic segments 12–14; axis nearly as broad as lateral lobes. Pygidium small, semicircular. Lower and Middle Cambric.

24. **E. grandis** Matthew. (Fig. 1557, *a–c*.) Cambric.
Sides of glabella concave; each ring of the thoracic axis marked

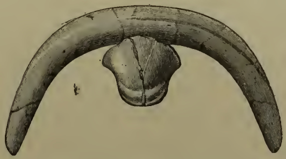

FIG. 1556, *e*. *Holmia bröggeri*, hypostoma and doublure. (After Matthew.)

with a median groove; surface of test covered with minute shallow pits.

Middle Cambric of St. John group (Protolenus bed) of New Brunswick.

25. **E. galeatus** Matthew. (Fig. 1557, *d–f*.) Cambric.

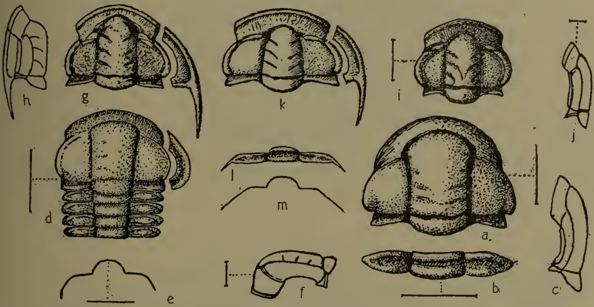

FIG. 1557. *a–c*, *Ellipsocephalus grandis*, cephalon and a thoracic segment; *d–f*, *E. galeatus*: *e*, section of thorax; *f*, side view of cephalon; *g*, *h*, *Protolenus paradoxoides*; *i*, *j*, *P.* (*Bergeronia*) *articephalus*; *k–m*, *P.* (*Bergeronia*) *elegans*. (After Matthew.) The markers are all ⅔ nat. size.

Very convex; surface minutely granular; thoracic rings as in *E. grandis*. Sides of glabella nearly straight.

Middle Cambric of St. John group (Protolenus bed) of New Brunswick.

XIV. PROTOLENUS Matthew.

Cephalon semicircular, convex, with genal spines, and bordered by a distinct fold. Glabella cylindro-conical, marked by furrows on the sides and with a neck furrow extending entirely across. Eye lobes long, narrow. The many flat pleura (grooved for part of their length) are curved backward and end in spines. Middle Cambric.

26. **P. paradoxoides** Matthew. (Fig. 1557, *g, h.*) Cambric.
Thorax narrow; pleura short; axis prominent, with a deep furrow in each ring; pleura flat, with a diagonal groove ending at base of spine, which is short and bent abruptly backward.

Middle Cambric of St. John group (Protolenus bed) of New Brunswick.

XIVA. Bergeronia Matthew.

This subgenus differs from *Protolenus* in having the pleura not flat, but strongly bent downward. Middle Cambric.

27. **P. (Bergeronia) elegans** Matthew. (Fig. 1557, *k–m.*) Cambric.
Cephalon very convex and broad.

Middle Cambric of St. John group (Protolenus bed) of New Brunswick.

28. **P. (Bergeronia) arcticephalus** Matthew. (Fig. 1557, *i, j.*) Cambric.
Differs from *P. elegans* in its narrower and proportionally longer and less convex cephalon.

Middle Cambric of St. John group (Protolenus bed) of New Brunswick.

XV. Paradoxides Brongniart.

Glabella enlarging anteriorly, with well defined lobes, the transverse furrows extending entirely across. Eye lobe shorter and farther from the glabella than in *Olenellus*, with its posterior end farther from the glabella than the anterior. Thorax with 17 to 20 free segments; pleura with spiniform extremities. Pygidium a small, plate-like termination of the axis. Middle Cambric.

29. **P. harlani** Green. (Figs. 1558, 1559, *a, b.*) Cambric.
Thorax with 17 to 19 segments.
Middle Cambric, Braintree slates of Massachusetts.

30. **P. lamellatus** Hartt. (Fig. 1559, *c.*) Cambric.
Anterior lobe of glabella marked with sharp, transverse lamellæ. Thorax with 16 segments.

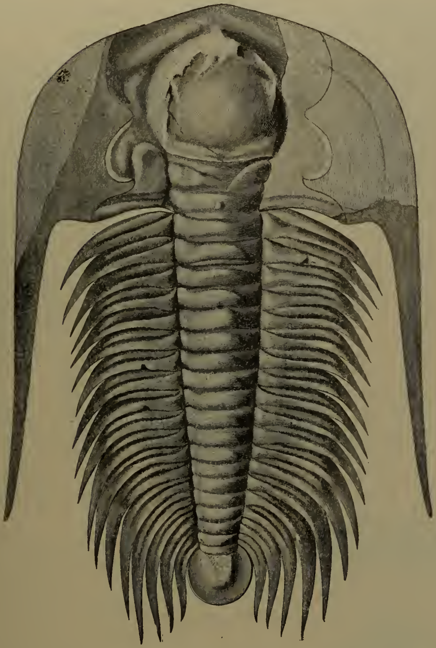

FIG. 1558. *Paradoxides harlani*, × ½. (After Walcott.)

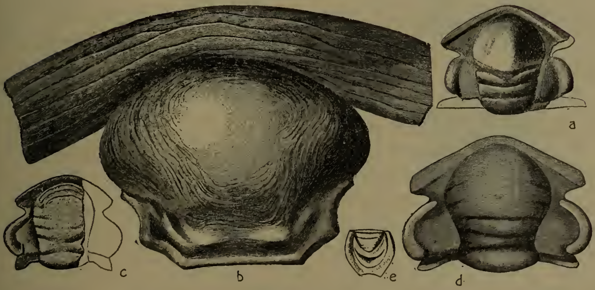

FIG. 1559. *a*, *b*, *Paradoxides harlani: a*, young cranidium, × ⅔, and *b*, doublure and hypostoma of adult, × ⅔; *c*, *P. lamellatus*, an imperfect cranidium, × ⅔; *d*, *P. eteminicus*, cranidium, × ⅔; *e*, pygidium of same, × ⅔. (All after Walcott.)

Middle Cambric of St. John group (Acadian) of New Brunswick. (First or lowest zone.)

31. **P. eteminicus** Matthew. (Fig. 1559, *d, e.*) Cambric.

Anterior border of cephalon making obtusely pointed angle; glabella subtriangular in front.

Middle Cambric of St. John group (Acadian) of New Brunswick. (Second zone.)

32. **P. abenacus** Matthew. (Fig. 1560.) Cambric.

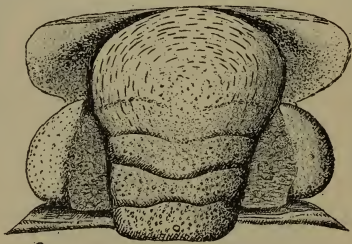

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FIG. 1560. *Paradoxides abenacus*, cephalon of broad form, slightly distorted. (After Matthew.)

Anterior portion of cephalon straight, without pronounced fold; anterior end of glabella broadly rounded.

Middle Cambric of St. John group (Acadian) of New Brunswick. (Third zone.)

33. **P. davidis** Salter. (Figs. 1561, 1562.) Cambric.

Eyes well forward. Thorax of 18 segments; pleura in the adult ending in long spines. Pygidium with a pair of large, pleura-like spines.

Middle Cambric of Newfoundland; also Europe. (Fourth zone.)

34. **P. forchhammeri** Angelin. (Fig. 1563.) Cambric.

Eyes set well back as in *P. harlani;* sides of anterior half of glabella converging at right angles.

Middle Cambric of St. John group (Lower Johannian) of Cape Breton; also Europe. (Fifth or uppermost Paradoxides zone.)

XVI. REMOPLEURIDES Portlock.

Glabella broad, convex, oval. Eyes large, reaching the neck segment. Thoracic segments 11 to 13; axis about as wide as the

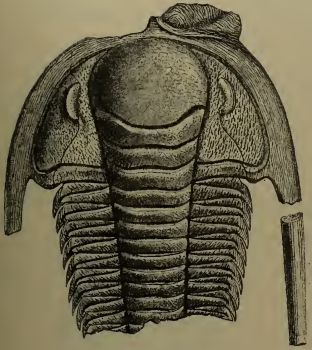

FIG. 1561. *Paradoxides davidis*, half grown individual, × ½, showing part of hypostoma bent upwards. (After Salter, Quart. Journ. Geol. Soc., XX., a European example.)

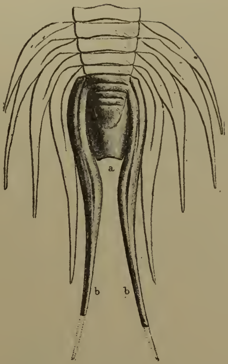

FIG. 1562. *Paradoxides davidis*, normal type of pygidium, × ½. (After Salter, Quart. Journ. Geol. Soc., XX.)

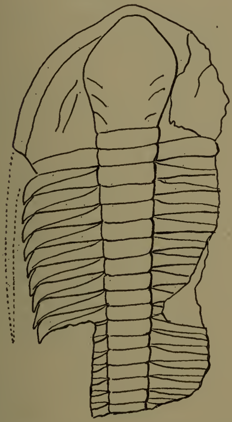

FIG. 1563. *Paradoxides forchhammeri*, outline of a European example. (After Salter.)

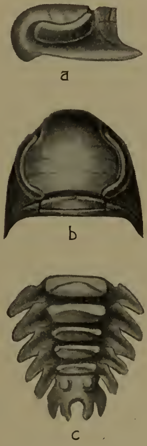

FIG. 1564. *Remopleurides canadensis*: *a*, *b*, cephalon, × 2; *c*, last thoracic segments and pygidium, × 4. (After Raymond.)

lateral lobes. Pygidium small, its axis often reduced to two annulations; the pleural portion produced behind into a spinose flat expansion. Ordovicic.

35. **R. canadensis** Billings. (Fig. 1564.) Ordovicic.

Genal spines short. Pygidium with four flat spines posteriorly and two nodes anteriorly.

Chazy of New York, Quebec, etc.

36. **R. lingualis** Ruedemann. (Fig. 1565.) Ordovicic.

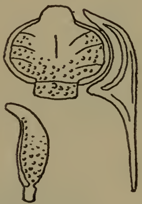

FIG. 1565. *Remopleurides lingualis*; top and side view of cranidium and free cheek. (After Ruedemann.)

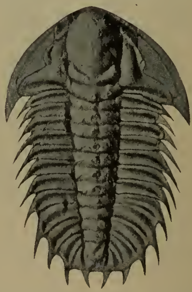

FIG. 1566. *Neolenus serratus*, × ⅔. (After Walcott.)

Palpebral lobes long and narrow, terminating bulb-like posteriorly. Genal spines long.

Lower Trenton of New York.

XVII. NEOLENUS Matthew.

Thorax and usually the pygidium with a spine upon each axial segment and always with each segment terminating in a spine.

Differs from *Parabolina* in having longer pygidium, shorter thorax, eye lobes placed farther back and marginal fold wider.

Differs from *Olenoides* in the strong tapering of the axial lobe from the anterior portion of the glabella to its posterior portion in the pygidium (in *Olenoides* the width for the entire distance is nearly unvarying); also differs in the more distinct segments of the pygidium, the more triangular outline of the cephalon and the narrow pleural grooves. Middle Cambric.

37. **N. serratus** Rominger. (Fig. 1566.) Cambric.

Glabellar furrows three, giving four lobes to each side of the glabella; axis of neck furrow very broad. Surface granular.

Middle Cambric of British Columbia.

38. **N. superbus** Walcott. (Fig. 1567, *a, b*.) Cambric.

Pleural spines produced backwards but slightly. Surface marked with irregular raised lines.

Middle Cambric of Utah.

39. **N. inflatus** Walcott. (Fig. 1567, *c–e*.) Cambric.

Glabella very broad anteriorly. Pygidium with many united segments. Surface as in *N. superbus*.

Middle Cambric of Utah.

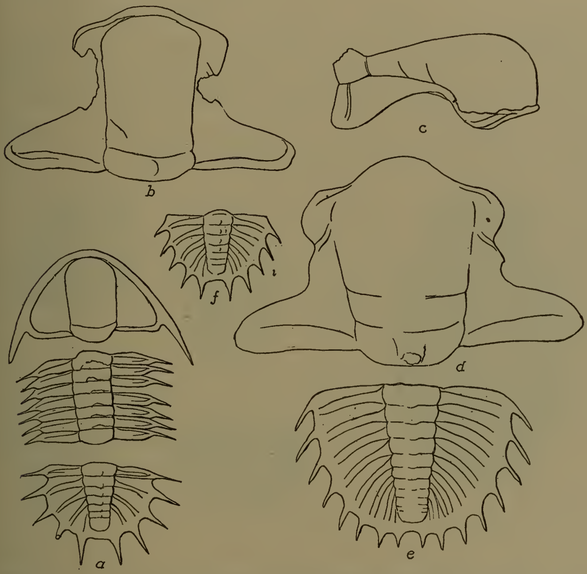

FIG. 1567. *a, b*, *Neolenus superbus*, entire individual and large cranidium, × ⅔; *c–e*, *N. inflatus*: *c*, side and *d*, top view of cranidium; *e*, pygidium, × ⅔; *f*, *N. intermedius*, pygidium, ⅔. (After Walcott.)

40. **N. intermedius** Walcott. (Fig. 1567, *f*.) Cambric.

Intermediate between *N. superbus* and *N. inflatus*. No occipital spine present. Sides of glabella nearly parallel. Pleural and pygidial spines extending backward abruptly, not curved as in *N. serratus*. Surface as in *N. superbus*.

Middle Cambric of Utah.

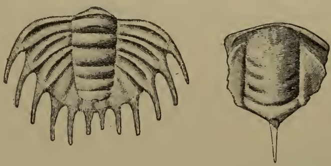

FIG. 1568. *Olenoides wasatchensis*, pygidium and central portion of head, imperfect. (After Walcott.)

XVIII. OLENOIDES Meek.

Glabella elongate with subparallel sides. Eyes elongate. Thorax with seven or more segments. Pleural grooves broad. Spines present on the genal angles, on ends of pleura, on each segment of the axis and on the neck ring. Pygidium broad, with all annulations terminating in short spines. Middle Cambric.

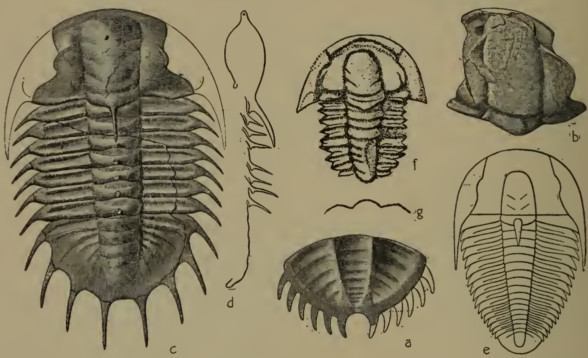

FIG. 1569. *a*, *b*, *Olenoides marcoui*, pygidium and cephalon, the latter crushed; *c*, *d*, *O. curticei*; *e*, *Agraulus quadrangularis*, restored; *f*, *g*, *Strenuella strenua*. (*f*, *g*, after Shimer; *e*, after Grabau; the others after Walcott.)

41. **O. marcoui** Whitfield. (Fig. 1569, *a*, *b*.) Cambric.

Pygidium with flattened spines upon the margin and with nodes upon the four anterior rings of the axis. It lacks the grooved pleura of the pygidium present in *O. wasatchensis* and *O. nevadensis*.

Lower? Cambric of Vermont and Quebec.

42. **O. wasatchensis** Hall and Whitfield. (Fig. 1568.) Cambric.

Ocular ridge near margin of cephalon. Pygidium with narrow pleural grooves, and the three posterior marginal spines shorter than the rest.

Middle Cambric of Utah and Nevada.

43. **O. curticei** Walcott. (Fig. 1569, *c, d*.) Cambric.

Form as in figure; marginal spines of pygidium rounded and long.

Middle Cambric of Georgia.

44. **O. nevadensis** Meek. Cambric.

Larger than preceding; length of thorax 1.7 inches, breadth 2.5 inches; pleural grooves broader. (Type of genus.)

Middle Cambric of Utah and British Columbia.

XIX. Zacanthoides Walcott.

Differs from *Olenoides* in the spine on the posterior end of the fixed cheek, in the larger eyes, situated nearer to the glabella, in the more oblique pleural grooves and longer pleural spines, and in the narrow pygidium which is composed mainly of the axis with two or three spinose segments turned abruptly backward. Thorax of 9 segments; a long spine on the axis of the next to the last segment. Cambric.

45. **Z. typicalis** Walcott. (Fig. 1570.) Cambric.

Glabella subquadrangular; pleura very short, with long spines. Pygidial spines narrow. (Type of genus.)

Middle Cambric of Nevada.

46. **Z. spinosus** Walcott. (Fig. 1571.) Cambric.

Glabella broader than in *Z. typicalis* and spinose segments of pygidium broader.

Middle Cambric of Nevada and British Columbia.

47. **Z. idahoensis** Walcott. (Fig. 1572, *a, b*.) Cambric.

Pleural spines longer and directed more strongly backward than in *Z. spinosus*. Glabella subquadrangular.

Middle Cambric of Idaho.

XX. ALBERTELLA Walcott.

Cephalon large, semicircular, with long genal spines. Glabella subquadrangular, with short, lateral furrows. Fixed cheeks narrow. Thorax with seven segments, the pleura ending in spines,

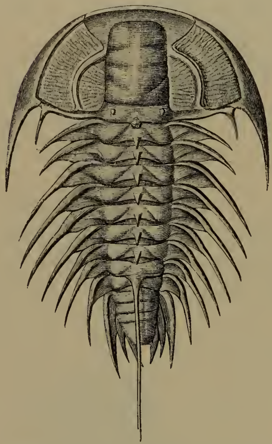

FIG. 1570. *Zacanthoides typicalis*, view of the type specimen, partly restored, × 2. (After Walcott.)

FIG. 1571. *Zacanthoides spinosus*, slightly enlarged. (After Walcott.)

those of the third segment in longer spines; the broad pleural furrow largely filled by an elongated tubercle. Pygidium large, axis broad, the first anterior or first and second united segments extended into a long spine on each side.

Differs from *Zacanthoides* in the spinose extension of the third or fourth thoracic segment and in the presence on the pygidium of only one pair of spines. Cambric.

48. **A. helena** Walcott. (Fig. 1572, *c.*) Cambric.

Moderately convex. Each ring of the thoracic axis with a small median node near the posterior edge and a low transverse ridge next to the dorsal furrow. (Type of genus.)

Middle (?) Cambric of Montana and western Alberta.

XXI. Ptychoparia Corda.

Cephalon with a narrow, raised marginal rim. Glabella narrowing anteriorly; furrows present. Segments of thorax usually 13 to 15. Pleura with backward pointing extremities. Pygidium moderately large. Cambric–Ordovicic.

Fig. 1572. *a*, *b*, *Zacanthoides idahoensis;* *b*, free cheek; *c*, *Albertella helena*. (After Walcott.)

49. **P. adamsi** Billings. (Fig. 1576, *a*, *b*.) Cambric.

Ocular ridge well developed. Form as in figure; glabella nearly parallel-sided.

Lower Cambric (Georgian) of Vermont and Quebec.

50. **P. kingi** Meek. (Fig. 1573.) Cambric.

Glabella short depressed until nearly on a level with the cheeks,

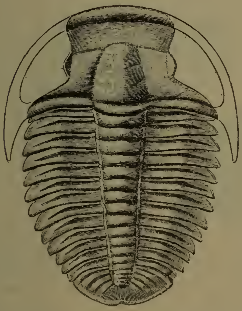

Fig. 1573. *Ptychoparia kingi*, the type specimen. (After Walcott.)

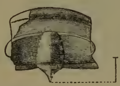

Fig. 1574. *Ptychoparia housensis*, the type specimen, enlarged. (After Walcott.)

separated from the rest of the cephalon by a deep furrow. Thoracic segments 13.

Middle Cambric of Utah.

51. **P. housensis** Walcott. (Fig. 1574.) Cambric.

Only posterior glabellar furrows apparent; fixed cheeks broad. Short occipital spine present. Surface of cephalon finely granulose.

Middle Cambric of Utah.

52. **P. piochensis** Walcott. (Fig. 1575.) Cambric.

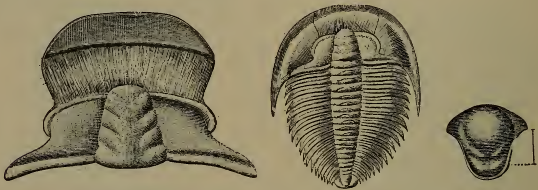

FIG. 1575. *Ptychoparia piochensis*, a large head, a small entire individual, and an hypostoma. (After Walcott.)

Neck ring with a small median node; glabella small, distinctly grooved, anterior cephalic limb broad; thorax of 19 segments. Pygidium small, of three or four united segments.

Middle Cambric of Nevada.

53. **P. robbi** Hartt. (Fig. 1576, *c*.) Cambric.

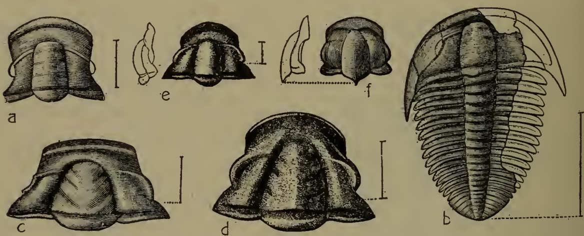

FIG. 1576. *a*, *b*, *Ptychoparia adamsi*, cranidium and entire individual (restored), enlarged; *c*, *P. robbi*, cranidium, enlarged; *d*, *e*, *P. ouangondiana*, two cranidia of different ages, enlarged; *f*, *Strenuella strenua*, cranidium. (All after Walcott.)

Anterior portion of cephalon nearly straight; its width about equal to the entire length of the cephalon. Glabella very convex, more elevated in the middle. Anterior furrows very short, pit-like. Occipital ring with a small, short, tubercle-like spine directed slightly backwards.

Middle Cambric of St. John group (Acadian) of New Brunswick.

54. **P. ouangondiana** Hartt. (Fig. 1576, *d, e.*) Cambric.

Cephalon narrowly rounded; anterior margin wide, with a strong fold, its width less than the length of the entire cephalon. Glabella long, very convex. Middle of occipital ring with a short spine. Neck furrow conspicuous. Surface smooth.

Middle Cambric of St. John group (Acadian) of New Brunswick.

55. **P. oweni** Meek and Hayden. Cambric and Ordovicic.

Free cheeks narrow. Glabella very convex, wide and long. Eyes short, arched. Frontal rim strongly rounded.

Upper Cambric of South Dakota; Middle (?) and Upper Cambric of Montana, etc.; Upper Cambric and Lower Ordovicic of Nevada.

56. **P. (Lonchocephalus) wisconsinensis** (Owen). Cambric.

Frontal limb very broad, occipital spine long and curving.

Flat Head formation of Yellowstone region; St. Croix of Minnesota and Wisconsin.

XXII. Solenopleura Angelin.

Cephalon wide, semicircular. Glabella prominent. Dorsal furrows deep. Fixed cheeks almost as high as the glabella. Frontal limb convex. Neck ring with a tubercle. Genal angles pointed. Thorax with 14 segments; ends of pleura bluntly rounded. Pygidium rather small, with few united segments. Surface of test granulose or tuberculate. Cambric.

57. **S. acadica** Whiteaves. (Fig. 1577.) Cambric.

A furrow bounds the inner side of the marginal rim. Surface of glabella finely granulose.

Middle Cambric of St. John group (Acadian) of New Brunswick.

58. **S. jerseyensis** Weller. Cambric.

Glabella with two pairs of furrows, the anterior pair very faint and transverse, the posterior stronger and arched backward. The entire glabella tapers backward into a very broad triangular spine; neck furrow deep, causing a slight separation of the spine and the glabella.

Lower part of Magnesian limestone (Middle Cambric) of New Jersey.

XXIII. AGRAULOS Corda.

Border of cephalon broad. Eyes small. Thoracic segments 16. Pygidium with three annulations to the axis. Cambric.

59. **A. quadrangularis** (Whitfield). (Fig. 1569, *e*.) Cambric.
Neck ring with cylindrical spine; cranidium subquadrangular.
Middle Cambric, Braintree slates of Massachusetts.

XXIV. STRENUELLA Matthew.

Differs from *Agraulos* in its elevated glabella, broad groove across the shield in front of the glabella, and in the long eye lobes. Neck ring with a broad, triangular, backward pointing projection.

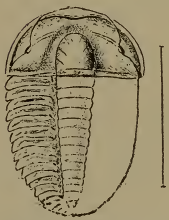

FIG. 1577. *Solenopleura acadica*, restored. (After Matthew.)

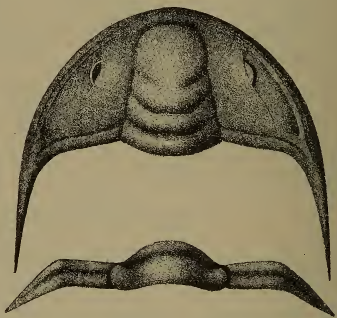

FIG. 1578. *Ptychaspis miniscaënsis*, cephalon and thoracic segment. (After Hall.)

Pleura strongly angular dorsoventrally (Fig. 1569, *g*). Lower Cambric.

60. **S. strenua** (Billings). (Figs. 1569, *f*, *g*; 1576, *f*.) Cambric.
Surface smooth. (Type of genus.)
Lower Cambric (Etcheminian) of Massachusetts and Newfoundland.

XXV. PTYCHASPIS Hall.

Cephalon broad. Fixed cheeks wide, depressed-convex. Glabella generally parallel-sided, convex, transversely lobed, prominent in front; eyes anterior to middle. Frontal limb narrow. Free cheeks nearly as wide as the fixed cheeks and with genal spines. Upper Cambric and Ordovicic.

61. **P. miniscaënsis** Owen. (Fig. 1578.) Cambric.

Glabella very strongly arched and tapering, eyes small. (Type of genus.)

Upper Cambric, Potsdam (St. Croix) of Wisconsin.

XXVI. Chariocephalus Hall.

Differs from *Ptychaspis* in its broader and shorter cephalon, in its large eyes situated near the anterior portion of the glabella, in the different facial sutures, the wide free cheeks, and the divergent genal spines. Upper Cambric.

62. **C. whitfieldi** Hall. (Fig. 1579.) Cambric.

Fixed cheeks narrow, suddenly contracted in front of the eyes.

Upper Cambric, Potsdam (St. Croix) of Wisconsin.

Fig. 1579. *Chariocephalus whitfieldi*. (After Hall.)

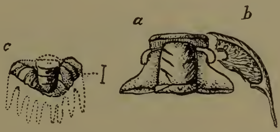

Fig. 1580. *Parabolina spinulosa*, cephalon with free cheek, and pygidium (*c*). (After Matthew.)

XXVII. Parabolina Salter.

Cephalon bordered by a marginal fold. Glabella of approximately the same width throughout. Ocular ridges prominent. Eyes small, anterior. Genal spines present. Thorax with 12 segments; axis narrow; pleura with sharply pointed extremities, bent backwards. Pygidium moderately small, with a lobed or spinose margin. Cambric.

63. **P. spinulosa** (Wahlenberg). (Fig. 1580.) Cambric.

Free cheeks and area in front of glabella ornamented by raised lines.

Upper Cambric (Bretonian) of New Brunswick.

XXVIIA. PARABOLINELLA Brögger.

This subgenus differs from *Parabolina* in that the glabella is shorter and broader; the eyes are farther back; the pygidium is small, without marginal notches or spines.

64. **P. (Parabolinella?) quadrata** Matthew. Cambric.

Differs from *P. spinulosa* in the more convex outline of the anterior part of the cephalon; in the greater distance (4.5 mm.)

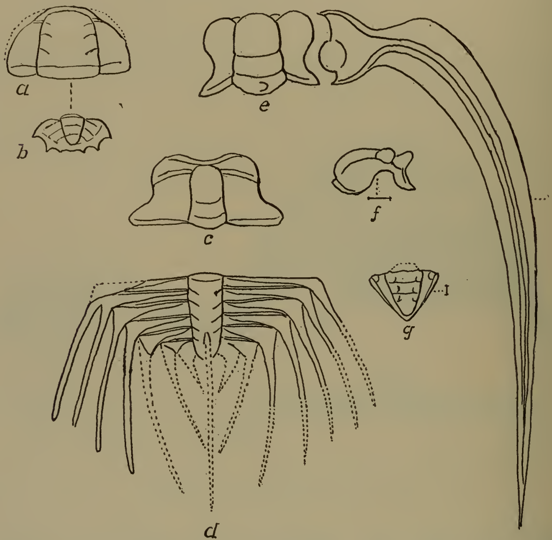

FIG. 1581. *a*, *b*, *Peltura scarabeoides*, enlarged; *c*, *d*, *Ctenopyge pecten*, cephalon and pygidium, both $\times \frac{5}{2}$; *e–g*, *Sphæropthalmus fletcheri*; *e*, front view of cephalon and free cheek; *f*, side view of cephalon; *g*, pygidium; all much enlarged. (After Matthew.)

between the subtruncate anterior part of the glabella and the marginal rim; the eye lobes anterior to the middle of the glabella and opposite the faint anterior (third and fourth) glabellar furrows. The glabella is widest anteriorly and narrowest at the posterior furrow. Posterior and second furrows deeply impressed in the outer third but not reaching the margin of the glabella.

Length of cephalon 25 mm.; width minus the free cheeks at the anterior end 25 mm.; at the posterior end 40 mm.

Upper Cambric (Bretonian) of Cape Breton.

XXVIII. Peltura Milne-Edwards.

Cephalon semicircular. Glabella wide and long, extending nearly to the frontal margin. Eyes small and far forward. Genal margins of cheeks rounded. Axis wider than the pleura. Pygidium shield-shaped, well developed, with notched margin. Upper Cambric.

65. **P. scarabeoides** (Wahlenberg). (Fig. 1581, *a, b.*) Cambric.
Glabella very large. (Type of genus.)
Upper Cambric (Bretonian) of Cape Breton; also Europe.

XXIX. Ctenopyge Linnarsson.

Cephalon like *Sphæropthalmus,* but the middle lobe of the body narrower proportionally; the posterior portion of the fixed cheeks broader. Glabella reaches anterior margin; facial suture a regular sigmoid curve. Pygidium large, its divisions ending in long spines. Cambric.

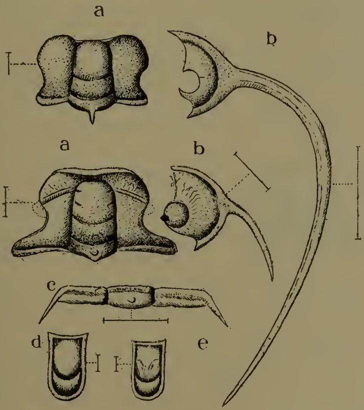

Fig. 1582. *a′, b′, Sphæropthalmus alatus,* var. *canadensis,* narrow form, × 4; *a, b, Ctenopyge acadica,* cephalon and free cheek, × 3; *c,* section of thorax, × 3; *d, e,* hypostoma, × 4. (After Matthew.)

66. **C. pecten** (Salter). (Fig. 1581, *c, d.*) Cambric.
Glabella parallel-sided and reaching the frontal margin. Divisions of the axis of the pygidium prominent only on its sides.
Upper Cambric (Bretonian) of Cape Breton, New Brunswick.

67. **C. acadica** Matthew. (Fig. 1582, *a–e.*) Cambric.
Spine of free cheek opposite median portion of head and strongly curved. The rectangular hypostoma, wholly bordered by a marginal fold, consists of an oval anterior portion and a lower crescent-shaped posterior portion.
Upper Cambric (Bretonian) of New Brunswick.

XXX. Sphæropthalmus Angelin.

Similar to *Leptoplastus,* but middle lobe of body broad, posterior portion of fixed cheeks narrower, genal spine long and arched, eyes spherical and noticeably facetted. Thorax with seven to nine segments. Pygidium triangular, without spines. Cambric.

68. **S. fletcheri** Matthew. (Fig. 1581, *e–g.*) Cambric.
Genal spine sickle-shaped, long, flat, very wide and stiffened by two sharp ridges that run along the middle. Pygidium with a tubercle at each anterior outer corner, and each axial segment with an obscure lobe at each side.
Upper Cambric (Bretonian) of Cape Breton.

69. **S. alatus** (Boeck) var. **canadensis** Matthew. (Figs. 1582, *a′, b′*; 1583.) Cambric.

Fig. 1583. *Sphæropthalmus alatus* var. *canadensis*, × 4. (After Matthew.)

Free cheeks semilunar in outline; genal spines round and comparatively short in the broad form, but long and flattened and with a ridge along the middle, in the narrow form of this variety.
Upper Cambric (Bretonian) of New Brunswick and Cape Breton (?).

XXXI. Leptoplastus Angelin.

Elongate-oval. Cephalon convex, margined by an elevated narrow border and a groove within it. Eyes placed in the middle of the cheeks, joined to the glabella by an ocular ridge. Facial sutures converging in front of the eyes. Genal angles set forward and produced into short, straight spines. Glabella subcylindric or conical. Lateral furrows oblique. Thorax of 11 or 12 segments. Pleura straight, grooved, short, pointed at the ends. Pygidium minute; margin with short spines. Cambric.

70. **L. spinosus** Matthew. (Fig. 1584.) Cambric.

Hypostoma very similar to that of *Ctenopyge acadica* but shorter and without the marginal fold in front. Free cheeks wider than

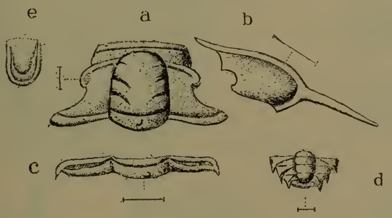

Fig. 1584. *Leptoplastus spinosus*: *a*, middle part of head shield; *b*, free cheek; *c*, segment of thorax; *d*, pygidium; *e*, young hypostoma. (After Matthew.)

long. Pygidium with prominent axis and three short, reflexed spines on each side.

Upper Cambric (Bretonian) of New Brunswick.

XXXII. Crepicephalus Owen.

Like *Ptychoparia* but with projecting posterolateral spines on the pygidium; these are outgrowths from the pygidium as a whole and not terminations of single anchylosed segments. Cambric.

71. **C. augusta** Walcott. (Fig. 1585.) Cambric.

Surface of the larger specimens papillose. Pygidial spines short.

Middle (?) Cambric Pioche formation of Nevada.

72. **C. texanus** Shumard. (Fig. 1586.) Cambric.

Large. Marginal fold of cephalon wide. Pygidium with two strong, curved spines.

Middle Cambric of Alabama, Texas and Wyoming. Middle and Upper Cambric (Weeks and Orr formations) of Utah.

XXXIII. Dikellocephalus Owen.

Cephalon semicircular, flat. Glabella oblong, with parallel sides and marked by three furrows of which the posterior two cross the glabella. Thorax with nine segments; axis narrower than the lateral lobes. Pygidium with a flattened border which is rounded in

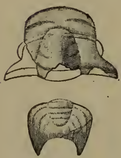

Fig. 1585. *Crepicephalus augusta*, cephalon and pygidium. (After Walcott.)

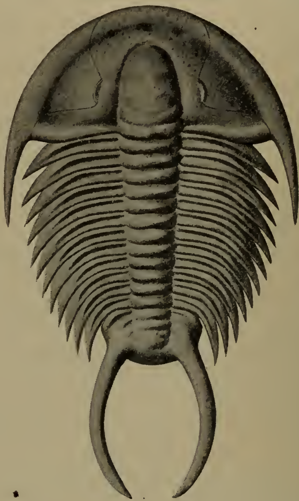

Fig. 1586. *Crepicephalus texanus*, × ⅔, partly restored. (After Walcott.)

the middle and produced laterally into a backward pointing projection on each side. Axis of pygidium extending only half its length and with four to six segments. Cambric.

73. **D. minnesotensis** Owen. (Figs. 1587, *a, b*; 1588, *a, b*.) Cambric.
Very large. Glabella almost flat. Form as shown in figures. Upper Cambric (St. Croix) of Minnesota, etc.

74. **D. osceola** Hall. (Fig. 1589.) Cambric.
Small, length of head one half inch or less. Eyes near glabella. Anterior to glabella is a broad groove with an abruptly elevated narrow border.

Upper Cambric (St. Croix) of Wisconsin; also Nevada.

75. **D. pepinensis** Owen. (Figs. 1587, *c*; 1588, *c, d.*) Cambric.

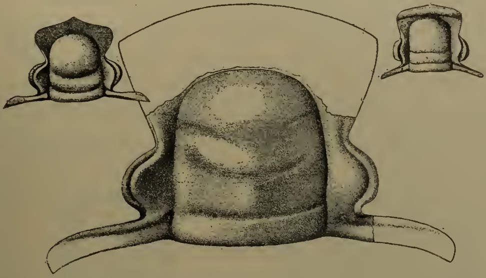

FIG. 1587. *a*, *Dikellocephalus minnesotensis*, cephalon, without free cheeks, of an average specimen; *b*, (upper left) a small variety; *c*, (upper right) *D. pepinensis*, central portion of head. All × ⅔. (After Hall.)

Facial sutures almost parallel to glabella in front of eyes. Pygidium semielliptical.

Upper Cambric (Potsdam) of Minnesota, etc.

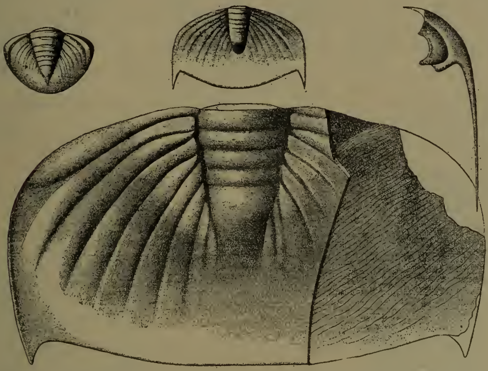

FIG. 1588. *a*, *Dikellocephalus minnesotensis*, large pygidium at bottom, with a small one (*b*) above in center; *c*, *d*, *D. pepinensis*, pygidium and free cheek, left and right. All × ⅔. (After Hall.)

76. **D. newtonensis** Weller. Cambric.

Very similar to *D. pepinensis* but palpebral lobes at about the middle of the length of the head; genal spines slightly shorter and broader; pygidium subsemicircular instead of semielliptical in outline and with its axis prominently rounded, not pointed.

Upper Cambric of New Jersey.

XXXIV. TRIARTHRUS Green.

Elliptical. Cephalon semicircular. Glabella large and well defined, with straight sides and rounded front, marked by three deep furrows extending toward the center from each side. Eyes small. Central axis of thorax wider than the lateral lobes; furrows of

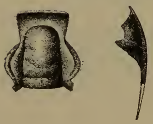

FIG. 1589. *Dikellocephalus osceola*, central part of head, × 2, and cheek, × 1. (After Hall.)

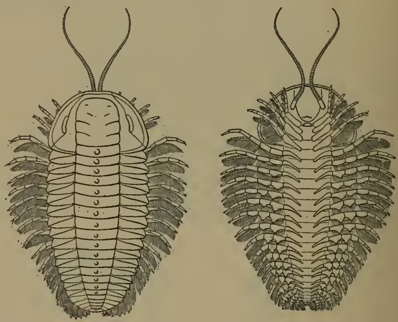

FIG. 1590. *Triarthrus becki*, restoration, showing legs and antennæ, upper and under side. (After Beecher.)

axis not continuous with those of pleura. Thoracic segments 14 to 16. Pleural segments grooved. Pygidium with six segments in the axis and with entire margin. Ordovicic.

77. **T. fischeri** Billings. Ordovicic.

Differs from *T. becki* in its small size (length of cephalon 5.5 mm.) and in the absence of the tubercles from the axial segments.

Upper Quebec group, Div. N and P (Chazy), of Newfoundland.

78. **T. becki** (Eaton). (Fig. 1590.) Ordovicic.

Center of each axial segment marked by a tubercle. (Type of genus.)

Trenton and Utica. Widely distributed in eastern North America.

XXXV. BATHYURISCUS Meek.

Glabella straight or slightly expanded in front, marked by three or four pairs of glabellar furrows. Eyes elongate. Thorax with seven to nine segments; axis strong; pleura with broad grooves. Pygidium semicircular; axis annulated. Cambric.

79. **B. productus** (Hall and Whitfield). (Fig. 1591.) Cambric.

FIG. 1591. *Bathyuriscus productus*, central part of head and pygidium. (After Walcott.)

Thorax of seven segments; pleural grooves extending only about two thirds the distance out from the axis. Pygidium, in well preserved specimens, showing about six rings on the axis and four or five grooves on the pleural portion, with broad, smooth margin.

Middle Cambric of Nevada and Utah.

80. **B. howelli** Walcott. (Fig. 1592.) Cambric.

Glabella expanding in front of second pair of glabellar furrows.

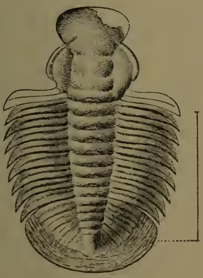

FIG. 1592. *Bathyuriscus howelli*, the type specimen, × 2. (After Walcott.)

FIG. 1593. *Bathyuriscus rotundatus*, a large individual. (After Walcott.)

Pleural grooves extending nearly to the end. Pygidium more strongly segmented than in *B. productus*, and pleural grooves more extended.

Middle Cambric of Nevada and British Columbia.

81. **B. rotundatus** Rominger. (Fig. 1593.) Cambric.

Differs especially from *B. howelli* in its narrower form, more arched palpebral lobes, different facial suture, nine thoracic segments, and the pygidium much longer, with axis and segmentation reaching its margin.

Middle Cambric of British Columbia.

XXXVI. Bathyurus Billings.

Differs from *Bathyuriscus* in the very obscure furrows of its subcylindrical glabella, and in the more strongly convex pygidium, with its longer axis and narrower border. Ordovicic.

82. **B. conicus** Billings. Ordovicic.

Glabella conical, narrowing forward, with a deep furrow all around. Surface covered with tubercles. Cephalon, at least anteriorly, bordered by a furrow. Length of cephalon ⅝ inch.

Beekmantownian of Champlain Valley and Canadian extension.

83. **B. amplimarginatus** Billings. Ordovicic.

Differs from *B. extans* in the broad smooth margin of the pygidium.

Beekmantown of Mingen Islands, and of Pennsylvania, etc.

84. **B. extans** Hall. (Fig. 1594.) Ordovicic.

Very convex. Pygidium with a prominent axis and a thickened margin. (Type of genus.)

Lowville and Black River of New York and Minnesota; Upper Stones River and Trenton of Wisconsin and Quebec.

85. **B. smithi** Billings. (Fig. 1595.) Ordovicic.

Minute. Glabella strongly convex, the most so in the middle. Dorsal and neck furrows deep; frontal margin obtusely rounded.

Black River of Ontario.

86. **B. spiniger** Hall. Ordovicic.

Differs from *B. extans* in its broader frontal border, in the presence of an occipital spine, and in its tuberculate glabella.

Trenton of New York, Ill. and Quebec; Lowville of Kentucky.

XXXVII. Asaphiscus Meek.

Very similar to *Bathyuriscus* but differs in the characters of the cephalon. Anterior to the depressed, conical glabella is a broad fold separated from the raised marginal rim by a broad furrow; eyes more anterior and farther from the glabella. No genal spines present. Cambric.

87. **A. wheeleri** Meek. (Fig. 1596.) Cambric.

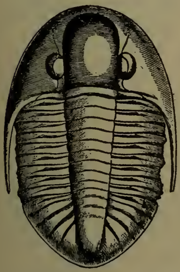

Fig. 1594. *Bathyurus extans.* (After Logan.)

Fig. 1595. *Bathyurus smithi.* (After Logan.)

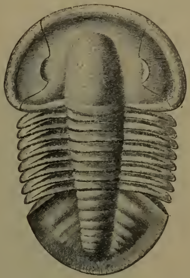

Fig. 1596. *Asaphiscus wheeleri*, partly restored type specimen, × ⅔. (After Walcott.)

Cephalon depressed. Segmentation of pygidium indistinct. Middle Cambric of Utah and Nevada.

XXXVIII. Ogygopsis Walcott.

Cephalon and pygidium well developed. Eye lobes not very strongly arched nor very close to the glabella. Thorax wider near pygidium than at cephalon. Geniculation of pleura recedes farther and farther from the axis in going backward. Pleura grooved. Cambric.

88. **O. klotzi** Rominger. (Fig. 1597.) Cambric.

Cephalon, thorax and pygidium nearly equal, with pygidium slightly the longest. Glabella with parallel sides; the three glabellar furrows very faint. Thoracic segments eight, remarkably parallel and at right angles to axis until at the margin they bend slightly backward into short spines. Segments of pygidium (11 or more) curve backward strongly and expand markedly toward the margin. Axis of both thorax and pygidium narrow, about one fifth of entire width.

Middle Cambric (Stephen formation) of British Columbia.

XXXIX. Asaphellus Calaway.

Like *Isotelus* but hypostoma subcircular with an oval centerpiece and posteriorly a very shallow emargination. Cambric.

89. **A. homfrayi** Salter var. **macropyga*** Grabau and Shimer. (Fig. 1598.) Cambric.

Fig. 1597. *Ogygopsis klotzi*, × ⅔. (After Walcott.)

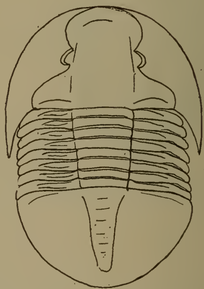

Fig. 1598. *Asaphellus homfrayi* var. *macropyga*, broad form of adult. (After Matthew.)

Cephalon broadly depressed around the margin; glabella scarcely marked out. This variety differs from the species in the thorax being shorter (not longer) than the pygidium, and the genal spines comparatively long (not very short). (This variety was described but not named by Matthew.)

Upper Cambric (Bretonian) of Cape Breton. This marks the highest zone of the Atlantic Cambric, equivalent to the Tremadoc of Great Britain.

XL. Asaphus Brongniart.

Body oval. Cephalon and pygidium large and nearly equal in size, with broad, infolded margin. Glabella expanded, nearly smooth. Free cheeks large. Eyes large and prominent. Hypostoma deeply forked posteriorly. Thorax of eight segments. Pleura grooved, with rounded extremities. Axis rather narrow. Pygidium trilobed, its axis distinctly segmented, the side lobes slightly segmented. Ordovicic.

90. **A. marginalis** Hall. (Fig. 1599.) Ordovicic.

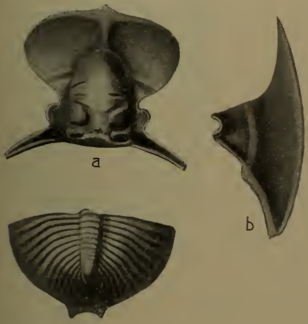

FIG. 1599. *Asaphus marginalis: a*, small cephalon ; *b*, free cheek ; *c*, pygidium. (After Raymond.)

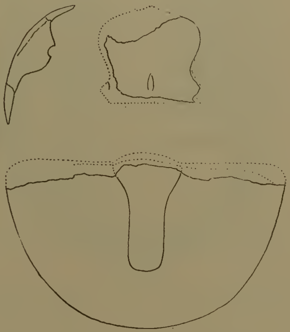

FIG. 1600. *Isotelus canalis*, free cheek, cranidium and pygidium, all × ½. (After Whitfield.)

Cephalon wide in front of glabella. Fixed cheeks very narrow. Segmentation of pygidium not reaching the border, leaving a smooth margin.

Beekmantown (?) of Pennsylvania; Chazy of New York.

XLI. ISOTELUS Dekay.

Differs from *Asaphus* in its broad axis and obsolete segmentation, at maturity, of glabella and pygidium. Ordovicic.

91. **I. canalis** Conrad. (Fig. 1600.) Ordovicic.

Cephalon with nearly rectangular, faintly defined glabella and moderate genal spines; pygidium with comparatively narrow and well defined axis.

Beekmantownian of New York, Vermont, Canada, etc.

92. **I. obtusus** Hall. Ordovicic.

Differs from *I. gigas* in its relatively broader glabella, thoracic pleura sharply turned down at the sides, pygidium without segmentation, and surface of entire test thickly covered with large punctæ. The species can usually be distinguished by this last character.

Chazy of New York.

93. **I. gigas** Dekay. (*Asaphus platycephalus* Stokes). (Figs. 1601, 1602.) Ordovicic.

Pygidium in adult shows scarcely any segmentation except upon the internal mold.

Black River of Canada; Trenton of North America; also in Utica of New York.

94. **I. maximus** Locke. (*Asaphus megistos* Locke.) (Fig. 1603.) Ordovicic.

Similar to *I. gigas* but with genal spines. This species may represent only a phase in the development of *I. gigas*.

Trenton-Richmond of New Jersey, Minnesota and Wisconsin.

XLII. Illænus Dalman.

Cephalon and pygidium large, semicircular, convex, smooth except for the slightly impressed dorsal furrows and the eyes. Glabella smooth, indistinct. Facial suture describes a slightly sigmoidal curve from anterior margin of cephalon to eye; from posterior edge of the eye it curves rather abruptly laterally to the posterior margin of the cephalon, a considerable distance in from the genal angle. Free cheeks small. Eyes usually large and situated laterally. Thorax usually with ten segments and with smooth pleura. Pygidium smooth, similar to the cephalon in form and size, and with short and inconspicuous axis. Ordovicic and Siluric.

A. Free cheek prolonged into genal spines....................I.
- I. Inner margin of free cheek with a rounded furrow..............104. *I. armatus.*
- I. Inner margin of free cheek without a furrow..............97. *I. angusticollis.*

B. Free cheeks not prolonged into spines....................II.
- II. Free cheeks much prolonged laterally..............95. *I. consimilis.*
- II. Free cheeks not prolonged laterally....................1.
  - 1. Eyes very small..............103. *I. imperator.*
  - 1. Eyes large....................a.
    - a. Head with an upward bending of the anterior margin....................11.
      - 11. Outline of head parabolic..............102. *I. insignis.*
      - 11. Outline of head semicircular....................aa.

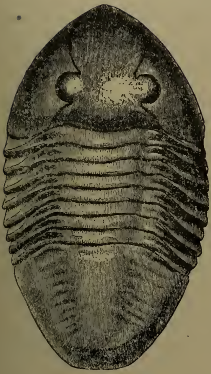

FIG. 1601. *Isotelus gigas*, narrow form, reduced. (After Hall.)

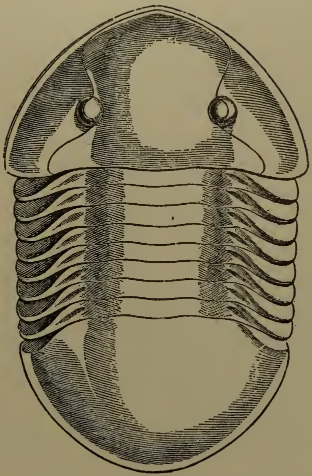

FIG. 1602. *Isotelus gigas*, broad form. (After Logan.)

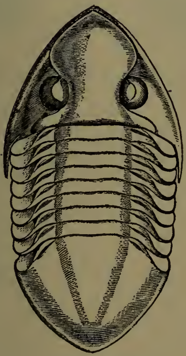

FIG. 1603. *Isotelus maximus*. (After Logan.)

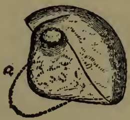

FIG. 1604. *Illænus americanus*, with the outline of the cheek of *I. consimilis*, dotted in *a*. (After Billings.)

aa. Surface of head marked with wave-like wrinkles. 99. *I. americanus.*
aa. Surface of head marked with coarse lines.....100. *I. crassicauda.*
a. Head without upward bending of the anterior margin.................22.
22. Dorsal furrows of head deeply impressed..............................bb.
bb. Sides of the pygidium truncated almost at right angles to anterior margin ....98. *I. latiaxiatus.*
bb. Sides of pygidium not abruptly truncated...........96. *I. globosus.*
22 Dorsal furrows of head not deeply impressed............101. *I. ioxus.*

95. **I. consimilis** Billings. (Fig. 1604, *a.*) Ordovicic.

Differs from *I. americanus* in the nearly flat glabella. Entire surface covered with rudely concentric, fissure-like striæ. Free cheeks produced very far laterally, giving to the head a very broad appearance; the posterior margin of the free cheek outside the eye forms an angle of 50° with the lateral margin of the cheek; in *I. americanus* the angle is 90° to 100°.

Quebec group, Div. L, M, N (Chazy), of Newfoundland.

96. **I. globosus** Billings. (Fig. 1605, *a, c.*) Ordovicic.

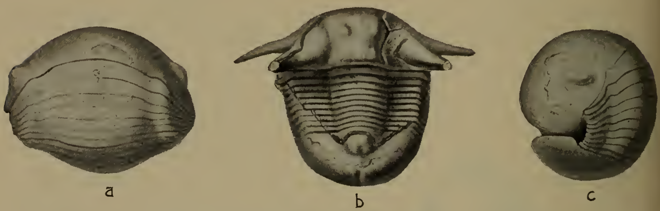

FIG. 1605. *a, c, Illænus globosus*, dorsal and side views; *b, Thaleops arctura*, nat. size. (After Raymond.)

The short dorsal furrows deeply impressed. Genal angles rounded. Thorax of ten segments; axis very wide; dorsal furrows deep. Pygidium unsegmented.

Chazy of New York, Montreal, and Mingen Islands.

97. **I. angusticollis** Billings. Ordovicic.

Cephalon with deep dorsal furrows, only posteriorly impressed. Eyes large. Free cheeks extended into sharp spines. Thorax with narrow axis and deep dorsal furrows. Pygidium short and wide with axis extending about half its length. Entire test finely punctate.

Black River of Ontario and Quebec.

98. **I. latiaxiatus** Raymond and Narraway. Ordovicic.

Very similar to *I. americanus* but cephalon is proportionally wider and has shorter, straighter and shallower dorsal furrows. It differs especially in that the pygidium is much more strongly truncated at the sides (almost at right angles to the anterior margin), less arcuate posteriorly, and with a more convex and prominent axial lobe. The pleural lobes of the thorax are flat for about half their width and are then abruptly deflected almost at a right angle.

Black River of New York and Ontario.

99. **I. americanus** Billings. (Fig. 1604.) Ordovicic.

Strongly convex. Length of entire individual about one and one fourth inches; greatest width of body at posterior portion of cephalon one inch. Transverse fold present at anterior part of cephalon. Eyes situated as in *Bumastus trentonensis*. Trilobation of head confined to posterior part, but here the glabella is quite convex. Axis extends about half across the pygidium. Surface of test marked with wave-like wrinkles. Thoracic axis slightly broader than in *I. crassicauda,* an axis three fourths inch in length being over one half inch in width; pygidium also proportionally smaller.

Trenton of New York and Ontario; Galena of Illinois, Wisconsin and Minnesota.

100. **I. crassicauda** (Wahlenberg). Ordovicic.

Oval, convex. Trilobation extending a short distance into cephalon. Cephalon large, with a short, raised rim, bordering its anterior margin; posterior extremities obscure. Pygidium semicircular, very convex posteriorly. Entire surface smooth. Thoracic axis of one specimen measured three fourths inch in length by less than one half inch in width. (Type of genus.)

Trenton of Vermont, New York, Pennsylvania, Nevada, etc.

101. **I. ioxus** Hall. (Figs. 1606, 1607.) Siluric.

Large. Cephalon subtruncate in front; dorsal furrows broad but not deeply impressed, obsolete in front of the eyes. Eyes large, narrow, near the posterolateral border of the cephalon. Free cheeks wide, bounded inwardly by a narrow ridge parallel with and directly beneath the eye; this ridge marks the inner margin of the depressed area of the cheeks.

Niagaran of New York, Indiana, Illinois, Wisconsin, Tennessee and Arkansas.

FIG. 1606. *Illænus ioxus.* (After Hall.)

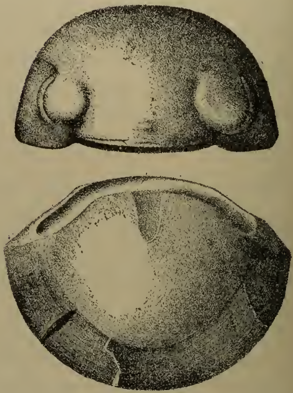

FIG. 1607. *Illænus ioxus*, cephalon and pygidium. (After Hall., 20th Mus. Rep.)

102. **I. insignis** Hall. (Fig. 1608.) Siluric.

Cephalon parabolic in outline, strongly convex; dorsal furrows terminate near anterior margin of cephalon in pit-like depressions. Eyes two and one half to three times as long as high. Anterior

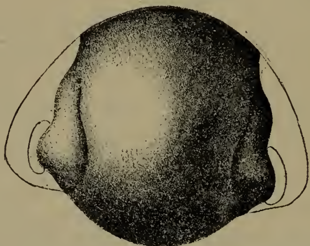

FIG. 1608. *Illænus insignis*, a cephalon with free cheeks, restored. (After Hall, 20th Mus. Rep.)

and lateral margins bent slightly upwards, forming a narrow, lip-like border. Pygidium usually with a slight median longitudinal ridge extending from near the center to the posterior extremities.

Niagaran of Ohio, Indiana, Illinois and Wisconsin.

103. **I. imperator** Hall. Siluric.

Cephalon without the free cheeks wider than long, strongly convex. Eyes short and small, situated far back, almost at the posterior border. Dorsal furrows strong, less than one half the length of the head. Pygidium subelliptical, twice as wide as long, trilobed anteriorly, the axial lobe occupying about one third the width.

Niagaran of Illinois and Wisconsin.

104. **I. armatus** Hall. (Fig. 1609.) Siluric.

FIG. 1609. *Illænus armatus*, two views of perfect cephalon, pygidium with last thoracic segment. (After Hall, 20th Mus. Rep.)

Rounded furrow present beneath the prominent eyes upon the inner margin of the free cheeks. Free cheeks convex, ending in rather short genal spines.

Niagaran of Indiana, Illinois and Wisconsin.

XLIII. BUMASTUS Murchison.

Differs from *Illænus* in practically lacking any longitudinal lobation of the body except slightly on the cephalon. Thorax with eight to ten segments. Ordovicic–Siluric.

105. **B. indeterminatus** (Walcott). Ordovicic.

Dorsal furrows curved. Whole margin of cephalon marked by four or five furrows. Genal spines present.

Chazy-Trenton of New York and Wisconsin; Black River of New York, Ontario and Quebec.

106. **B. milleri** (Billings). Ordovicic.

Differs from *B. trentonensis* in its broader and shorter form, more prominent dorsal furrows on cephalon, and thoracic segments wider and always nine in number.

Black River of Ontario.

107. **B. trentonensis** Emmons. (Fig. 1610, *a, b*.) Ordovicic.
Very convex. Cephalon with no prominences except the eyes.

FIG. 1610. *a, b, Bumastus trentonensis*, enrolled and extended; *c, d, Nileus vigilans*, two views of enrolled individual. (After Clarke.)

Trenton of New York, New Jersey, Illinois, Wisconsin Minnesota and Quebec.

108. **B. niagarensis** Whitfield. (*Illænus madisonianus* Whitfield.) Siluric.

Cephalon differs from that of *I. insignis* in its subelliptical outline, less convexity, and absence of lip-like border; pygidium differs in the absence of the median ridge and in the presence, posteriorly, of an ill-defined concave border. Thorax of 10 segments and with no indication of dorsal furrows.

Clinton of Ohio; Niagaran of Illinois, Wisconsin and Arkansas.

XLIV. Thaleops Conrad.

Very similar to *Illænus* but with deep lobation of cephalon posteriorly, long, attenuate, projecting free cheeks, eyes borne on depressed, divergent stalks. Genal spines blunt, short and projecting. Axis of pygidium deeply defined. Entire surface punctate. Ordovicic.

109. **T. arctura** (Hall). (Fig. 1605, *b*.) Ordovicic.
Differs from *T. ovata* in its more prominent palpebral lobes which rise at an angle of about 30° with the surface of the fixed cheeks. Genal spines smaller and with nearly circular cross section.

Chazy of Vermont and New York; Black River of Ontario.

110. **T. ovata** Conrad. Ordovicic.
Genal spines strong, with a keel on the upper surface, thus giving a triangular cross section. Palpebral lobes at same level as summit of fixed cheeks. (Type of genus.)

Black River of Ontario; Trenton of Illinois, Iowa, Wisconsin and Minnesota.

XLV. NILEUS Dalman.

Very similar to *Bumastus,* but the eyes are larger, crescent-shaped, and placed farther forward; the cephalon is more depressed. Posteriorly the facial sutures extend obliquely outward and backward from the eyes to within the broadly rounded genal angle; anteriorly they first curve outward and then converge nearly parallel with and almost reaching the anterior margin. Thorax indistinctly trilobate and composed of eight very broad segments. Ordovicic.

111. **N. vigilans** Meek and Worthen. (Fig. 1610, *c, d.*) Ordovicic.
Eyes elevated, curved to form three fourths of a circle.
Black River-Lorraine of Illinois and Minnesota.

XLVI. PROËTUS Steininger.

Cephalon semicircular, the thickened margin bounded inwardly by a marginal furow. Glabella very convex, extending nearly to the anterior margin of the cephalon, and rounded anteriorly; occipital lobes usually present. Glabellar furrows often quite obsolete externally but sometimes with their position indicated by dark lines on the surface which seem to show an internal thickening of the test. Neck furrow well marked. Eyes prominent, smooth, and close to the glabella. Palpebral lobes lower than the glabella. Facial sutures extending inward from the posterior margin inside the genal angle to the eyes and then forwards, cutting the anterior margin separately. Thoracic segments usually ten, convex, the pleura medially grooved by oblique furrows. Pygidium semicircular, bounded by a flattened margin; its axis very convex and not reaching the tip, and with usually less than 14 annulations. Entire surface of test granulose. Ordovicic–Carbonic.

112. **P. pachydermatus** Barrett. Siluric.
Glabella subtriangular, tapering forward, with a pair of ovoid, disconnected, basal lobes; the two anterior pairs of furrows faint, the third, just anterior to the ovoid basal lobes, is prominent,

curved, and connected with the neck furrow. In other respects it differs from *P. rowi* in its smaller and more posteriorly placed eyes and longer and narrower pygidium (average size of pygidium is 10 mm. in length by 13 mm. in width). Surface of glabella and pygidium finely papillose.

Upper Siluric (Decker Ferry) of New Jersey.

113. **P. protuberans** Hall. Devonic.

Entire middle lobe of body very prominent. Glabella tapering forward, not distinctly lobed. Cheeks sloping abruptly from the prominent eyes to the outer margin. Genal angles subacute. Neck ring and furrow strong; occipital lobe small. Pleura abruptly bent downward near their ends. Pygidium semicircular, its axis with about eight annulations, the lateral lobes with four or five ribs. Surface granulose.

Lower Devonic (Coeymans) of New York, New Jersey and Oklahoma.

114. **P. latimarginatus** Hall. Devonic.

Differs from *P. rowi* in its narrower form, less tapering glabella, much shorter palpebral lobes; cephalon with a broad, flat margin; three pairs of obscure lateral furrows present on glabella.

Middle Devonic (Schoharie grit) of Indiana.

115. **P. crassimarginatus** Hall. (Fig. 1611.) Devonic.

Fig. 1611. *Proëtus crassimarginatus.* (After Hall.)

Genal spines broad and flat. Glabella large, very convex, subquadrate; no external evidence of glabellar furrows; neck ring broad upon the axis, narrowing upon the cheeks. Pygidium equally trilobate.

Onondaga of New York, Ohio and Ontario.

116. **P. folliceps** Hall. (Fig. 1612.) Devonic.

Genal angles broadly rounded. Glabella very convex, without furrows. Eyes prominent, elevated to about the height of the glabella. Pygidium without a flattened margin but with surface convex and sloping abruptly to the sides.

Onondaga of New York and Michigan.

Fig. 1612. *Proëtus folliceps.* (After Hall.)

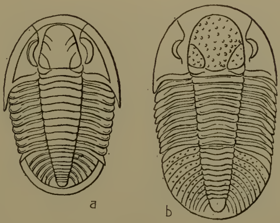

Fig. 1613. *a*, *Proëtus rowi; b*, *P. macrocephalus.* (After Hall.)

117. **P. macrocephalus** Hall. (Fig. 1613, *b*.) Devonic.

Glabella wide and pustulose; a single deep pair of glabellar furrows extend from the anterior angle of the eyes to the neck furrow. Genal spines thin, acute.

Marcellus-Tully of New York.

118. **P. rowi** (Green). (Fig. 1613, *a*.) Devonic.

Glabella without a trace of lateral furrows except when the test is broken away, but with a pair of ovoid, disconnected basal lobes, the occipital lobes. Eyes very large. Genal spines long. Pygidium with a conspicuously thickened border. Surface smooth or faintly pustulose.

Hamilton of New York, etc.

119. **P. missouriensis** Shumard. Mississippic.

Glabella large, tapering slightly anteriorly. Fourth pair of glabellar furrows strong, reaching the neck ring; third and second pairs short; first pair obsolete. Pygidium semicircular, flattened-convex, with width double the length, and with broad, slightly concave margin. Test granulose.

Kinderhook (Louisiana limestone) of Missouri; Waverly of Ohio.

120. **P. peroccidens** Hall and Whitfield. Mississippic.

Differs from *P. macrocephalus* in its longer genal spines, its longer and narrower glabella, free from pustules. Pygidium abruptly convex at sides and posteriorly; its axis with pustules arranged in four longitudinal rows.

Mississippic limestone of Utah.

XLVII. Cyphaspis Burmeister.

Small, oval. Cephalon semicircular. Genal angles produced into long spines. Glabella arched, short and narrow, bounded on all sides by a deep furrow, and with two lobes attached to the base. Cheeks broad and granulose. Eyes small and crescent-shaped. Thorax with 10 to 17 segments, which are all rounded at the extremities. Pygidium semicircular, with two to eight segments in the axis. Ordovicic–Devonic.

121. **C. matutina** Ruedemann. Ordovicic.

Glabella somewhat roundly quadrangular, moderately convex; the anterior two pairs of glabellar furrows faint and oblique, the third semicircular, extending to the neck furrow and separating the pair of less convex basal lobes. Entire surface of cephalon smooth. Otherwise much like *C. ornata.*

Rysedorph conglomerate of New York; Chambersburg limestone of Pennsylvania.

122. **C. trentonensis** Weller. Ordovicic.

Differs from *C. ornata* in its minute size (length of cephalon 5 mm.; width at anterior end between facial sutures 4.5 mm.; length of glabella 3 mm.); relatively large basal lobes; glabella very strongly arched both longitudinally and transversely; frontal border narrow, smooth, bounded by a sharply impressed furrow; between this furrow and the glabella the area (closely pitted) is convex and slightly broader than the frontal border. Frontal border smooth. Glabella and basal lobes tuberculate.

Trenton of New Jersey.

123. **C. ornata** Hall. (Fig. 1614.) Devonic.

Frontal border with a single row of bead-like tubercles and a broad furrow between it and the glabella.

Hamilton of New York, etc.

XLVIII. Phillipsia Portlock.

Like *Proëtus* but with a more prominent glabella, with strong basal glabellar lobes (due to the strong fourth pair of lateral furrows reaching the neck furrow), longer and more segmented pygidium, and nine thoracic segments. Occipital lobes obsolete or obsolescent. This genus replaces *Proëtus* in the late Palæozoic horizons. Differs from *Griffithides* in the subparallel sides of the glabella.

The subgenus *Brachymetopus* McCoy has the glabella very short and the pygidium generally granulose on the axial rings and pleura. Devonic–Permic.

124. **P. (Brachymetopus) tuberculata** Meek and Worthen. Mississippic.

Pygidium very convex, nearly three fourths inch long and seven eighths inch wide; axis of pygidium of about 17 segments, each of which has six small tubercles, arranged so as to form six rows.

Fig. 1614. *Cyphaspis ornata*, fragment of cephalon. (After Hall.)

Fig. 1615. *Phillipsia* (*Brachymetopus*) *lodiensis*. (Pal. Ohio.)

Pleura likewise ornamented by rows of tubercles. Margin flat and prominent.

Burlington of Illinois and Missouri.

125. **P. (Brachymetopus) immatura** Herrick. Mississippic.

Very similar to *P. tuberculata* but much smaller. Pygidium marked with duplicate ribs anteriorly, which are slightly nodose at their marginal ends. Axis and lateral lobes each with about three large, distant tubercles.

Burlington of Missouri; Waverly of Ohio.

126. **P. (Brachymetopus) lodiensis** Meek. (Fig. 1615.) Mississippic.

Axis of thorax ornamented with five longitudinal rows of small tubercles and the pleura with two rows.

Waverly of Ohio.

127. **P. meramecensis** Shumard. Mississippic.

Pygidium slightly wider than long, very convex; median lobe slightly narrower than the side lobes, with about 13 segments which are quite convex centrally, becoming flattened on the sides; side lobes strongly curved downward. Surface strongly granulose.

Upper Waverly of Ohio, Iowa and Missouri.

128. **P. missouriensis** Shumard. Mississippic–Carbonic.

Thorax of 11 segments; pleura rounded, not furrowed. Pygidium elevated, with width greater than length. Surface finely punctate. Margin rather broad and smooth. Width of axis equal to about three fourths of a lateral lobe; annulations about 18. Lateral lobes and axis rather strongly arched transversely. Length of pygidium .7 inch; greatest width .8 inch.

Waverly of Ohio; Coal Measures of Missouri.

129. **P. major** Shumard. Carbonic.

Entire individual elongate-oval in outline. An elongate individual measures in total length 32 mm., width 16 mm., length of cephalon 13.6 mm., thorax 6.4 mm., pygidium 12 mm. Genal spines long, extending to the pygidium. Glabella subquadrangular, wider than the cheeks; fourth glabellar furrow strong, third and second weak, first absent. Eyes large. Pygidium slightly longer than wide; median lobe high, arched longitudinally, compressed and furrowed on each side, with about 23 segments; lateral lobes broader than median one, turned abruptly downward at the sides, but sloping behind more gradually to the smooth, flat border.

Upper Coal Measures of Missouri, Kansas and Nebraska; Carbonic of Colorado, Montana, etc.

XLIX. Griffithides Portlock.

Oval. Glabella expanded anteriorly, depressed and narrowed back of the middle; basal lobes present. Eyes small. Thorax with nine segments. Pygidium rounded, with 13 segments. Differs from *Phillipsia* in the shape of the glabella. Mississippic–Carbonic.

130. **G. portlocki** Meek and Worthen. Mississippic.

Cephalon broadly rounded, the flattened border confined to the side; genal spine short; basal lobes of glabella small, depressed. Eyes small, in the form of oval tubercles and isolated from the much depressed palpebral lobes. Thorax with axis slightly wider than a lateral lobe. Pygidium about a fourth wider than long, with a rather narrow, flattened margin; outline as of *G. scitula*. Entire test granular. One specimen measures in length of cephalon, thorax and pygidium respectively 9.5, 11 and 11 mm.; width of thorax 22 mm.

Keokuk of Illinois, Missouri, Iowa and Nevada.

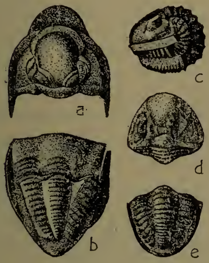

FIG. 1616. *a*, *b*, *Griffithides sangamonensis*, cephalon and pygidium; *c–e*, *G. scitulus*, three views of an enrolled specimen. (Ind. Surv.)

FIG. 1617. *Bronteus lunatus*. (After Logan.)

131. **G. scitulus** Meek and Worthen. (Fig. 1616, *c–e*.) Carbonic.

Small. Genal spines reaching back to the fifth thoracic segment. Cheeks small in comparison with eyes and glabella. Whole surface granular.

Widely distributed in the Coal Measures of the United States.

132. **G. sangamonensis** M. and W. (Fig. 1616, *a, b*.) Carbonic.

Differs from *G. scitulus* in its larger size, more regularly rounded anterior cephalic margin and more pointed or subtriangular pygidium.

Coal Measures of Illinois.

L. Bronteus Goldfuss.

Cephalon less than one third the entire length. Genal angles pointed. Glabella rapidly expanding anteriorly; glabellar furrows indistinct or obsolete. Free cheeks larger than the fixed. Eyes near the posterior border. Thorax of ten segments. Pygidium longer than cephalon or thorax; axis very short, with radiating furrows extending fan-like from it toward the margin. Ordovicic–Devonic.

133. **B. lunatus** Billings. (Fig. 1617.) Ordovicic.

Pygidium marked by six ribs radiating from each side of the axis; the posterior ones are straight, the anterior curved backwards. The axial rib is at times slightly bifid; all ribs flatten out and disappear as they approach the margin.

Trenton of New Jersey, Minnesota and Quebec.

134. **B. acamas** Hall. Siluric.

Dorsal furrows extending slightly more than one third the entire length of the head from the neck furrow; posterior pair of glabellar furrows cutting off a pair of basal lobes; a pair of occipital lobes present. Pygidium with seven slightly elevated ribs radiating from each side of the short axis, each curving first backward and then outward; axial rib with twice the width of the others at the end of the axis and with sides curving outward more and more rapidly until it ends in a width of four or five times that at its beginning. All ribs fade out before reaching the margin.

Niagaran of Illinois and Wisconsin.

LI–LVI. Lichadidæ Barrande.

Cephalon not more than one fourth the entire length; genal angles spiniform. Glabella broad, with very prominent central lobe and one to three lateral lobes on each side. Eyes small. Thorax with nine to eleven segments and with grooved and sickle-shaped pleura. Pygidium large, flat, commonly with notched margin corresponding to the pleural grooves. Surface granulose. Ordovicic–Devonic.

The closely related members of the Lichas family may be subdivided as follows:

A. Glabella with one pair of lateral lobes...I.
 I. Median lobe conical...LIII. *Conolichas.*
 I. Median lobe not conical..1.
  1. Median lobe subquadrate ....LII. *Amphilichas.*
  1. Median lobe constricted in the middle.................................LI. *Arctinurus.*
B. Glabella with two pairs of lateral lobes...II.
 II. Occipital lobes situated posteromedially from the posterior pair of laterals.
LVI. *Metopolichas.*
 II. Occipital lobes situated posterolaterally of posterior pair of laterals ....2.
  2. First lateral furrow extending backward to the neck furrow.
LV. *Dicranopeltis.*
  2. First lateral furrow extending backward to the posterolateral lobe.
LIV. *Corydocephalus.*

LI. Arctinurus Castelnau.

Median lobe of glabella constricted in the middle and extending to neck furrow; only an anterior pair of lateral lobes (the union of the first and second laterals) present, and extending to the neck furrow; occipital lobes absent. Pygidium with axis of one or two segments reaching about half way to posterior border, the broad post-axial region with a notched margin; side lobes with three pairs of grooved segments, the two anterior at least ending in free points. Siluric.

Fig. 1618. *Lichas* (*Arctinurus*) *boltoni*, much reduced. (After Hall.)

Fig. 1619. *Amphilichas minganensis*, cephalon nearly complete and pygidium, × 4/3. (After Raymond.)

135. **A. boltoni** (Bigsby). (Fig. 1618.) Siluric.
Glabella with an anterior nasute extension. Eyes usually crushed, looking in form and position like a second pair of lateral lobes. Pygidium wider than long, deeply notched.

Niagaran of New York and Ontario.

136. **A. occidentalis** (Hall). (Fig. 1621, *a*.) Siluric.
Pygidium with the two lateral margins nearly parallel. Differs from *A. boltoni* in having the pleural segments of the pygidium more elongate and directed more nearly in a posterior direction.
Niagaran of Indiana, Illinois and Tennessee.

137. **A. nereus** (Hall). Siluric.
Differs mainly from *A. boltoni* in that the post-axial lobe of the pygidium has a rounded outline, with a small median notch.
Niagaran of New York and Arkansas.

LII. AMPHILICHAS Raymond. (*Platymetopus* Angelin in part.)

Glabella with a large median and a pair of large side lobes, all subquadrate, very slightly expanding anteriorly, and extending posteriorly to the neck furrow; occipital lobes absent. Pygidium broad and flat, with three pairs of grooved pleura, each ending in a broad, backward pointing lobe. Ordovicic–Devonic.

138. **A. minganensis** (Billings). (Fig. 1619.) Ordovicic.
Small (length of cephalon 14 mm., width of base of cranidium 22 mm.). Cephalon very convex, bent sharply downward in front; bounded by a flat border. Median lobe of glabella nearly rectangular posteriorly, expanding rapidly anteriorly to the middle; neck ring broad, flat. Pygidium with strongly elevated, but rapidly tapering axis; each side lobe consisting of three grooved pleura, curving so as to point directly backward, and each ending in a free point. (Type of genus.)
Chazy of Vermont, New York and Quebec.

139. **A. trentonensis** (Conrad). Ordovicic.
Cephalon nearly semicircular, very convex, the curve along the median line of the glabella from anterior to posterior margins being nearly a semicircle. Median lobe of glabella shaped like an hour-glass; lateral lobes almost as high as the median. Width of cranidium 35 or 40 mm.
Trenton of New York, New Jersey, Pennsylvania, Ohio, etc.

140. **A. pustulosus** (Hall). Devonic.
Median lobe of glabella extremely elevated, standing out beyond and above the side lobes, its length and greatest width about equal;

side lobes more prominent posteriorly than anteriorly. Pygidium with a very prominent axis, which extends about one third its length and rises posteriorly into a rounded knob from which rise two strong spines; the median lobe rises in the middle into a node which bears two spines and then slopes backward and bifurcates; each side lobe with three grooved pleura, each ending in a strong mucronate process, the rounded sinuses between which extend about one third the distance to the axis; the two posterior pleura are straight, the anterior curving slightly backward. Entire surface of test covered by strong pustules with some spines on the axis and ribs of the pygidium.

Helderbergian of New York and New Jersey.

LIII. Conolichas Dames.

Glabella with median and one pair of lateral lobes; the median and sometimes the lateral conically elevated, the elevations often inclined backward. Ordovicic–Devonic.

141. **C. eriopis** Hall. (Fig. 1620.) Devonic.

Fig. 1620. *Conolichas eriopis*, two pygidia. (After Hall and Clarke.)

Median lobe of glabella elongate-pyriform, with anterior half very convex; side lobes very convex posteriorly. Eyes prominent, crescent-shaped. Pygidium as shown in figure. Surface pustulose, and with more or less regularly placed spines.

Onondaga of New York.

LIV. Corydocephalus Corda.

Cephalon crested with tubercles or spines. Glabella with middle lobe protuberant in front and extending back to the neck furrow; the first and second lateral lobes united, forming a single pair of large, forward projecting, compound lobes, while between these and the neck furrow is a pair of occipital lobes. Genal spines curved outward and backward. Pygidium with a thickened border; axis elevated; pleural segments two, each produced into a backward curving spine. Siluric.

142. **C. phlyctainodes** (Green). (Fig. 1621, *b–e*.) Siluric.

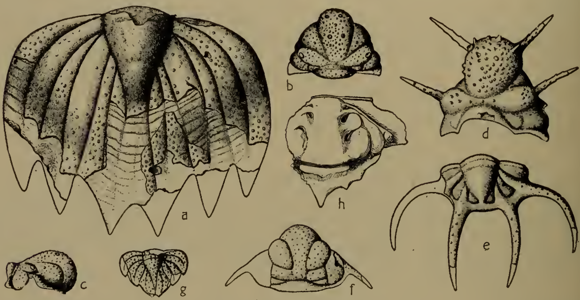

FIG. 1621. *a*, *Arctinurus occidentalis*, pygidium, × ⅔; *b–e*, *Corydocephalus phlyctainodes*: *b*, *c*, top and side view of spineless cranidium; *d*, a spinose cranidium; *e*, pygidium (all × ⅔); *f*, *g*, *Dicranopeltis decipiens*, cephalon and pygidium, × ⅔; *h*, *Acidaspis quinquespinosa*, imperfect cranidium, × ⅔. (*a–g*, after Weller; *h*, after Van Ingen.)

Side lobes of glabella acutely angular behind; median lobe with a pair of spines and each lateral lobe with a single long spine. Pygidium with posterior part of each grooved segment ridge-like and continued into the spine.

Niagaran of New York, Ohio, Indiana, Illinois and Arkansas.

LV. Dicranopeltis Corda.

Cephalon triangular in outline, tuberculate. First glabellar furrow curving back to the neck furrow and deep anteriorly. Anterior lateral lobes relatively larger and posterior lateral and occipital lobes relatively smaller than in *Corydocephalus,* while all the lateral furrows except the anterior pair are placed more transversely and the glabella is narrower posteriorly. Axis of pygidium with two annulations; lateral lobes flattened, with three pairs of grooved segments, each ending in a free point. Siluric.

143. **D. decipiens** Winchell and Marcy. (Fig. 1621, *f, g*.) Siluric.
Genal spines strong, flattened. Axis of pygidium strongly convex anteriorly, tapering to a point posteriorly.
Niagaran of Illinois and Wisconsin.

LVI. Metopolichas Gürich.

Cephalon tuberculate. Glabella broadly subtriangular, with a broad median lobe, a pair of broad anterolaterals and posterolaterals, and posteromedially from these, within the neck furrow, a pair of small occipital lobes. Free cheeks broad, produced laterally into broad genal spines curving outward and backward. Pygidium broad; axis moderately short, of two rings; side lobes broad, with three pairs of grooved segments, the two anterior ending in free points. Siluric.

144. **M. breviceps** (Hall). Siluric.
Neck ring broad and flat. Pygidium semioval, longer than wide; its axis forming a little more than one third its entire width.
Niagaran of Ohio and Indiana.

LVII. Acidaspis Murchison.

Dorsal shield spinose; genal angles spiniform; margin of cephalon thickened and spinose. Glabella with a large median and two lateral lobes. Eyes small. Free cheeks large; facial sutures extend from just within the genal angles inward to the eyes and then forward, cutting the anterior margin on each side of the glabella. Occipital spine present. Thorax of eight or nine segments, with ridged pleura extended into hollow spines. Pygidium usually small, with spinose margin. Ordovicic–Devonic.

145. **A. quinquespinosa** Salter-Lake. (Fig. 1621, *h*.) Siluric.
Cephalon nearly straight in front; surface tuberculate. A straight ocular ridge runs from the eye to the anterior edge of the glabella. The portion of the fixed cheeks between the eye and the glabella is swollen. Axial part of neck ring broad, with five spines posteriorly.
Niagaran of Arkansas.

146. **A. hamata** (Conrad). (Fig. 1622.) Devonic.

Median lobe of glabella subrhomboidal, separated from the two lateral lobes by a furrow reaching the neck furrow. Median lobe rises backward. Neck ring with a tubercle in the middle and pro-

FIG. 1622. *Acidaspis hamata*, central portion of head with occipital spines, profile and surface views. (Pal. N. Y., III.)

jecting behind in two long recurved spines.

Helderbergian of New York.

147. **A. tuberculata** Conrad. (Fig. 1623.) Devonic.

FIG. 1623. *Acidaspis tuberculata*, a nearly complete small individual; central portion of the head; free cheek with eye tubercle. (Pal. N. Y., III.)

Lateral lobes of glabella oval. Eye at inner angle of free cheeks. A single occipital spine present. Glabella pustulose.

Helderbergian of New York.

148. **A. callicera** Hall and Clarke. Devonic.

Differs from *A. tuberculata* in its less depressed and narrower glabella, its weaker marginal spines, its weaker occipital spine, and its almost straight genal spines.

Onondaga of New York and Ontario.

LVIII. ODONTOPLEURA Emmrich.

Distinguished from *Acidaspis* in that the occipital ring is smooth or has merely a central tubercle. Ordovicic.

149. **O. parvula** (Walcott). (Fig. 1624, *a*.) Ordovicic.
Glabellar furrows weak. Eyes large.

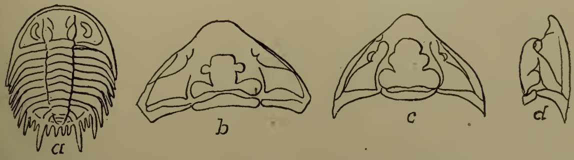

FIG. 1624. *a, Odontopleura parvula; b, Calymene callicephala*, cephalon; *c, d, C. senaria*, cephalon. (After Clarke.)

Trenton of New York, New Jersey and Minnesota.

LIX. GLAPHURUS Raymond.

Differs from *Odontopleura* in having 11 or 12 segments to the thorax and a pygidium with spineless margin. There is a single pair of long, narrow, lateral lobes parallel to the large median gla-

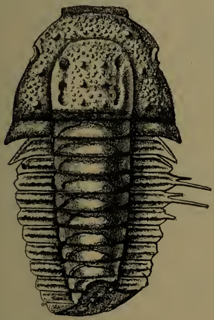

FIG. 1625. *Glaphurus pustulatus*, a nearly entire specimen, × 4. (From an unpublished drawing by Raymond.)

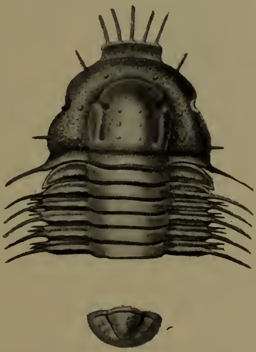

FIG. 1626. *Glaphurus pustulatus*, a nearly complete anterior portion, × 2, and pygidium, × 3. (After Raymond.)

bellar lobe. Eyes small, opposite the anterior half of the glabella. Ordovicic.

150. **G. pustulatus** (Walcott). (Figs. 1625, 1626.) Ordovicic.

Margin of cephalon and thorax spinose. Pygidium small, with very wide axis. (Type of genus.)

Chazy of Vermont, New York, etc.

Order PROPARIA Beecher.

LX. Encrinurus Emmrich.

Cephalon tuberculated. Glabella prominent, slightly spindle-shaped, its furrows indistinct or absent. Free cheeks narrow, separated anterior to the glabella by a small plate. Eyes small, placed on short, conical prominences. Thorax of 11 segments. Pygidium elongate, triangular, numerously segmented. Ordovicic and Siluric.

151. **E. trentonensis** Walcott. Ordovicic.

Pygidium differs from that of *E. ornatus* in lacking the depression along the median line of the axis, and each third or fourth of the 25 annulations bears a median tubercle. The nine or ten ribs on the side lobes curve backward very strongly and are not marked by tubercles. Axis of pygidium terminates within the posterior margin.

Trenton of New Jersey, Illinois, Wisconsin, etc.

152. **E. ornatus** Hall and Whitfield. (Fig. 1627.) Siluric.

Cephalon strongly pustulose. Glabella pear-shaped. Pygidium with depression along middle of axis, marked with tubercles at intervals; also the pleural segments tuberculate.

Niagaran of Maine, New York, Ohio, Indiana, Arkansas, Tennessee, Alabama, Quebec, etc.

LXI. Calymene Brongniart.

Cephalon with a thickened margin. Glabella conical, broadest behind, very convex, divided by three pairs of deep lateral furrows, forming three globular lobes on each side. Eyes small. Facial sutures curving strongly outward, and cutting the lateral margin (see Fig. 1624, *b, d*). Thorax of 13 segments; axial furrows deep. Pygidium of six to eleven segments, usually not distinctly marked off from the thorax. This genus possessed very prominently the power of enrollment. Ordovicic–Devonic.

153. **C. senaria** Conrad. (Fig. 1624, *c, d.*) Ordovicic.

Anterior extension of cephalon narrowed and shovel-shaped, not abruptly concave. Pleural segments of pygidium grooved.

Trenton of New York, New Jersey, Ohio, Minnesota, etc.

154. **C. callicephala** Green. (Fig. 1624, *b.*) Ordovicic.

Differs from *C. senaria* in the broad and abruptly concave, anterior extension of the cephalon, in the absence of genal spines and in the absence of grooving upon the pleural segments of the pygidium.

Trenton-Lorraine of New York, Virginia, Ohio, Indiana, Minnesota, etc.

155. **C. vogdesi** Foerste. Siluric.

Anterior border of head very broad and flat, much like *C. niagarensis.* Pygidium semicircular anteriorly, and almost straight

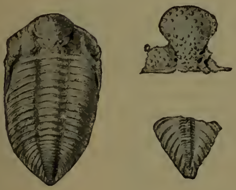

FIG. 1627. *Encrinurus ornatus.* (After Hall.)

FIG. 1628. *Calymene niagarensis.* (After Hall.)

along the posterior margin. Length of a cephalon 15 mm.; width of glabella including posterior lobes 11.7 mm., at frontal lobe 6.5 mm. Length of pygidium 7–17 mm.; breadth 13–27 mm.

Clinton of New York, Ohio, Georgia, Tennessee and Alabama.

156. **C. rostrata** Vogdes. Siluric.

Cephalon with a distinct projecting process in front of the glabella. The facial sutures cut the anterior border at the apex, giving to the anterior part of the cranidium a triangular form; at their junction the marginal border is raised and forms a triangular process which supports the projection.

Clinton of New York and Georgia.

157. **C. niagarensis** Hall. (Fig. 1628.) Siluric.

Genal angles rounded. Glabella strongly convex, elevated above the cheeks; anterior to the first glabellar lobe it is longer, wider and more abruptly rounded than in *C. callicephala* and *C. senaria*. Thorax with side lobes flattened on top for about a third of the length of the pleura and then bent abruptly downward; segments arch forward on the axis, each bearing a rounded node just within the dorsal furrows. The pleura of the pygidium are also more flattened than in the first two species and terminate within the marginal border. The entire pygidium is larger and is promi-

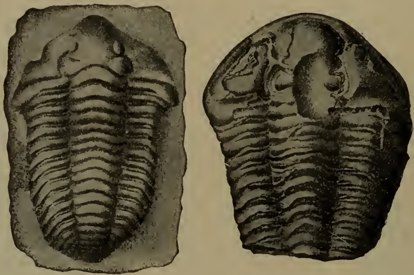

FIG. 1629. *Calymene platys*, × ⅔. (After Hall.)

nently set off from the thorax by its very abrupt inflection and by its ornamentation.

Niagaran throughout central and eastern North America; Guelph of New York, Ohio and Ontario.

158. **C. platys** Green. (Fig. 1629.) Devonic.

Very large. Hypostoma subquadrate, with a notch on each of the four sides. Pygidium truncate and emarginate on the posterior border.

Onondaga of New York and Indiana.

LXII. HOMALONOTUS Koenig.

Large and indistinctly trilobed owing to the obsolescence of the longitudinal furrows. Cephalon wider than long, somewhat pointed anteriorly and with rounded genal angles. Glabella nearly quadrate, nearly smooth, or very faintly furrowed. Eyes small. Thorax of 13 segments. Pygidium triangular and smaller than the cephalon. Facial sutures shown in Fig. 1631. Ordovicic–Devonic.

159. **H. delphinocephalus** (Green). (Fig. 1630.) Siluric.

Dorsal shield convex; cephalon depressed in front. Pygidium strongly triangular, acute, with 12 annulations. Entire surface granulose.

Niagaran of New York and Ontario to Indiana.

FIG. 1630. *Homalonotus delphinocephalus*, × ⅔. (After Hall.)

160. **H. vanuxemi** Hall. Devonic.

Like *H. delphinocephalus* in form but differs in the pygidial axis having 9 or 10 annulations instead of 12, and in the anterior extremity of the cephalon being more broadly produced, giving to it a shovel-like appearance.

Helderbergian of New York and New Jersey; Oriskany of New Jersey.

161. **H. dekayi** (Green). (Fig. 1631.) Devonic.

FIG. 1631. *Homalonotus dekayi* (reduced). (After Hall.)

Pygidium nearly smooth, the trilobation and segmentation being obsolescent. Surface of test pitted.

Hamilton and Marcellus of New York and New Jersey.

LXIII. Ceraurus Green.

Glabella strongly convex, subquadrate or expanding in front, its width one third less than that of the cephalon, rounded and prominent anteriorly, and with three lateral furrows on each side. Eyes small, minutely facetted, considerably removed from the glabella. Genal spines on the fixed cheeks. Facial sutures shown in Fig. 1632. Thorax usually with 11 segments, rarely with 9 to 13. Pleura flattened for a distance and then curved downward and backward. Pygidium small, with segments terminating in projections. Ordovicic and Siluric.

The subgenus *Crotalocephalus* Salter has the posterior glabellar lobes wholly isolated; the pygidium with the free pleural segments ending in six distant, sharp, incurved spines. (Type *C. niagarensis.*)

162. **C. (Crotalocephalus) hudsoni** Raymond. Ordovicic.

Differs from *C. pompilius* in having the glabella expanded toward the front and in the more prominent pustules of the surface. From *C. pleurexanthemus* it differs in having the cheeks smaller and more convex, the eye farther forward and the posterior glabellar lobes isolated.

Chazy of New York.

163. **C. (Crotalocephalus) pompilius** Billings. Ordovicic.

Glabella subrectangular; posterior glabellar lobe subquadrate. Surface papillose.

Chazy of New York, Quebec, etc.

164. **C. pleurexanthemus** Green. (Fig. 1632.) Ordovicic.

Glabella broadest in front. Whole surface of head strongly papillose. (Type of genus.)

Lowville-Lorraine (especially Trenton) throughout most of North America.

165. **C. (Crotalocephalus) niagarensis** Hall. (Fig. 1633.) Siluric.

Neck furrow arches forward and joins the posterior glabellar furrow, thus making the posterior glabellar lobe triangular. The convex lateral and posterior borders are, at their junction, produced straight backward into a slender genal spine.

Niagaran of New York, Indiana, Tennessee, Wisconsin, etc.

LXIV. PSEUDOSPHÆREXOCHUS Schmidt.

Distinguished from *Ceraurus* by the following characters: convex glabella, tapering anteriorly; lateral furrows usually oblique; posterior lobe large, usually not isolated. Glabella one third or

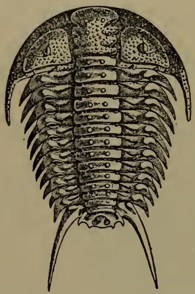

FIG. 1632. *Ceraurus pleurexanthemus.* (After Logan.)

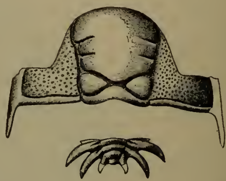

FIG. 1633. *Crotalocephalus niagarensis*, cranidium and pygidium, × ⅔. (After Weller.)

more the width of the cephalon. Free cheeks larger than fixed cheeks. Eyes very close to glabella. Genal angles usually rounded. Pygidium with eight divergent spines. Ordovicic.

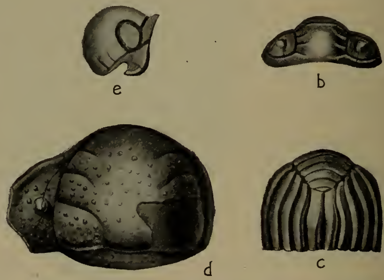

FIG. 1634. *a–c*, *Pliomera canadensis* : *a*, an entire individual ; *b*, cephalon separate ; *c*, pygidium of larger specimen ; *d*, *Pseudosphærexochus vulcanus*, cephalon, × 2 ; *e*, *Sphærexochus parvus*, side view of cephalon, × 2. (All after Raymond.)

166. **P. vulcanus** Billings. (Fig. 1634, *d*.) Ordovicic.

Cephalon bordered by a convex rim. Glabella very large and convex. Surface of test covered with low scattered tubercles.

Chazy of New York and Newfoundland.

LXV. PLIOMERA Angelin. (*Amphion* Pander.)

Cephalon broad, short, with a distinct rim around the margin. Glabella moderately elevated, with two pairs of side furrows and short frontal furrows. Free cheeks small. Thorax with 15 to 19 segments, with inflated pleura. Pygidium smaller than the cephalon; pleural ribs extended into spines. Ordovicic.

167. **P. canadensis** Billings. (Fig. 1634, *a–c*.) Ordovicic.

Spines of pygidium wide and close together and so curved that all point directly posteriorly.

Chazy of Vermont, New York and Quebec.

LXVI. SPHÆREXOCHUS Beyrich.

Glabella very convex or globular, with three pairs of lateral furrows, the posterior one cutting off subcircular basal lobes. Eyes minutely facetted. Thorax of 10 segments; pleura smooth, convex. Pygidium smaller than cephalon, composed of three segments, free at their ends. Ordovicic and Siluric.

168. **S. parvus** Billings. (Fig. 1634, *e*.) Ordovicic.

Neck segment narrow, with furrow deeply impressed. Fixed cheeks small, rounded at genal angles, with a wide border completely surrounding them.

Chazy of Vermont, New York, Quebec, etc.

169. **S. romingeri** Hall. (Fig. 1635.) Siluric.

FIG. 1635. *Sphærexochus romingeri*. Two views of cephalon, natural size; pygidium enlarged, × 2. (After Hall, 20th Mus. Report.)

Much larger than *S. parvus*.

Niagaran of Ohio, Indiana, Illinois, Wisconsin, Arkansas and Tennessee.

LXVII. PHACOPS Emmrich.

Genal angles obtuse or produced into minute spines. Glabella tumid, prominent, widest anteriorly; the two anterior pairs of furrows indistinct. Eyes large, conspicuous, bearing numerous lenses. Thorax of 11 segments, with grooved pleura which are rounded at their extremities. Pygidium semicircular, moderately large, composed of few annulations; margin entire. Siluric–Upper Devonic.

170. **P. pulchella** Foerste. Siluric.

Glabella strongly convex laterally; its sides forming an angle of about 50° with each other. Fixed cheeks strongly convex and sharply defined posteriorly. Length of glabella and occipital ring 5.2 mm., equalling the width of the anterior portion of the glabella. Neck furrow deepest laterally.

Clinton of Ohio and Tennessee.

171. **P. logani** Hall. (Fig. 1636.) Devonic.

Fig. 1636. *Phacops logani.* (After Hall.)

Differs from *P. rana* in the presence of two weak anterior pairs of glabellar furrows besides the strong posterior pair; eyes with about 100 lenses; a prominent tubercle marks the ends of each annulation of the thoracic axis and of the posterior glabellar lobe; the pleural segments of the pygidium are bent backward more strongly and are grooved medially.

Helderbergian of New York, New Jersey and Oklahoma.

172. **P. cristata** Hall. (Fig. 1637.) Devonic.

Cephalon with genal spines; a strong furrow beneath the margin of the cephalon bears laterally ten or eleven crenulations. Glabella strongly projecting. The two anterior pairs of glabellar furrows indistinct; the posterior pair deep but undefined, making the posterior lobes obscure. Center of neck ring and each annulation of thoracic axis bearing a spine. Pleural segments of pygidium strongly grooved medially, giving them a dichotomous appearance; this medial depression does not show upon the internal mold. Glabella and genal angles pustulose; remainder of test smooth.

Oriskany of Ontario; Onondaga of New York.

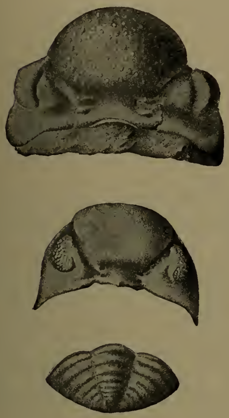

FIG. 1637. *Phacops cristata*. (After Hall.)

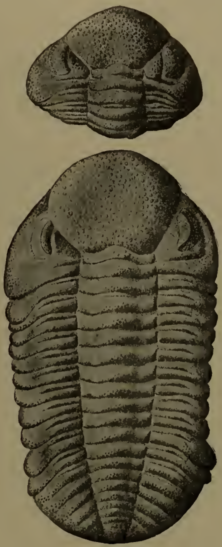

FIG. 1638. *Phacops rana*. (After Hall.)

173. **P. rana** (Green). (Fig. 1638.) Devonic.

The two anterior glabellar furrows obsolete. Eyes with 40 to 50 lenses arranged in eight to ten diagonal rows. Entire test strongly pustulose.

Hamilton and Onondaga throughout eastern North America.

LXVIII. PTERYGOMETOPUS Schmidt.

Very similar to *Phacops* but the cephalon is obtusely angular in front and the lateral furrows of the glabella are well defined. Ordovicic.

174. **P. callicephalus** (Hall). (Fig. 1639, *c, d.*) Ordovicic.

Pygidium shorter and less triangular than in *P. intermedius,* and with its axis not constricted in the middle nor extending to the posterior end.

Lowville-Trenton of New York, New Jersey, Kentucky, Minnesota, Winnipeg, etc.

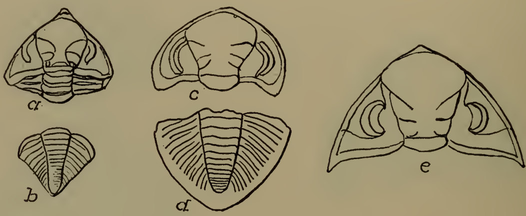

FIG. 1639. *a, b, Pterygometopus intermedius*, enrolled and pygidium; *c, d, P. callicephalus*, cephalon and pygidium; *e, P. eboraceus*, cephalon. (After Clarke.)

175. **P. intermedius** (Walcott). (Fig. 1639, *a, b.*) Ordovicic.

Pygidium triangular, its axis constricted in the middle.

Trenton of New Jersey, Illinois, Wisconsin and Minnesota.

176 **P. eboraceus** Clarke. (Fig. 1639, *e.*) Ordovicic.

Differs from *P. intermedius* in its broader occipital ring which bears at the center a conspicuous tubercle.

Trenton of New York and Frobisher Bay.

LIX. Dalmanites Emmrich.

Glabella widest anteriorly but not much expanded, marked with two or three distinct lateral furrows. Genal angles produced into spines. Eyes large, prominent, with many distinct lenses. For facial sutures see Fig. 1640. Thorax of 11 segments with grooved pleura. Pygidium large, triangular, frequently with terminal spines and 11 to 20 or more annulations. Ordovicic–Devonic.

The subgenus *Synphoria* Clarke includes those forms which have the first and second lateral glabellar lobes more of less coalesced.

Corycephalus Hall includes those forms with the frontal and lateral margins of the cephalon bearing a single row of short spines.

Odontocephalus Conrad includes those with only the frontal border of the cephalon with a series of spines which are in contact at their outer edges.

Frontal margin of cephalon :
- a. Slightly crenulate............184. *D. pleuroptyx.*
- b. With a row of short spines (also on lateral margins)............181. *D. dentatus.*
- c. With a series of spines in contact at their outer edges...........187. *D. selenurus.*
- d. With a single long spine..........*.
  - *. Pygidium ending in a long spine.......... 182. *D. nasutus.*
  - *. Pygidium ending acutely, without a spine..........180. *D. vigilans.*
- e. Acute..........178. *D. limulurus.*
- f. Rounded..........**.
  - **. Neck ring with spine..........185. *D. anchiops.*
  - **. Neck ring without spine..........†.
    - †. Pygidium with a row of spines upon the axis..........186. *D. calypso.*
    - †. Pygidium without spines upon axis..........‡.
      - ‡. Pygidium narrow, elongate-triangular..........177. *D. achates.*
      - ‡. Pygidium broadly triangular..........§.
        - §. Axis with 20 to 21 annulations..........183. *D. micrurus.*
        - §. Axis with 12 to 13 annulations..........179. *D. danæ.*

177. **D. achates** Billings. (Fig. 1640.) Ordovicic.

Frontal margin of cephalon broadly curved. Pygidium narrow, elongate, triangular, with about 14 annulations in the axis and about 10 pleura.

Trenton of New York, Ohio and Ontario.

178. **D. limulurus** Green. (Fig. 1641.) Siluric.

Cephalon pointed anteriorly. Glabellar lobes broad anteriorly and narrow posteriorly. Pygidium triangular and ending in a long slender spine; axial annulations 15; pleura grooved medially. Entire surface granular.

Niagaran of New York, Ohio, Tennessee and Ontario.

179. **D. danæ** Meek and Worthen. Siluric.

Differs from *D. limulurus* in its larger size, in the absence of the marginal rim anterior to the glabella, in the more rounded outline of the pygidium, with fewer (12–13) annulations of the axis. From *D. pleuroptyx* and *D. micrurus*, it differs in the lesser number of segments of the pygidium and in the less granular surface.

Niagaran of Illinois.

180. **D. (Synphoria) vigilans** Hall. Siluric.

Cephalon with pointed genal spines and a long slender upward-curving spine at the frontal margin. Frontal lobe occupying about one half of the entire glabella; the anterior and second lateral lobes somewhat confluent along their outer edges; the third not at all confluent. Eyes elevated above the level of the glabella. Pygidium subtriangular, pointed posteriorly; axis of 11 annulations and side lobes with about nine grooved pleura. Length of cephalon to base of anterior spine 17.5 mm., width 33 mm.; length of pygidium 17 mm., width 20 mm.; length of axis 13 mm.

Niagaran of Indiana, Illinois, Arkansas and Wisconsin.

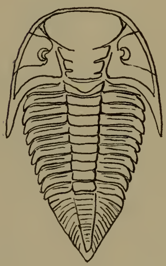

Fig. 1640. *Dalmanites achates.* (After Clarke.)

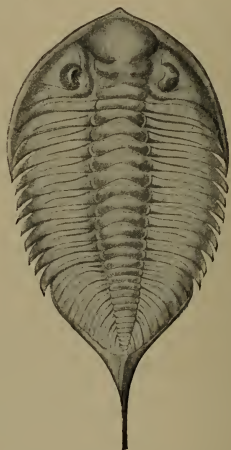

Fig. 1641. *Dalmanites limulurus.* (After Hall.)

181. **D. (Corycephalus) dentatus** Barrett. Devonic.

Very similar in form to *D. limulurus* but lateral and front margins of cephalon with a row of prominent, short, triangular spines. Thoracic pleura extended into sharp, posteriorly pointing spines; pygidial pleura eight instead of eleven. Glabella and pygidium coarsely papillose.

Helderbergian of New York and New Jersey.

182. **D. nasutus** (Conrad). (Fig. 1642.) Devonic.

Cephalon extended into a bifurcating spine. Pygidium prolonged into a single long spine. Entire surface of test pustulose.

Helderbergian of New York, etc.

183. **D. micrurus** (Green). Devonic.

Pygidium very similar in form and surface markings to that of *D. pleuroptyx* but its axis has 20 or 21 annulations and there are 14 to 16 pleura; these latter are likewise less curved than in *D. pleuroptyx*.

Helderbergian of New York, etc.

FIG. 1642. *Dalmanites nasutus*, cephalon and pygidium. (After Hall.)

184. **D. pleuroptyx** (Green). (Fig. 1643.) Devonic.

Marginal rim anterior to glabella crenulate. Pygidium with axis of about 17 annulations; pleura (11–13) marked by a medial groove. Surface of entire test granulose.

Helderbergian-Onondaga of New York, New Jersey and Canada.

185. **D. (Synphoria) anchiops** (Green). (Fig. 1644.) Devonic. First and second glabellar lobes coalesced; third pair very small.

Fig. 1643. *Dalmanites pleuroptyx.* (After Hall.)

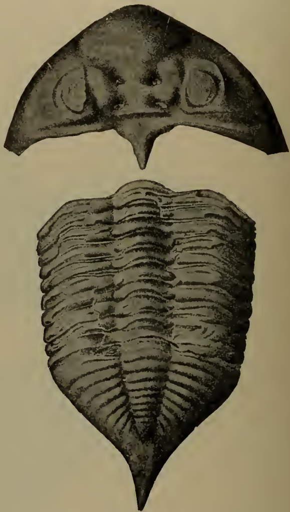

Fig. 1644. *Dalmanites anchiops* var. *armatus.* (After Hall.)

Occipital spine present. Genal spines reaching third thoracic segment (in the variety *armatus* these spines are obsolete while the occipital spine is longer). Thorax nearly rectangular. Surface of cephalon covered by strong tubercles; rest of test smooth or granular.

Oriskanian of Ontario; Onondaga of New York, New Jersey, Indiana, Kentucky and Michigan.

186. **D. (Synphoria) calypso** Hall. (Fig. 1645.) Devonic. First and second glabellar lobes coalesced; third pair inconspicuous. Pygidium convex; axis sharply angular, with about 15 annulations, surmounted by a row of flattened spines. Pleura flat, becoming obsolete upon the wide and slightly thickened border.

Onondaga of New York, Ohio and Kentucky.

187. **D. (Odontocephalus) selenurus** (Eaton). (Fig. 1646.) Devonic.

Frontal border of cephalon with nine spines; genal angles obtuse or produced into minute spines. Pygidium ending in two divergent spines, their bases distant; pleura eight.

Onondaga of New York, etc.

FIG. 1645. *Dalmanites calypso.* (After Hall and Clarke.)

FIG. 1646. *Dalmanites selenurus.* (After Hall and Clarke.)

LXX. CRYPHÆUS Green.

A Dalmanites in which the genal spines are much prolonged; glabellar furrows three; pleura of pygidium prolonged into five conspicuous spines. Devonic.

188. **C. boothi** Green. (Fig. 1647, *a*, *b*.) Devonic.

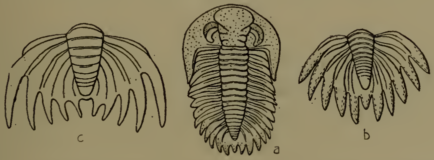

FIG. 1647. *a*, *b*, *Cryphæus boothi*, entire specimen, × ⅔, and pygidium; *c*, var. *calliteles.* (Copies from Hall and Clarke.)

Genal spines broad, lying nearly in a vertical plane, and reaching to the sixth thoracic segment. Pygidium with 11 flat, thick, pustulose spines. (Type of genus.)

Hamilton group of New York, Pennsylvania and Michigan.

188*a*. **C. boothi** var. **calliteles** Green. (Fig. 1647, *c*.) Devonic.

Genal spines reaching the eighth segment. Neck ring very broad, bearing a stout, spine-like node at its center. Each annulation of the thoracic axis bears a similar node. Pygidium with the lateral lobes smooth, narrow, lanceolate, elevated along the middle, and tending toward a parallel arrangement, with the outer ones much longer than the inner ones; the middle or axial lobe is, in adults, shorter than the rest but longer than in *C. boothi* and acutely angled; in young specimens it is very small.

Hamilton and Tully of New York.

Subclass **Phyllopoda** Latreille.

Small crustacea of elongated form, often with distinctly segmented bodies; body covered usually with a flat, shield-shaped or laterally compressed carapace, producing in the latter case a bivalve shell; modern species live in fresh water or in salt marshes.

Literature.

1882. **Clarke, J. M.** Am. Journ. Science, 23 (Devonic).

1888. **Hall, James, and Clarke, J. M.** Pal. N. Y., 7, p. 206.

1862. **Jones, T. Rupert.** A Monogragh of the Fossil Estheriæ. Palæontographical Society Monographs, Vol. 14.

1900. **Clarke, J. M.** Occurrence of Phyllopod Crustacean Estheria, etc., in Eastern N. Y. State Pal. Report, 1900, p. 103 (Mus. Bull. 54, Vol. 1).

Order BRANCHIOPODA Latreille.

I. Estheria Rüppel.

Carapace bivalved; the two valves are thin, rounded, and united by a straight, toothless margin. External surface with concentric ridges or striæ, between which are more or less regularly interlacing or branching striæ; beaks not sharply defined, the umbonal region sometimes bearing a strong eye or muscle node. Devonic–Recent.

1. **E. membranacea** Pacht. (Fig. 1648.) Devonic.

Subcircular; beak subcentral; concentric lines rather prominent, numerous; hinge line straight in front of and behind the beak.

Oneonta-Catskill of New York; Old Red Sandstone of Europe.

2. **E. dawsoni** Jones. Mississippic.

Elongate, length about one and two thirds times height; beak in anterior third, in front of which shell slopes abruptly; posterior

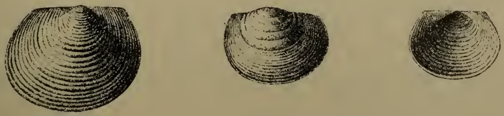

FIG. 1648. *Estheria membranacea*, exterior and interior views, × 4, except middle which is × 8. (After Clarke.)

end subtruncate, slightly produced below the hinge line.

Horton beds of Nova Scotia; also Scotland.

3. **E. ortoni** Clarke. (Fig. 1649.) Carbonic.

Beak more anterior than preceding; anterior end rounded; concentric striæ distant, few; irregular radiating and branching ridges on lower part of shell, and strong node in umbonal region.

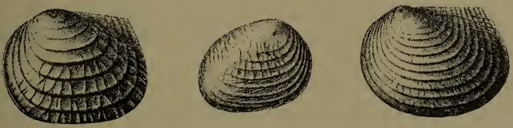

FIG. 1649. *Estheria ortoni*, two left and a smaller right valve, × 8. (After Clarke.)

Lower barren beds (Conemaugh) of Ohio (with *Leaia tricarinata*).

4. **E. ovata** (Lea). Triassic.

Similar to *E. ortoni* (Fig. 1649, *c*) but about twice as large, and the beak nearer the anterior end which is regularly rounded; there are no radiating ridges and the valves are equal. Surface finely pitted, and with strong concentric lines.

Newark formation of North and South Carolina, eastern Virginia and Pennsylvania. Triassic of Kanab Valley, Utah.

II. Schizodiscus Clarke.

Carapace bivalve, shield-shaped, with a straight hinge which is in the major axis of the shield; each valve nearly a semicircle; surface marked with concentric ridges. Devonic.

5. **S. capsa** Clarke. Devonic.

Beak somewhat excentric; anterior end curved to less radius than posterior; concentric striation regular.

Hamilton of New York, etc.

III. Leaia Jones.

Carapace angulated by diagonal ridges which run from near the beak to the lower margin. Carbonic.

6. **L. tricarinata** (Meek and Worthen). (Fig. 1650.) Carbonic.

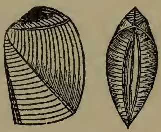

Fig. 1650. *Leaia tricarinata*, × ½. (Ind. Surv.)

Fig. 1651. *Protocaris marshi*, × ½. (After Walcott.)

With three carina-like smooth ridges, the anterior curved, the dorsal ones defining an escutcheon-like area.

Coal Measures of Indiana and Illinois.

7. **L. leidyi** Jones. Carbonic.

Ridges beaded, anterior one straight; no dorsal one; concentric lines more distant and fewer than in *L. tricarinata*.

Pottsville of Pennsylvania.

IV. Protocaris Walcott.

Carapace univalve, with no evidence of a dorsal suture; abdomen of many segments and a single pair of tail spines. Cambric.

8. **P. marshi** Walcott. (Fig. 1651.) Cambric.

Carapace bent downward on the sides, with 31 segments extending out beneath it; surface smooth; no evidence of eyes.

Lower Cambric of Vermont.

V. Anomalocaris Whiteaves.

These bodies resemble the segmented abdomen of a branchiopod, each segment with a pair of lamellate appendages which are gently rounded; posterior terminal segment with three pairs of spines; no carapace known; of doubtful affinities.

9. **A. canadensis** Whiteaves. Cambric.

Body from 9–13 segments, exclusive of caudal segment. (Type of genus.)

Middle Cambric (Stephen formation) of British Columbia, abundant.

Subclass **Ostracoda** Latreille.

Small crustacea, indistinctly segmented and completely enclosed in a horny or calcareous bivalve *shell*. The *valves* are joined dorsally by a membrane; they are either in contact, or overlap. In specialized types a *denticulate hinge structure* is present. The valves separate along the ventral side and ends. The shell corresponds to the *carapace* of other crustaceans.

The surface of the shell may be smooth, or variously modified by *tubercles, lobes* and *sulci;* an *eye tubercle,* situated in the anterodorsal region is often present. The surface may be *pitted* or *reticulated* by a regular net-work of lines; or it may be *ridged* or *striated* by horizontal, more or less branching and uniting ridges. *Nodes* are frequently found, either of indefinite outline or as regularly and sharply defined *tubercles.* A characteristic feature of many groups is the development of one or more vertical grooves or sulci. Sharp lines and *ridges,* parallel to the ventral margin or otherwise disposed are found in many genera; a marginal expansion or *flange,* often overhanging the contact margin of the valves, is not infrequently found.

The valves may be of equal size, or unequal, the larger overlapping the smaller lid-like all around, or ventrally. In most Palæozoic genera the *hinge line* is formed by the straight dorsal margin of the valves, while in other cases this margin is rounded, the true hinge being below it.

The orientation of the valves is a simple matter when an eye tubercle is present, as this always marks the anterodorsal end. The thicker end of the shell is, as a rule, the posterior, but this is not absolute. When the two ends are unequal, the one showing the backward sweeping curve is the anterior, the most projecting end, basally, being the posterior (see, further, Ulrich and Bassler, *loc. cit.*, 1908, p. 280).

Most living ostracods are marine or brackish water types; the Cypridæ, however, are an exception, occurring in fresh water. They are gregarious, either living as plankton, or leading a benthonic life in shallow ocean depths. Most of these shells are minute and will usually be overlooked, unless searched for with a lens on the surfaces of fine shale laminæ. Washings of the residue of weathered or dissolved rocks often yield a rich harvest of these organisms.

Literature.

A. *Palæozoic.*

1858. **Jones, T. Rupert.** On the Palæozoic Bivalve Entomostraca of Canada. Can. Org. Remains, Dec. III., pp. 91–102, pl. XI.

1889. **Jones, T. Rupert.** On some Palæozoic Ostracoda from Pennsylvania. American Geologist, Vol. IV., pp. 337–342, with plates.

1890. **Jones, T. Rupert.** On some Palæozoic Ostracoda from North America, etc. Quart. Journ. Geol. Soc. London, Vol. 46, pp. 1–31, pls. I–IV.

1890–91. **Ulrich, E. O.** New and Little Known American Palæozoic Ostracoda. Journal Cincinnati Society of Natural History, Vol. 13, pp. 104–137; 173–211, pls. 7–18.

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1906–08. **Ulrich, E. O., and Bassler, R. S.** North American Palæozoic Ostracoda, pts. II and III. Proceedings of the U. S. National Museum, Vol. XXX., pp. 149–164, pl. XI.; and Vol. XXXV., pp. 277–340, pls. XXXVII.–XLIV.

B. *Mesozoic and Cenozoic.*

1886. **Jones, T. Rupert.** On some Fossil Ostracoda from Colorado. Geol. Magazine, n. ser., Decade III., Vol. III., pp. 145–148, pl. IV.

1893. **Jones, T. Rupert.** On some Fossil Ostracoda from S. W. Wyoming and from Utah. Geol. Magazine, n. ser., Decade III., Vol. X., pp. 385–391, pl. XV.

1901. **Ulrich, E. O.** Eocenic Ostracoda of Maryland. Md. Geol. Surv., Eocene Volume.

1904. **Ulrich, E. O., and Bass er, R. S.** Miocenic Ostracoda of Maryland and Virginia. Md. Geol. Survey, Miocene Volume.

The classification of the Ostracoda is still in an unsettled state. The work of Messrs. Ulrich and Bassler among the Palæozoic ostracods will, it is expected, supply us with one, based on genetic principles, and the student is referred to their papers as they appear. For later genera the works of Jones and especially those of Brady on the recent species should be consulted. The arrangement in the following pages is chronologic so far as possible, no attempt at grouping into larger divisions being made.

Artificial Key to the Genera.

A. Dorsal edge of valves straight, forming hinge-line..I.
- I. Shell without sulci, nodes, ridges or prominent depressions..........................1.
  - 1. Surface smooth, often glossy.. ....*a*.
    - *a*. Valves regularly convex but unequal and overlapping......... ....oo.
      - oo. Left valve the larger, overlapping right valve......III. *Leperditella*.
      - oo. Right valve the larger, overlapping left valve.... ....*aa*.
        - *aa*. Shell large, generally with eye tubercle... ....IV. *Leperditia*.
        - *aa*. Shell small................................. ....†.
          - †. Without eye tubercle..............................VI. *Schmidtella*.
          - †. With eye tubercle; ventral edge thickened. VIII. *Paraparchites*.
    - *a*. Valves convex, equal, not overlapping......... ....11.
      - 11. Large, 3 mm. or more in length............................V. *Isochilina*.
      - 11. Small, less than 3 mm. in length.......................VII. *Aparchites*.
  - 1. Surface pitted, striated or reticulated...*b*.
    - *b*. Hinge-line shorter than shell...22.
      - 22. With central or subcentral spot or pit; valves subequal, not overlapping...*bb*.
        - *bb*. Spot faint, margin without rim.....................XI. *Primitiopsis*.
        - *bb*. Spot strong, subcentral, margin elevated......XXXVII. *Kirkbya*.
      - 22. With excentric umbilical pit; right valve overlapping the left. XXXVIII. *Barychilina*.
    - *b*. Hinge-line forming greatest length of shell or nearly so. XVII. *Macronotella*.
- I. Shell with broad dorsal depression...2.
  - 2. Depression subtriangular, defined by sharp converging ridges. I. *Hipponicharion*.
  - 2. Depression indefinite..II. *Beyrichona*.
- I. Shell with one or more definite vertical or oblique grooves or sulci, with or without additional spines or nodes...3.
  - 3. With a single median or submedian depression or sulcus.........................*c*.
    - *c*. With pronounced marginal flange..33.
      - 33. Flange continuous...XVI. *Eurychilina*.
      - 33. Flange absent from anterior portion............XXVIII. *Ctenobolbina*.
    - *c*. Without marginal flange (a supramarginal sharp ridge may be more or less developed)........................... ....44.

44. Surface smooth...*cc.*
cc. Marginal ridge faint or absent...††.
††. Sulcus not bounded by prominent nodes ....*.
*. Median depression broad, undefined........IX. *Primitiella.*
*. Median depression a well defined sulcus....................1′′.
1′′. Sulcus narrow, not extending below the middle.
X. *Primitia.*
1′′. Sulcus broad, extending nearly to ventral margin.
XV. *Dilobella.*
††. Sulcus with a prominent rounded node on each side.
XIII. *Ulrichia.*
††. Sulcus surrounded by swollen node-like or ridge-like surface of shell.. ....XXXV. *Beyrichiella.*
cc. Marginal ridge pronounced...†††.
†††. Sulcus with one or two strong spines on each side, marginal ridge continuous....................................XIX. *Dicranella.*
†††. Sulcus with prominent elongated rounded nodes only, marginal ridge not complete............................XX. *Drepanella.*
44. Surface pitted...XIV. *Halliella.*
3. With two sulci, producing three unequal lobes.......................................*d.*
d. Sulci vertical, mostly straight...55.
55. Anterior node sometimes compound ; margin with flat overhanging flange...XXIX. *Beyrichia.*
55. Anterior and posterior nodes confluent with shell ; sulci short ; marginal rim faint or absent...*dd.*
dd. Valves subequal...XXX. *Klœdenia.*
dd. Valves unequal, the right overlapping the left.
XXXIV. *Klœdenella.*
d. Sulci curved and oblique, anterior one generally much weaker or even obsolete ....XXVIII. *Ctenobolbina.*
3. With three sulci, the intermediate nodes often narrow and ridge-like.........*e.*
e. A marginal or submarginal rim formed by ventral union of outer nodes..66.
66. Inner ridges not swollen at ends, and uniting with marginal rim...*ee.*
ee. Ridges thin, often dividing, no spines present.
XXVII. *Tetradella.*
ee. Ridges thick, posterior one with horn-like or mushroom-like process ....XXVI. *Ceratopsis.*
66. Inner ridges thick, uniting ventrally into a horse-shoe-shaped ridge. *ff.*
ff. Horse-shoe ridge large, often swollen at the ends...XXV. *Bollia.*
ff. Horse-shoe ridge minute, dorsally situated.....XXIV. *Placentula.*
e. No distinct marginal rim, all the lobes irregular and confluent...........77.
77. Right valve the larger.............................XXXIV. *Klœdenella..*
77. Left valve the larger....................................XXXVI. *Jonesina.*
I. Shell with ridges, nodes or spines, but with the sulci not definitely developed...4.
4. No marginal flange or rim, but supramarginal ridges may occur...............*f.*
f. Surface with two narrow ridges, converging ventrally..I. *Hipponicharion.*
f. Surface with curved ridge, generally parallel to basal margin............88
88. Ridge narrow, elevated..*gg.*
gg. Ridges U-shaped or crosier-shaped, no further nodes.
XVIII. *Jonesella.*

gg. Ridge curved parallel to basal margin or partly so................4†.

4†. With continuous or discontinuous nodes, ridge complete. XX. *Drepanella*.

4†. With spines instead of nodes, ridge continuous. XIX. *Dicranella*.

4†. Without nodes or prominent spines, ridge continuous or discontinuous...**.

**. Surface smooth (except for small anterior spines in one species), marginal ridge often discontinuous..XXI. *Moorea*.

**. Surface with twisted ridges.................................2″.

2″. Ridges few and S-shaped, one partly enclosed by incomplete marginal rim......................XXII. *Strepula*.

2″. Ridges numerous, dividing and mostly longitudinal. XXXVII. *Kirkbya*.

2″. Ridges ring-like, or forming figure 8. XXIII. *Octonaria*.

88. Ridge broad, nodes strong.............................XXXI. *Scofieldia*.

f. Surface without curved ridges, but with strong dorsal spine. XII. *Æchmina*.

4. With more or less well developed marginal flange or frill.................. ...*g*.

g. Flange extending around most of the valve, radiately striated, surface pitted, base swollen, a rounded posterior and elongate anterior node present...XXXII. *Treposella*.

g. Flange extending only part way around ventral margin, not distinctly striated — a large median round and a smaller posterior round node present, besides minor nodes or spines...................XXXIII. *Hollina*.

B. Dorsal edge more or less curved or irregular; hinge-line within or below it......II.

II. Valves without teeth, surface mostly smooth......................................5.

5. Surface without median depression.................. ....*h*.

h. Shell extremely ventricose..99.

99. Left valve the larger, overlapping the right; no depressed spot or pit......................... ....XXXIX. *Pachydomella*.

99. Right valve the larger, overlapping the left, with subanterior depressed spot or pit.................... ....XXXVIII. *Barychilina*.

h. Shell of moderate convexity..ooo.

ooo. Valves overlapping dorsally as well as ventrally.....................*hh*.

hh. Left valve the larger.. .....5†.

5†. Form elongate...***.

***. Right valve with posterior spinose prolongation. XL. *Krausella*.

***. Without spinose prolongation.........XLV. *Bythocypris*.

5†. Form subtriangular or rhomboidal............XLIII. *Bairdia*.

hh. Right valve the larger ....XLVIII. *Cytherella*.

ooo. Valves overlapping ventrally but not dorsally.........................*ii*.

ii. Greatly elongate, thickest in center, pointed posteriorly. XLIV. *Pontocypris*.

ii. Moderately elongate, wedge-shaped, thickest posteriorly, hinge toothed ....XLIX. *Metacypris*.

ii. Reniform or oval..6†.

6†. With anterior or ventral hook-like projection. XLVI. *Cypridea*.

6†. Without hook-like projection.................. ...XLVII. *Cypris.*
000. Valves not overlapping...*jj.*
jj. Ovoid, with anterodorsal hook-like projection.... XLII. *Cypridina.*
jj. Elongate, bean-shaped, without hook or notch .....L. *Cytherideis.*
5. Surface with median vertical furrow or depression..................................*i.*
i. Depression strong, a narrow sulcus present....................XLI. *Entomis.*
i. Depression faint and indefinite..111.
111. Dorsal view triangular, hinge with a single posterior tooth.
XLIX. *Metacypris.*
111. Dorsal view ovoid or oblong..L. *Cytherideis.*
II. Valves with teeth and sockets along hinge-line, surface generally nodose or pustulose...6.
6. A single tooth present at each end of the hinge-line.............. .. ..*j.*
j. Ventral margin not projected laterally...222.
222. Teeth connected by horizontal bar...........................LI. *Cythere.*
222. Teeth not connected by bar...............................LIA. *Cythereis.*
j. Ventral margin with lateral wing-like projection......LIII. *Cytheropteron.*
6. Hinge-line with a row of small teeth..............................LII. *Cytheridea.*
6. A single posterior tooth, laminated anterior projection....XLIX. *Metacypris.*

I. Hipponicharion Matthew.

Valves subequal, wide, semielliptical and subequilateral; free margin with two prominent marginal ridges converging but not meeting at ventral border. Central area greatly depressed, with an inconspicuous central ridge near hinge line. Cambric.

(This and the next genus are doubtfully referred to the Ostracoda.)

1. **H. cavatum** Matthew. (Fig. 1652, *a, b.*) Cambric.

Lateral ridges strong, nearly meeting in center of valve; median ridge fainter, slightly sigmoidal.

Middle Cambric, Protolenus beds of New Brunswick.

2. **H. minus** Matthew. (Fig. 1652, *c, d.*) Cambric.

Lateral ridges fainter, median ridge shorter than in preceding. Occurs with preceding.

II. Beyrichona Matthew.

Subtriangular, with a rudely semicircular depressed area below hinge, covering less than half the height of the valve. Cambric.

(This and the preceding genus are doubtfully referred to the Ostracoda.)

3. **B. tinea** Matthew. (Fig. 1652, *e–g*.) Cambric.
Height greater than length of hinge line; dorsal depression large. Middle Cambric, Protolenus beds of New Brunswick.

4. **B. planata** Matthew. (Fig. 1652, *h*.) Cambric.

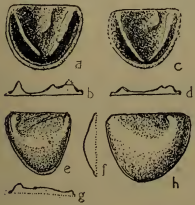

FIG. 1652. *a, b, Hipponicharion cavatum; c, d, H. minus; e–g, Beyrichona tinea; h, B. planata.* (All after Matthew, enlarged.)

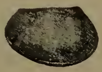

FIG. 1653. *Leperditia fabulites;* left valve. (After Ulrich.)

Hinge line longer than height of valve; dorsal depression smaller than in preceding.
Occurs with preceding.

III. LEPERDITELLA Ulrich.

Similar to *Leperditia* but the left instead of the right valve is the larger and has a groove within its ventral border into which the simple edge of the right valve is received. Eye tubercle wanting while a more or less obscure broad depression is generally present in the central part of the dorsal half. Length 1 to 3 mm. Genotype *Leperditia inflata* Ulrich. About fifteen species. Ordovicic.

5. **L. inflata** Ulrich. (Fig. 1656, *a–c*.) Ordovicic.
Valves strongly convex, giving the shell an inflated appearance. Lowville and Black River formations of Kentucky, etc.

IV. LEPERDITIA Rouault.

Shell suboblong with an oblique backward swing, comparatively large, 2 or 3 mm. to 22 mm. in length; dorsal edge straight, generally angular at the extremities; ventral outline rounded, greatest thickness in the ventral half, the lower edge being usually also blunt. Valves unequal, the right the larger and overlapping the ventral edge of the left; hinge simple. Surface frequently horny in appearance, smooth and glossy in most cases, granulose or minutely punctate in others; a small tubercle or "eye-spot" is generally present on the anterodorsal fourth, while a large rounded, subcentrally situated muscular imprint is a well-marked feature of the interior and sometimes distinguishable even on the exterior. Genotype *L. brittanica* Rouault.

About forty species. Range: Chiefly Cambric, Ordovicic and Siluric, the Devonic and Cambric species being small and doubtfully referred to the genus.

6. **L. fabulites** Conrad. (Fig. 1653.) Ordovicic.

Of medium size; greatest length about the middle of shell; anterior end more sharply rounded than posterior; eye tubercle small; hinge line central.

Stones River of Minnesota, Cincinnati region, Tennessee, New York and Pennsylvania; Black River of Canada.

7. **L. cæcigena** S. A. Miller. (Fig. 1656, *d, e.*) Ordovicic.

Anterior end less produced than posterior; anterobasal margin sloping abruptly.

Cincinnati group of Indiana.

8. **L. angulifera** Whitfield. (Fig. 1654.) Siluric.

FIG. 1654. *Leperditia angulifera* right, left and anterior views. (After Whitfield.)

Anterior end nearly rectangular; sides flat, abruptly inturned basally and anteriorly.

Lower Monroe of Ohio, etc.

9. **L. scalaris** Jones. (Fig. 1655.) Siluric.

Large general form similar to *L. fabulites*, but left valve with strong rounded and elongate node below hinge line.

Cobleskill of eastern New York, New Jersey, etc.; Akron of western New York, Ontario, etc.

10. **L. alta** (Conrad). Siluric.

Small, nearly symmetrical, strongly convex; length one and one half times height; eye tubercle pronounced, one fourth length of

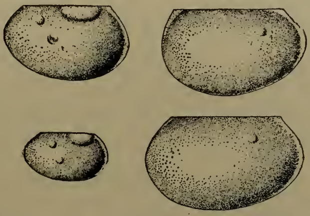

FIG. 1655. *Leperditia scalaris*, left and right valves, × 2. (After Grabau.)

valve from anterior end, and similar distance from dorsal line.

Abundant in Manlius of New York, New Jersey, Pennsylvania, etc.; also in Lower Monroe of Ontario, Ohio, Michigan, etc.

11. **L. hudsonica** Hall. (Fig. 1656, *f–h*.) Devonic.

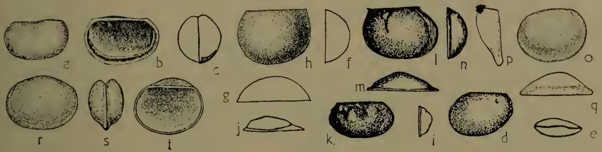

FIG. 1656. *a–c*, *Leperditella inflata* (5),* external and internal views of right valve, end view, × 6; *d*, *e*, *Leperditia cæcigena* (7), right valve and end view, enlarged; *f–h*, *L. hudsonica* (11), right valve and profiles, × 25; *i–k*, *Isochilina subnodosa* (12), × $\frac{4}{3}$; *l–n*, *I. jonesi* (13), left valve, × ⅔; *o–q*, *Schmidtella crassimarginata* (16), right valve, × 6; *r–t*, *S. umbonata* (17), left, end, and interior of right valve, × 14. (*f–h*, after Jones, the others after Ulrich.)

* The numbers following names in parenthesis refer to the number preceding the species in the text.

Very small, deeply convex; hinge proportionately long; anterior cardinal angle nearly a rectangle; eye tubercle faint or wanting.

Hamilton of New York.

V. ISOCHILINA Jones.

Like *Leperditia*, except that the valves do not overlap, but are equal in every respect. Surface sometimes lobulate or nodose.

Length 3 to 20 mm. About twenty-five species. Ordovicic–Siluric.

12. **I. subnodosa** Ulrich. (Fig. 1656, *i–k*.) Ordovicic.

Elongate; sides irregularly elevated or subnodose.

Upper Trenton of Kentucky, etc.

13. **I. jonesi** Wetherby. (Fig. 1656, *l–n*.) Ordovicic.

Proportionately higher than preceding, regularly convex, posterior end more produced, hinge line with submucronate ends; eye tubercle sharp, near dorsal margin.

Upper Trenton of Kentucky, abundant.

14. **I. cylindrica** (Hall). Siluric.

Oval-elongate, strongly convex, so as to make conjoined valves nearly cylindrical.

Medina of New York.

FIG. 1657. *a*, *Isochilina fabacea* (15), left valve, × 18; *b*, *Aparchites fimbriatus* (18), right valve, × 10; *c–f*, *Paraparchites nicklesi* (19), exterior, interior and profiles of left valve; *g–i*, *P. humerosus* (20), exterior and interior of right valve and anterior view, × 10; *j*, *k*, *Dicranella bicornis* (40), left valve and profile, × 10; *l–n*, *Drepanella crassinoda* (41), right valve, × 10, and posterior view; *o*, *D. elongata* (42), left valve, × 10; *p*, *Eurychilina reticulata* (34), left valve, × 10; *q–s*, *E. equalis* (35), left valve, × 9; *t*, *E. striatomarginata* (36), valve, × 9; *u*, *v*, *Macronotella scofieldi* (37), × 10. (*a*, after Jones, the other after Ulrich.)

15. **I. fabacea** Jones. (Fig. 1657, *a*.) Devonic.

Small, elongate, regularly rounded in front, more abruptly behind, with slight concavity above; center of dorsal region faintly impressed; surface finely reticulate.

Hamilton of New York, etc.

VI. Schmidtella Ulrich.

Shell 2 mm. or less in length, broadly subovate, most convex in the dorsal region, right valve overlapping the left along the ventral margin; neither eye tubercle nor sulcus. Ten species. Ordovicic and Siluric.

16. **S. crassimarginata** Ulrich. (Fig. 1656, *o–q*.) Ordovicic.

Center of valve strongly elevated, surrounded by marginal depression. (Type of genus.)

Stones River of Minnesota and Cincinnati region.

17. **S. umbonata** Ulrich. (Fig. 1656, *r–t*.) Ordovicic.

More symmetrical than preceding, more strongly elevated dorsally with hinge line sunken.

Black River of Minnesota.

VII. Aparchites Jones.

Shell not exceeding 3 mm. in length, equivalved, subovate or oblong; hinge straight; ventral edge thickened, often beveled or channelled; surface convex, mostly in the ventral half, smooth. Genotype *A. whiteavesi* Jones. Over thirty species. Ordovicic and Siluric.

18. **A. fimbriatus** Ulrich. (Fig. 1657, *b*.) Ordovicic.

Margin with blunt spines or fimbriæ.

Richmond of Minnesota.

VIII. Paraparchites Ulrich and Bassler.

Like *Aparchites,* but the right valve overlaps the left. Mississippic–Permic.

19. **P. nicklesi** Ulrich. (Fig. 1657, *c–f*.) Mississippic.

Hinge line prominent; anterior end more oblique than posterior; eye tubercle sharp; convexity moderate.

Warsaw of Illinois, etc.

20. **P. humerosus** Ulrich and Bassler. (Fig. 1657, *g–i*.)
Carbonic–Permic.

More convex than preceding; hinge line sunken from elevation of dorsal portion.

Elmdale and Wreferd formations of Kansas (Carbonic); Carbonic–Permic of Texas; abundant.

IX. Primitiella Ulrich.

Small, straight-backed, equivalved shells, usually with a broad, undefined mesial depression in the dorsal slope. Genotype *P. constricta* Ulrich. About twenty-five species, chiefly Ordovicic. A few from the Siluric and Devonic.

21. **P. unicornis** Ulrich. (Fig. 1658, *j, k, k'*.) Ordovicic.

Fig. 1658. *a–c*, *Jonesella crepidiformis* (38), right, posterior and ventral views, × 12; *d, e*, *J. pedigera* (39), left valve, × 12; *f, g*, *Tetradella quadrilirata* (59), two right valves, × 13; *h, i*, *T. lunatifera* (60), × 14; *j, k, k'*, *Primitiella unicornis* (21), right valve, × 14; *l, l'*, *Primitia cincinnatiensis* (22), left and dorsal views, × 14; *m, m', n*, *P. tumidula* (23), left valve, × 14; *o, o'*, *Ulrichia nodosa* (29), right valve, × 14, and dorsal view, × 24; *p, p', q*, *U. emarginata* (30), right, anterior and dorsal views, × 14; *r, r'*, *Halliella labiosa* (31), left valve and dorsal view, × 14; *s, s', t*, *Dilobella typa* (33), × 14; *u*, *Ctenobolbina granosa* (63), left valve, × 13; *v*, *C. minima* (64), right valve, × 20; *w, w'*, *C. loculata* (65), right exterior and left interior, × 14; *x, x'*, *Bollia unguloidea* (51), left (?) valve, × 14. (All after Ulrich.)

With a short spine near the posterior-ventral margin.

Trenton-Eden of the Cincinnati region; Richmond of Minnesota.

X. PRIMITIA Jones and Holl.

Distinguished from *Primitiella* by having a well-marked subcentral pit or sulcus instead of an undefined depression. As a rule also the valves are shorter, the outline being generally more ovate. Genotype *P. mundula* Jones. At least fifty species are distinguished through the Paleozoic rocks.

22. **P. cincinnatiensis** S. A. Miller. (Fig. 1658, *l, l′*.) Ordovicic.
Swollen behind the sulcus, with rounded node in front of it.
Upper half Cincinnati group of Cincinnati region.

23. **P. tumidula** Ulrich. (Fig. 1658, *m, m′, n*.) Ordovicic.
Sulcus shorter than in preceding, with faint node on either side.
Richmond of Minnesota.

24. **P. seminulum** Jones. (Fig. 1660, *d*.) Devonic.
Antero-dorsal end rectangular; sulcus deep, central; surface reticulated.
Hamilton of New York.

XI. PRIMITIOPSIS Jones.

Oblong strongly convex shells with a long straight hinge line, a faintly defined central spot, reticular ornament and a narrow concave area on the inner side of the posterior edge. Genotype *P. planifrons* Jones. Siluric–Devonic.

25. **P. punctulifera** (Hall). (Fig. 1660, *e–g*.) Devonic.
With three small, smooth tubercles, one central and two posterior; reticulation obsolete at ends.
Hamilton of New York, Ontario, etc.; common.

XII. ÆCHMINA Jones and Holl.

Primitia-like ostracoda, having instead of a sulcus a single, sometimes enormously developed, horn-like process. Genotype *Æ. cuspidata* J. and H. Eight species. Ordovicic–Devonic.

26. **A. spinosa** (Hall). (Fig. 1659.) Siluric.
Spine strong, pointing upward, outward and forward, sometimes slightly bent; a rounded, thickened border surrounds free margins of valves, sometimes pitted.
Niagaran (Rochester shale) of New York, Ontario, etc.

27. **A. abnormis** Ulrich. (Fig. 1660, *h–j*.) Siluric.
With two thickened, elongate, rounded marginal nodes besides the spine.
Niagaran (Rochester shale) of New York, etc.

FIG. 1659. *Æchmina spinosa* (26), right valves, much enlarged. (After Hall.)

28. **A. marginata** Ulrich. (Fig. 1660, *k*.) Devonic.
Like *A. spinosa,* but with narrower border and much larger spine.
Hamilton of New York.

XIII. ULRICHIA Jones.

Differs from *Primitia* in having a well developed node on each side of the sulcus, which in this case is scarcely impressed. Genotype *U. conradi* Jones. About a dozen species. Ordovicic–Mississippic.

29. **U. nodosa** Ulrich. (Fig. 1658, *o, o'*.) Ordovicic.
Dorsal nodes very unequal, the anterior much the largest; two others near posteroventral margin.
Lower Cincinnati group of Cincinnati region.

30. **U. emarginata** Ulrich. (Fig. 1658, *p, p', q*.) Mississippic.
Dorsal nodes nearly equal; other nodes nearer center than in preceding; hinge line shorter.
Chester shales of Kentucky.

XIV. HALLIELLA Ulrich.

Similar to *Primitia,* but with a larger sulcus, narrow at the dorsal edge, and widening as it extends downward.
Ordovicic–Devonic.

31. **H. labiosa** Ulrich. (Fig. 1658, *r, r'*.) Ordovicic.
Nearly semicircular; hinge line forming nearly the greatest length; sulcus narrow, short; surface finely pitted.
Trenton of Minnesota, etc.

32. **H. retifera** Ulrich. (Fig. 1660, *p, p′, q*.) Devonic.

Sulcus broader, hinge line relatively shorter than in preceding; posterior end the more convex.

Bryozoa beds (Onondaga) of Falls of Ohio.

FIG. 1660. *a–c, Ceratopsis chambersi* (57), interior and exterior of right valve, × 12; *d, Primitia seminulum* (24), left valve, × 18 (somewhat imperfect in middle); *e–g, Primitiopsis punctulifera* (25): *e*, young valve; *f, g*, adult left valve, × 18; *h–j, Æchmina abnormis* (27), right valve, × 10; *k, A. marginata* (28), left valve, × 14; *l, l′, m, Moorea bicornuta* (44), right valve, × 15; *n, n′, Strepula plantaris* (45), interior and exterior of left valve, × 18; *o, S. sigmoides* (46), left valve, × 18; *p, p′, q, Halliella retifera* (32), left and right valves, and basal view of latter, × 14; *r, r′, s, Ctenobolbina fulcrata* (61), right and left valve and posterior view of latter, × 10; *t, t′, C. ciliata* (62), exterior of left and interior of right valve, × 7½; *u, Hollina spiculosa* (82), right valve, × 10; *v, H. armata* (80), right valve, × 10; *w, w′, x, H. cavimarginata* (81), exterior, posterior and interior of left valve, × 10; *y, y′, y″, H. antispinosa* (79), three views of a left valve, × 10; *z, z′, Bollia pumila* (52), × 10. (*d–g, m* and *n, n′, o*, after Jones; the rest after Ulrich.)

XV. DILOBELLA Ulrich.

Subovate or somewhat reniform, bilobed Beyrichian shells; lobes very large, subequal and almost completely separated by a deep subcentral vertical or oblique sulcus. One species. Ordovicic.

(Several species from the Lower Siluric drift of Prussia, and referred to *Entomis* by Krause, probably belong here.)

33. **D. typa** Ulrich. (Fig. 1658, *s, s′, t.*) Ordovicic.
Extremities nearly equally rounded, with a slight flattening of anterior margin.
Black River of Minnesota.

XVI. Eurychilina Ulrich.

Oblong or semielliptical shells, having a subcentral primitian sulcus, the posterior edge of which is often raised into a small, rounded node; hinge straight, nearly equalling the length of the shell; anterior, ventral and posterior margins provided with a wide, often radiately marked, frill-like border, usually curved on its inner side so as to form a concave area around the true contact edges of the valves. Twenty or more species. Ordovicic.

(In a section of this or a closely related new genus of which *E. obesa* Ulrich and *Primitia plana* Krause are good representatives, the valves show neither a well defined sulcus nor a node.)

34. **E. reticulata** Ulrich. (Fig. 1657, *p.*) Ordovicic.
Elongate, with broad, radially striated, flat marginal frill; sulcus posterior of center; anterior end long. (Type of genus.)
Stones River and Black River of Minnesota, etc.

35. **E. equalis** Ulrich. (Fig. 1657, *q–s.*) Ordovicic.
Shorter than preceding and proportionately higher and more symmetrical; sulcus central; margin smooth, thick, rounded.
Chazy of Kentucky and Tennessee.

36. **E. striatomarginata** (S. A. Miller). (Fig. 1657, *t.*) Ordovicic.
Differs from preceding in slightly greater elongation and less prominent, finely striated marginal rim.
Upper Cincinnatian of Indiana.

XVII. Macronotella Ulrich.

Shell semicircular or semiovate, with a long, nearly straight hinge; valves equal, inflated centrodorsally, without ridges or sulcus, but exhibiting a smooth subcentral spot where the reticular ornament is omitted. Ordovicic.

37. **M. scofieldi** Ulrich. (Fig. 1657, *u, v.*) Ordovicic.
Hinge line forming greatest width of shell; ends acute or rect-

angular; length one and one half to one and three fourths times height. (Type of genus.)

Stones River of Minnesota and Cincinnati region.

XVIII. Jonesella Ulrich.

Small oblong or subovate Ostracoda, distinguished by a curved ridge on the posterior two thirds. Four species. Ordovicic.

38. **J. crepidiformis** Ulrich. (Fig. 1658, *a–c*.) Ordovicic.

Curved ridge U-shaped; carapace convex.

Lower Cincinnatian of Kentucky.

39. **J. pedigera** Ulrich. (Fig. 1658, *d, e*.) Ordovicic.

Curved ridge crosier-shaped; long arm at ventral border.

XIX. Dicranella Ulrich.

Distinguished from *Ulrichia* in having one or both nodes developed into long horn-like diverging prominences. Five species. Ordovicic.

40. **D. bicornis** Ulrich. (Fig. 1657, *j, k*.) Ordovicic.

With two well developed horn-like prominences, diverging at an acute angle and rising above hinge line; a pronounced ridge runs parallel to margin. (Type of genus.)

Stones River and Black River of Minnesota.

XX. Drepanella Ulrich.

Depressed-convex, suboblong valves with a more or less complete, often sickle-shaped, sharply elevated marginal ridge, within which the surface exhibits two or more usually distinct nodes; ventral edge thick; size usually 2.5 mm. by 1.5 mm. Eight species. Ordovicic.

41. **D. crassinoda** Ulrich. (Fig. 1657, *l–n*.) Ordovicic.

Outer ridge close to margin slightly interrupted anteriorly; two large and one small (anterior) vertical nodes, and a short longitudinal one in anterobasal portion. (Type of genus.)

Stones River of Kentucky.

42. **D. elongata** Ulrich. (Fig. 1657, *o*.) Ordovicic.

Elongate; outer ridge some distance from margin, absent at anterior end; two moderate nodes in posterior half confluent with surface.

Stones River of Kentucky.

43. **D. macra** Ulrich. (Fig. 1664, *a–c*.) Ordovicic.

Differs from *D. crassinoda* in that the marginal ridge in anterior half becomes obsolete, the short longitudinal one joining the posterior half; anterior node larger.

Stones River of Minnesota, Tennessee, etc.

XXI. Moorea Jones and Kirkby.

Very small, more or less oblong or ovate shells; valves compressed-convex, the free edges bounded by a raised marginal ridge, sometimes wanting along the ventral side; inner region flat or gently convex, without nodes, sulcus or pit. Genotypes *M. obesa* and *M. tenuis* J. and K. Ordovicic–Carbonic.

44. **M. bicornuta** Ulrich. (Fig. 1660, *l, l′, m*.) Devonic.

Marginal ridge only in posterior portion, crescentic; anterior end with two short spine-like processes.

Hamilton group of New York, Ontario, etc.

XXII. Strepula Jones and Holl.

Suboblong shells, with rounded ends, valves slightly convex, without sulcus, traversed by numerous, twisted, thin ridges or ribs. Genotype *S. concentrica* J. and H. Five species. Siluric–Devonic.

45. **S. plantaris** Jones. (Fig. 1660, *n, n′*.) Devonic.

Slipper-shaped; anterior end with six short spines, posterior end pitted, twisted ridge depressed S-shaped.

Hamilton of New York.

46. **S. sigmoides** Jones. (Fig. 1660, *o*.) Devonic.

Anterior end acute; sigmoid ridge oblique, enclosed in and united with a ridge parallel to margin.

Hamilton of New York, etc.

XXIII. Octonaria Jones.

Similar to *Moorea,* but distinguished in having the surface of the valves raised into a thin spiral or ring-like ridge, which in the more typical forms resembles the figure 8. Genotype *O. octoformis* Jones. Ten or more species. Ordovicic–Devonic.

47. **O. curta** Ulrich. (Fig. 1666, *l, l'*.) Siluric.

Valves deep; sides nearly rectangular; surface with thick, oval, ring-like elevation.

Rochester shale of New York.

48. **O. clavigera** Ulrich. (Fig. 1666, *m, m', n.*) Devonic.

Elongate; surface with club-shaped ridge.

Bryozoan bed (Onondaga) of Falls of Ohio.

49. **O. stigmata** Ulrich. (Fig. 1666, *o, o'*.) Devonic.

Outer ring-like ridge enclosing several others of less regular outline.

With the preceding.

XXIV. Placentula Jones and Holl.

Probably related to *Bollia,* but differing in having the "loop" generally in front of the center and close to the dorsal margin. As a rule a rim-like ridge forms the outer border of the valves. Genotype *P. excavata* J. and H. Five or six species. Ordovicic and Siluric.

50. **P. marginata** Ulrich. (Fig. 1666, *d, d'*.) Ordovicic.

With small, indistinct subcentral loop, and strong marginal ridge, almost spinous at dorsal margin.

Cincinnatian of Cincinnati region.

XXV. Bollia Jones and Holl.

Distinguished by a centrally situated loop-like or horse-shoe-shaped ridge, the upper extremities of which are often bulbous; a more or less complete marginal ridge may be present or wanting. Genotype *B. uniflexa* J. and H. Twenty-five species. Ordovicic–Carbonic.

51. **B. unguloidea** Ulrich. (Fig. 1658, *x, x'*.) Ordovicic.

Marginal rim thick; inner U-shaped ridge close to it; arms of unequal length, scarcely expanded dorsally.

Trenton of Minnesota.

52. **B. pumila** Ulrich. (Fig. 1660, *z, z'*.) Ordovicic.

Inner U-shaped ridge thin, distant from marginal ridge, and with swollen ends.

Upper Cincinnatian of Ohio, Indiana, etc.

53. **B. symmetrica** (Hall). (Fig. 1661.) Siluric.

Inner ridge horse-shoe-shaped, faint ventrally; marginal ridge faint, obsolete ventrally.

Rochester shale of New York, etc.

54. **B. lata** (Vanuxem). Siluric.

Similar to *B. symmetrica,* but horse-shoe ridge very thick.

Abundant in Clinton sandstones of New York and elsewhere.

55. **B. obesa** Ulrich. (Fig. 1665, *a–c.*) Devonic.

Anterior end of U-shaped ridge swollen; outer ridge low, thick, interrupted ventrally.

Bryozoan bed (Onondaga) of Falls of Ohio.

FIG. 1661. *Bullia symmetrica,* nat. size and enlarged. (After Hall.)

FIG. 1662. *Ceratopsis oculifera,* dorsal view, × 12, and left valve, × 10. (After Jones.)

56. **B. ungula** Jones. (Fig. 1665, *d, e.*) Devonic.

U-shaped ridge thick, marginal ridge thin, low; differs from *B. lata* in form of ridge and in proportions of length and height.

Bryozoan bed (Onondaga) of Falls of Ohio.

XXVI. CERATOPSIS Ulrich.

Distinguished from *Tetradella* by the remarkable process which arises from the dorsal extremity of the posterior ridge. This may be straight and horn-like with one of the edges toothed (*C. chambersi* Miller) or expanded somewhat mushroom-like (*C. oculifera* Hall). Six species. Ordovicic.

57. **C. chambersi** (Miller). (Fig. 1660, *a–c.*) Ordovicic.

Spine strong, horn-like, with toothed edge.

Black River and Trenton of Minnesota, Eden of Ohio, etc.

58. **C. oculifera** (Hall). (Fig. 1662.) Ordovicic.

Somewhat more elongate than preceding, anterior end more oblique and acutely or rectangularly pointed. Spine blunt, mushroom-like, with frilled border. (Type of genus.)

XXVII. Tetradella Ulrich.

Valves marked by four more or less curved vertical ridges ventrally united; one or both of the inner ridges sometimes duplex (*T. lunatifera*) or all four may be split up into separate nodes (*T. dissecta* Kr.). Eighteen species. Ordovicic–Siluric.

59. **T. quadrilirata** (H. and W.). (Fig. 1658, *f, g.*) Ordovicic.
Posterior and ventral ridges with blunt spinose processes; the second of the ridges from front dividing at base. (Type of genus.)
Black River of Minnesota; Stones River and Richmond of Cincinnati region.

60. **T. lunatifera** Ulrich. (Fig. 1658, *h, i.*) Ordovicic.
Without spinous processes; second and fourth ridge duplex.
Trenton of Minnesota; Richmond of Cincinnati region.

XXVIII. Ctenobolbina Ulrich.

Shell oblong or subovate; posterior two fifths generally bulbous or subglobular, separated from the remainder by a deep, obliquely curved sulcus extending from the dorsal margin more than half across the valves towards the postventral border; anterior three-fifths often with another oblique but less impressed sulcus; dorsal margin long and straight, hingement simple; ventral edge thick, the true contact margins generally concealed in a lateral view by a frill or flattened false border. Fifteen species. Ordovicic–Carbonic.

61. **C. fulcrata** Ulrich. (Fig. 1660, *r, r′, s.*) Ordovicic.
Anterior sulcus ill-defined; posterior border thick with coarse pits.
Black River of Minnesota.

62. **C. ciliata** (Emmons). (Fig. 1660, *t, t′.*) Ordovicic.
Larger than preceding; posterior sulcus crescent-shaped, narrow and deep, anterior one shallower and narrower. (Type of genus.)
Eden of Cincinnati region.

63. **C. granosa** Ulrich. (Fig. 1658, *u.*) Devonic.
With pronounced, slightly lobate, frill extending ventrally and half way to posterior dorsal margin.
New Scotland of New York.

64. **C. minima** Ulrich. (Fig. 1658, *v.*) Devonic.

Minute, with one narrow oblique sulcus, no frill and single short posterior basal spine.

Hamilton of New York.

65. **C. loculata** Ulrich. (Fig. 1658, *w, w'.*) Mississippic.

Differs from *C. granosa* in its deeper, more oblique sulcus, a small posterior node behind it, and the frill more pronouncedly lobate or subspinose.

Kinderhook (Maury shale) of Tennessee.

XXIX. Beyrichia McCoy.

Comparatively large (2 to 5 mm. long), moderately convex, semiovate or semicircular to oblong; dorsal angles sharp, ventral

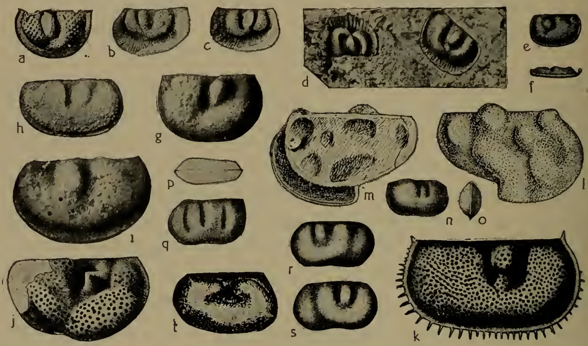

Fig. 1663. *a, Beyrichia granulosa* (66), × 7; *b, c, B. waldronensis* (67), right and left valve, × 7; *d, B. moodeyi* (68), left and right valves on slab, × 7; *e, f. Klœdenia initialis* (70), side and ventral edge views of right valve, × 14; *g, K. manliensis* (71), left valve, × 7; *h, K. sussexensis* (72), left valve, × 7; *i, K. marginalis* (73), × 7; *j, K. centricornis* (74), left valve, × 14; *k, K. fimbriata* (75), left valve, × 14; *l, m, Hollina insolens* (78), exterior and interior of left valve, × 14; *n–p, Klœdenella pennsylvanica* (86), left, end and ventral views of complete shell, × 10; *q, K. halli* (87), × 14; *r, s, K. turgida* (88), right and left valves, × 14; *t, Beyrichiella confluens* (89), left valve, × 14. (After Ulrich and Bassler.)

rounded; two vertical furrows divide surface into three unequal and unsymmetrical and variable lobes, the anterior generally the largest and sometimes broken; marginal flange flat, overhanging contact edges which are beveled inwards. Seventy-three species, four of them American. Ordovicic–Devonic, chiefly Siluric.

66. **B. granulosa** Hall. (Fig. 1663, *a.*) Siluric.
Anterior end rectangular or pointed; middle lobe smallest, smooth, others granulated; marginal flange narrow, depressed, smooth.
Niagaran of Indiana.

67. **B. waldronensis** Ulrich and Bassler. (Fig. 1663, *b, c.*) Siluric.
All lobes smaller than in preceding, more distant and all finely granulose; marginal flange broad, flat and striated.
Waldron shale (Niagaran) of Indiana.

68. **B. moodeyi** Ulrich and Bassler. (Fig. 1663, *d.*) Siluric.
Differs from preceding in its smooth lobes, and narrower and more strongly striated marginal border.
Monroan of West Virginia.

69. **B. hamiltonensis** Jones. (Fig. 1665, *l.*) Devonic.
All lobes very small; both anterior and posterior lobes furcating, surface granulated, some of the granules spinulose at hinge margin.
Hamilton shales of New York.

XXX. Klœdenia Jones and Holl.

Differs from *Beyrichia* in the shorter and fainter sulci, which define a small median lobe while the others are confluent with marginal portion of valve; marginal rim narrow or absent. Twenty American species; nine European. Ordovicic–Devonic, chiefly Siluric.

70. **K. initialis** (Ulrich). (Fig. 1663, *e, f.*) Ordovicic.
Small, median lobe in posterior third; marginal rim very narrow.
Black River of Minnesota.

71. **K. manliensis** (Weller). (Fig. 1663, *g.*) Siluric–Devonic.
Median lobe small, nearly surrounded by rather deep sulci; marginal rim very narrow.
Manlius limestone of New Jersey; Helderbergian of New Brunswick.

72. **K. sussexensis** (Weller). (Fig. 1663, *h.*) Siluric–Devonic.
Anterior sulcus strong, posterior weak; marginal rim narrow; surface granulose; form elongate.
Upper Monroan of New Jersey; Helderbergian of New Brunswick, etc.

73. **K. marginalis** Ulrich and Bassler. (Fig. 1663, *i.*) Devonic.
Similar to *K. manliensis,* but more elongate, with wider margin, shallower sulci, and smooth surface.
Helderbergian (?) of New Brunswick.

74. **K. centricornis** Ulrich and Bassler. (Fig. 1663, *j.*) Devonic.
Valves more elongate than other species, median lobe spine-like; surface coarsely pitted.
Coeymans limestone of Cumberland, Maryland.

75. **K. fimbriata** Ulrich and Bassler. (Fig. 1663, *k.*) Devonic.
Median lobe with constrictions, margin spinous, surface pitted.
Coeymans limestone of New York.

XXXI. Scofieldia Ulrich and Bassler.

Carapace 2 to 3 mm. long, oblong, subquadrate, compressed; a small median node around which other nodes and ridges are arranged symmetrically. One species. Ordovicic.

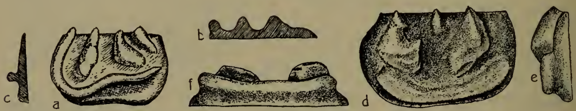

Fig. 1664. *a–c, Drepanella macra* (43), right valve, with longitudinal and vertical sections through center of valve; *d–f, Scofieldia bilateralis* (76): *d,* right valve; *e, f,* ventral and posterior views of a left valve, all × 10. (After Ulrich.)

76. **S. bilateralis** Ulrich. (Fig. 1664, *d–f.*) Ordovicic.
With a large irregular triangular and ridged node on each side of the small subspinous median node, and a broad curved ridge along ventral margin. (Type of genus.)
Trenton of Minnesota.

XXXII. Treposella Ulrich and Bassler.

Carapace small, about 1 mm. long, semiovate to subquadrate; curved free margins, with radiately striated frill; ventral margin swollen, forming a low ridge in right, and an elongate ventral node ("pouch") in the left valve; a rounded posterior and elongate anterior node occur above this. Devonic.

77. **T. lyoni** (Ulrich). (Fig. 1665, *i–k.*) Devonic.
Posterior node round, anterior balloon-shaped, projecting above

hinge; left valve with strong ventral node ("pouch"), surface pitted. (Type of genus.)

Bryozoan bed (Onondaga) of Falls of Ohio.

XXXIII. Hollina Ulrich and Bassler.

Equivalved, elongate, tapering anteriorly; marginal frill, concave on inside, overhanging contact edge and often wanting anteriorly. A rounded node near hinge line, partly in front of center, a second usually smaller, is lower and behind the center; they may be joined but are generally separate; other nodes and ridges may occur. Twelve species. Devonic–Carbonic.

78. **H. insolens** (Ulrich). (Fig. 1663, *l, m.*) Devonic.

Marginal frill ending posterodorsally in a rounded node, and is continued upward from ventral end in curved ridge nearly to main node; another elongate node below the posterior one, and a curved one in anterior end. (Type of genus.)

Bryozoan bed (Onondaga) of Falls of Ohio.

79. **H. antispinosa** (Ulrich). (Fig. 1660, *y, y′, y″.*) Devonic.

Principal nodes connected by rounded ventral swelling; a third elongated node in anterior end, with marginal frill extending to it.

Bryozoan bed (Onondaga) of Falls of Ohio.

80. **H. armata** (Ulrich). (Fig. 1660, *v.*) Devonic.

An elongate swelling below main node, and ending in blunt node; a more spinose node below the secondary one; marginal frill indefinite.

Bryozoan bed (Onondaga) of Falls of Ohio.

81. **H. cavimarginata** (Ulrich). (Fig. 1660, *w, w′, x.*) Devonic.

Differs from preceding in having marginal frill thick on posterior half and pitted on interior; swelling below main node ending in two nodes.

Occurs with preceding.

82. **H. spiculosa** Ulrich. (Fig. 1660, *u.*) Devonic.

Marginal frill thick, pronounced, extending around two thirds of free margin; a stout spine occurs behind the secondary node, and the surface, hinge line, and anterior margin are marked by scattered spinules.

Bryozoan bed (Onondaga) of Falls of Ohio.

83. **H. kolmodini** Jones. (Fig. 1665, *f–h.*) Devonic.

Marginal frill obsolescent; a thick curving ridge within the posterior ventral border partly embraces the minor lobe.

Bryozoan bed (Onondaga) of Falls of Ohio.

84. **H. tricollina** Ulrich. (Fig. 1665, *m.*) Devonic.

Marginal frill sharp, not quite reaching posterodorsal margin;

FIG. 1665. *a–c*, *Bollia obesa* (55), left valve, × 10; *d*, *e*, *B. ungula* (56), left valve, × 10; *f–h*, *Hollina kolmodini* (83), exterior, dorsal and interior views of right valve, × 10; *i–k*, *Treposella lyoni* (77), three views of right valve, × 10; *l*, *Beyrichia hamiltonensis* (69), × 10; *m*, *Hollina tricollina* (84), left valve, × 13; *n*, *o*, *Kirkbya costata* (95), × 10; *p–r*, *K. lindahli* (96), × 10; *s*, *t*, *K. venosa* (97), right valve, × 14; *u–x*, *Barychilina punctostriata* (99), left, posterior, dorsal and right view of a complete carapace, × 10; *y*, *z*, *Pachydomella tumida* (100), right and anterior views, × 14. (*l*, after Jones; the rest after Ulrich.)

minor node small; a third rounded node near posterodorsal margin.

Hamilton group of New York, etc.

85. **H. radiata** Jones and Kirkby. (Fig. 1666, *a.*) Carbonic.

Marginal frill only on ventral side; major and minor nodes close together; surface, including nodes, pustulose.

Cottonwood shales of Kansas.

XXXIV. KLŒDENELLA Ulrich and Bassler.

Differs from *Klœdenia* chiefly in the more cylindrical form of the shell and the greater inequality of its valves, the right overlapping the left; differs from *Beyrichia* in the relative convexity and lobation of the valves. About ten species. Siluric–Devonic.

86. **K. pennsylvanica** (Jones). (Fig. 1663, *n–p*.) Siluric.
With a narrow median sulcus and a second one just behind this; anterior end nearly rectangular. (Type of genus.)
Manlius (Lewistown limestone) of Perry Co., Pennsylvania, etc.

87. **K. halli** (Jones). (Fig. 1663, *q*.)
Like the preceding but with three sulci, somewhat unevenly spaced, the median is a little behind the center; all extending two thirds the distance to ventral margin.
Salina of New York, etc.

88. **K. turgida** Ulrich and Bassler. (Fig. 1663, *r, s*.) Devonic.
Differs from the preceding in its rounded anterior end, shorter hinge line, shorter and less definite sulci.
Coeymans limestone of Cumberland, Maryland.

XXXV. Beyrichiella Jones and Kirkby.

Small, length 1 mm. or less, elongate, subquadrate, thickened anteriorly, bilobed by a rather broad median sulcus; lobes connected by low ventral ridge; left valve overlapping right. Genotype *B. cristata* J. and K. Three species, one of them American. Carbonic.

89. **B. confluens** (Ulrich). (Fig. 1663, *t*.) Mississippic.
Lobes confluent in the broad ventral ridge which occupies about one half the height of the shell.
Chester shales of Kentucky.

XXXVI. Jonesina Ulrich and Bassler.

Differs from *Klœdenella* in having the left valve the largest (instead of the right) and occasionally overlapping the right. Length about 1 mm. Genotype *J. fastigiata* (Jones and Kirkby). Six described species, two of them American. Carbonic.

90. **J. gregaria** Ulrich and Bassler. (Fig. 1666, *b*.) Carbonic.
With one pronounced narrow sulcus behind the middle, dividing two rather indistinct nodes; a small dorsal spine near anterior end.
Upper Carbonic of Kansas City, Missouri. Extremely abundant.

91. **J. bolliaformis** Ulrich and Bassler. (Fig. 1666, *c, c'*.) Carbonic.
Nodes more pronounced, smaller, connected basally by a transverse ridge, with a second broad ill-defined ridge below this.
Cottonwood shales of Kansas; Upper Carbonic of Texas.

XXXVII. Kirkbya Jones.

Distinguished from *Moorea* by the presence of a subcentral pit. Surface ornament usually reticulated, sometimes with longitudinal

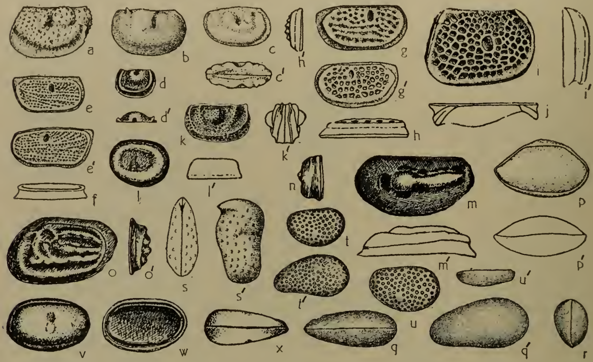

Fig. 1666. *a*, *Hollina radiata* (85), right valve, × 14; *b*, *Jonesina gregaria* (90), left valve, × 15; *c*, *c′*, *J. bolliaformis* (91), left and dorsal views of entire carapace, × 15; *d*, *d′*, *Placentula marginata* (50), right valve, × 14; *e*, *e′*, *f*, *Kirkbya cymbula* (92), left and right valves and ventral view, × 14; *g*, *g′*, *h*, *h′*, *K. germana* (93), left valve and end view, and right valve and ventral view, × 14; *i*, *i′*, *j*, *K. subquadrata* (94), right valve, × 14; *k*, *k′*, *K. centronota* (98), right and end views, × 14; *l*, *l′*, *Octonaria curta* (47), × 14; *m*, *m′*, *n*, *O. clavigera* (48), right ventral and end views, × 14; *o*, *o′*, *O. stigmata* (49), right valve, × 18; *p*, *p′*, *Bairdia beedei* (110), right and ventral views, × 14; *q*, *q′*, *r*, *Bythocypris cylindrica* (113), dorsal left and posterior views, × 14; *s*, *s′*, *Cypridea tuberculata* var. *wyomingensis* (115), left and ventral view, × 14; *t*, *t′*, *u*, *u′*, *Cytherella* (?) *rugosa* (117), × 14; *v–x*, *C. ovatiformis* (118).

ridges. Genotype *K. permiana* Jones. Eight or ten species. Devonic–Carbonic.

92. **K. cymbula** Ulrich. (Fig. 1666, *e*, *e′*, *f*.) Devonic.

Elongate, subquadrangular; anterior angle acute; reticulation fine.

Bryozoan bed (Onondaga) group of Falls of Ohio.

93. **K. germana** Ulrich. (Fig. 1666, *g*, *g′*, *h*, *h′*.) Devonic.

Similar to preceding, but anterior end rectangular and reticulation coarse.

With the preceding.

94. **K. subquadrata** Ulrich. (Fig. 1666, *i, i′, j.*) Devonic.

Proportionately shorter and higher; anterior end rounded; reticulation coarse.

With the preceding.

95. **K. costata** (McCoy). (Fig. 1665, *n, o.*) Mississippic.

Elongate, unsymmetrical; surface with longitudinal inosculating costæ instead of reticulations.

Warsaw of Illinois; also "Lower Carboniferous limestone" of England.

96. **K. lindahli** Ulrich. (Fig. 1665, *p–r.*) Mississippic.

Strongly convex; marginal rim much less prominent than in the Devonic species; ends rounded; pit pronounced; surface reticulated.

Warsaw of Illinois.

97. **K. venosa** Ulrich. (Fig. 1665, *s, t.*) Mississippic.

Nearly symmetrical, with straight hinge line and rounded ends; surface with fine, rather distant, inosculating and branching ridges.

Chester of Kentucky.

98. **K. centronota** Ulrich and Bassler. (Fig. 1666, *k, k′.*) Carbonic.

Nearly symmetrical, angular; marginal ridge sharp; a second more strongly curved ridge within, enclosing a central tubercle above the pit; surface finely reticulated.

Cottonwood shales of Kansas.

XXXVIII. Barychilina Ulrich.

Shell subrhomboidal or ovate; valves thick, unequal, the right the larger, overlapping the left ventrally and at the two ends; edges of valves much thickened; a sharply defined narrow or round umbilical pit situated in front of the center; surface numerously ridged or coarsely striated longitudinally. Several species. Devonic and Carbonic.

99. **B. punctostriata** Ulrich. (Fig. 1665, *u–x.*) Devonic.

Surface striated; umbilical pit one third length of shell from front. (Type of genus.)

Bryozoan bed (Onondaga) of Falls of Ohio.

XXXIX. Pachydomella Ulrich.

Shell extremely ventricose; valves thick and strong, the left much the larger, its thick edges overlapping those of the right valve all around; dorsum arched, ventral edge more nearly straight, ends rounded, a faintly impressed subcentral spot present. Devonic.

100. **P. tumida** Ulrich. (Fig. 1665, *y, z.*) Devonic.

Shell deeper than high; right valve smaller and more ventricose. (Type of genus.)

Bryozoan bed (Onondaga) of Falls of Ohio.

XL. Krausella Ulrich.

Elongate; dorsal margin curved, ventral nearly straight; valves unequal, the left overlapping the right both dorsally and ventrally; a single spine occurs on each shell, this being a prolongation of the posterior extremity of the smaller (right) valve. Genotype *K. inæqualis* Ulrich. Ordovicic, perhaps Siluric.

101. **K. arcuata** Ulrich. (Fig. 1667, *a–c.*) Ordovicic.

Valves moderately convex; spine blunt, anterior end sharply rounded.

Stones River of Minnesota, Cincinnati region and Tennessee.

XLI. Entomis Jones.

Shell subovate, fabiform or subreniform; valves with a slightly curved, submedian vertical furrow beginning near the center and increasing in strength to the hinge line; in front of the furrow occasionally a rounded tubercle. Surface marked generally with raised concentric, transverse or longitudinal lines. Genotype *E. tuberosa* Jones. Ordovicic–Carbonic.

Numerous species, some of them probably not congeneric, have been referred to this genus. *E. serrato-striata* Sandburger, the best known species of the genus is extremely abundant in the Upper Devonic of Germany and England.

102. **E. madisonensis** Ulrich. (Fig. 1667, *r, s.*) Ordovicic.

Ends regularly rounded; sulcus narrow and rather deep; no pronounced tubercle.

Upper Cincinnatian of Indiana.

103. **E. waldronensis** Ulrich. (Fig. 1668, *m, n.*) Siluric.

Sulcus narrow, long, nearly straight, with a small tubercle in front of sulcus; slightly more elongate than preceding.

Waldron (Niagaran) shales of Indiana.

104. **E. rhomboidalis** Jones. (Fig. 1667, *t, u.*) Devonic.

Form subrhomboidal, somewhat oblique; sulcus short and broader than in other species; surface with fine inosculating longitudinal striæ.

Hamilton of New York.

XLII. Cypridina Milne-Edwards.

Shell generally acuminate, oviform, rarely somewhat oblong; anterodorsal edge projecting beak-like over the strongly defined notch; muscle spot large, subcentral, often visible on the exterior.

FIG. 1667. *a–c, Krausella arcuata* (101), right valve, × 10; *d–f, Bairdia leguminoides* (108), right ventral and anterior views, × 14; *g–i, B. cestriensis* (109), left right and dorsal views, × 14; *j, j', k, Pontocypris* (?) *acuminata* (111), left valve, × 10; *l, l', m, n, Bythocypris* (?) *robusta* (112), left, posterior dorsal and right views, × 10; *o–q, Bairdia devonica* (107), ventral, right and posterior views, × 10; *r, s, Entomis madisonensis* (102); *t, u, E. rhomboidalis* (104), right valve, × 16; *v, w, Cypridina herzeri* (105), left valve, × 10; *x, y, C. subovata* (106), left valve, × 3. (After Ulrich and Jones (*t, u*).)

Numerous living forms in the Pacific and Indian oceans and in the Mediterranean; fossil from the Ordovicic to the Eocenic, particularly in the Carbonic.

105. **C. herzeri** Ulrich. (Fig. 1667, *v, w.*) Mississippic.
Elongate; anterior hook and notch nearly on level with ventral margin.
Upper Waverly (Keokuk) of Ohio.

106. **C. subovata** Ulrich and Bassler. (Fig. 1667, *x, y.*) Carbonic.
Shorter than preceding, more nearly circular; anterior notch large, beak dorsally situated.
Lawrence shale of Kansas.

XLIII. Bairdia McCoy.

Shell subtriangular or rhomboidal, with the greatest height near the middle, inequivalved, relatively strong, generally smooth, with both extremities narrowly rounded or pointed; dorsal margin more or less strongly convex, hinge formed by the overlapping edge of the left valve. Genotype *B. curta* McCoy. Ordovicic–Recent, particularly in the Carbonic.

107. **B. devonica** (Ulrich). (*Bythocypris devonica.*) (Fig. 1667, *o–q.*) Devonic.
Subtriangular, with ends narrowly rounded.
Bryozoan bed (Onondaga) of Falls of Ohio.

108. **B. leguminoides** Ulrich. (Fig. 1667, *d–f.*) Devonic.
Of subrhomboidal outline; dorsal surface strongly curved; anterior end pointed.
Hamilton of New York.

109. **B. cestriensis** Ulrich. (Fig. 1667, *g–i.*) Mississippic.
Less regularly rhomboidal than preceding; posterior end pointed.
Chester shale of Kentucky.

110. **B. beedei** Ulrich and Bassler. (Fig. 1666, *p, p'.*) Carbonic.
Differs from preceding in its somewhat more symmetric outline and proportionately greater height.
Cottonwood shales of Kansas.

XLIV. Pontocypris Sars.

Similar to *Bythocypris* except that the shell is very delicate and the hinge simple without overlap. Siluric–Carbonic, Pleistocenic and Recent.

111. **P.(?) acuminata** Ulrich. (Fig. 1667, *j, j', k*.) Mississippic.
Very long and narrow, the posterior end strongly pointed.
Lower Waverly of Ohio.

XLV. Bythocypris Brady.

Shell smooth, reniform, ovate or elliptical; left valve larger than the right, overlapping it usually on both the dorsal and ventral margins; dorsal margin convex, the ventral edge straighter, sometimes slightly concave.

This is a recent genus into which a number of Ordovicic–Carbonic forms have been placed by Jones and others. Some authorities question whether some or even all of these would not be more naturally placed in the Siluric genus *Cytherellina* Jones and Holl.

112. **B.(?) (Cytherellina?) robusta** Ulrich. (Fig. 1667. *l, l', m, n*.) Ordovicic.

Elongate; posterior end acutely rounded; anterior end more regularly rounded; ventral margin nearly straight.

Stones River of Minnesota.

113. **B. (Cytherellina?) cylindrica** Hall. (Fig. 1666, *q, q' r*.) Ordovicic.

Like preceding, but valves more nearly equal and ends more broadly rounded.

Trenton of Minnesota; Trenton and Eden of the Cincinnati region; Utica of Canada.

114. **B. subæquata** Ulrich. (Fig. 1669, *a–d*.) Eocenic.

Elongate, low; dorsum gently curved, almost parallel to ventral margin; ends nearly equally rounded.

Aquia formation of Maryland.

XLVI. Cypridea Bosquet.

Like *Cypris,* but with a small, hook-like projection at the antero-ventral angle. Jurassic–Cretacic.

115. **C. tuberculata** var. **wyomingensis** Jones. (Fig. 1666, *s, s'*.) Cretacic.

Elongate; ventral border gently convex, dorsal gently concave, with faint median depression; anterior hook short, thick, sharp; surface pustulose.

Bear River formation of Wyoming.

XLVII. Cypris Müller.

Reniform or oval, thin, translucent shells, with somewhat thickened hinge margins; ventral surface often sinuate; surface smooth, punctate or hirsute. Jurassic–Recent. (Fresh water.)

116. **C. purbeckensis** E. Forbes. Jurassic–Cretacic.
Subreniform, arched dorsally, nearly straight, or somewhat incurved ventrally, broadly and obliquely rounded in front; edge view acute-oval; surface smooth, contact margins simple.
Morrison of Colorado; Bear River of Wyoming; common in the English Purbeck beds.

XLVIII. Cytherella Jones.

Shell oblong or subovate, compressed, especially in front; valves unequal, thick, generally with an even, smooth surface, but occasionally undulating and ornamented with pits or granules; contact margin of the larger valve grooved on its inner edge for the reception of the flange-like edge of the smaller left valve; commonly a small rounded spot present near the center of the valves. Genotype *C. ovata* Roemer. Ordovicic–Recent.

117. **C.(?) rugosa** Jones. (Fig. 1666, *t, t′, u, u′*.) Ordovicic.
Surface rather coarsely pitted.
Black River of Canada; Trenton of Minnesota.

118. **C. ovatiformis** Ulrich. (Fig. 1666, *v–x*.) Mississippic.
Nearly oval; surface smooth.
Chester of Kentucky.

119. **C. marlboroensis** Ulrich. (Fig. 1669, *e–h*.) Eocenic.
Very like the preceding, but slightly more regular; surface finely pustulose.
Eocenic (Pamunkey) of Maryland.

XLIX. Metacypris Brady and Robertson.

Subrhomboidal shells, rounded in front, obscurely angular behind; dorsal view heart-shaped in female, broadly ovate in male; ventral surface deeply impressed along central and posterior portions of median line; right valve slightly larger than left, with hinge formed anteriorly by a laminated angular projection and posteriorly a strong flange, bearing a single tooth. Cretacic–Recent.

120. **M. consobrina** Jones. (Fig. 1668, *a–c.*) Cretacic.

Very tumid posteriorly, relatively short; dorsal and ventral margin nearly parallel; a faint median sulcus present.

Bear River formation of southwestern Wyoming.

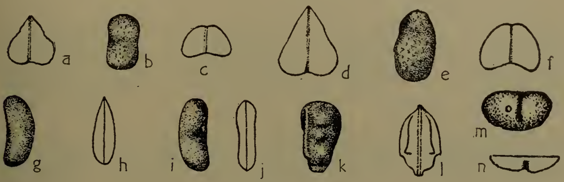

FIG. 1668. *a–c*, *Metacypris consobrina* (120), dorsal, lateral (left) and posterior view, × 20; *d–f*, *M. subcordata* (121), dorsal, lateral and posterior view, × 20; *g*, *h*, *Cytherideris equalis* (122), lateral and dorsal views, × 20; *i*, *j*, *C. impressa* (123), lateral and dorsal views, × 20; *k*, *l*, *Cythere monticula* (124), lateral and dorsal views, × 20; *m*, *n*, *Entomis waldronensis* (103), lateral and dorsal views of left valve, × 1. (*a–l*, after White; *m*, *n*, after Ulrich.)

121. **M. subcordata** Jones. (Fig. 1668, *d–f.*) Cretacic.

Larger than preceding; lateral constriction more anterior; height proportionally greater and ventral margin more deeply impressed; surface pitted.

Bear River formation of southwestern Wyoming.

L. CYTHERIDEIS Jones.

Elongate to triangular, with simple hinge; surface smooth, pitted or tuberculated. Cretacic–Recent.

122. **C. equalis** Jones. (Fig. 1668, *g, h.*) Cretacic.

Elongate, bean-shaped; valves thinner anteriorly; somewhat wedge-like.

Bear River of Wyoming.

123. **C. impressa** Jones. (Fig. 1668, *i, j.*) Cretacic.

Medially constricted by broad ventrolateral constrictions; ends nearly of equal thickness, narrow and curved.

Bear River of Wyoming.

LI. Cythere Müller.

Reniform to subquadrate shells, generally widest in front; surface punctate, nodose or spinulose; hinge of right valve with strong teeth, one at each end of a horizontal bar; left valve with corresponding groove and sockets. The connecting bar is wanting in the subgenus *Cythereis*. Cretacic–Recent.

124. **C. monticula** Jones. (Fig. 1668, *k, l*.) Cretacic.
Elongate, rounded, with faint lateral tubercle; high in front, narrow and subtruncate behind; ventral region with a definite sharp ridge for two thirds its length.

Bear River formation of Wyoming.

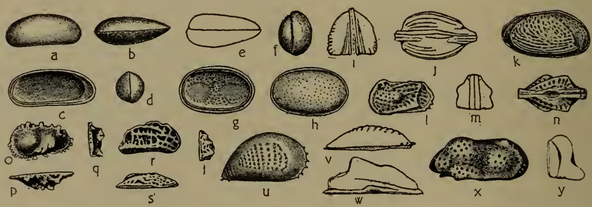

Fig. 1669. *a–d, Bythocypris subæquata* (114), right, dorsal end and interior of left valve, × 14; *e–h, Cytherella marlboroensis* (119), dorsal, anterior, right (interior) and left, × 14; *i–k, Cythere marylandica* (125), posterior and right ventral, × 14; *l–n, C. bassleri* (126), left ventral and anterior, × 14; *o–q, C. alaris* (131), left valve, × 9; *r–t, C. vaughani* (132), right valve, × 9; *u, v, Cytheridea perarcuata* (133), right, × 14; *w–y, Cytheropteron nodosum* (135), right valve, × 17. (Maryland Survey.)

125. **C. marylandica** Ulrich. (Fig. 1669, *i–k*.) Eocenic.
Valves in contact, satchel-shaped; surface pitted.
Aquia formation of Maryland.

126. **C. (Cythereis) bassleri** Ulrich. (Fig. 1669, *l–n*.) Eocenic.
Surface with ridges and a median node, and with pittings.
Aquia formation of Maryland.

127. **C. clarkana** Ulrich and Bassler. (Fig. 1670, *a, b*.) Miocenic.
Without ridges, rounded, but strongly pitted or tuberculated; margin somewhat spinulose.
Chesapeakean of Maryland and Virginia.

128. **C. exanthemata** Ulrich and Bassler. (Fig. 1670, *c, d*.) Miocenic.

Narrower anteriorly than preceding; surface coarsely and rudely spinulose.

Chesapeakean of Maryland and Virginia.

129. **C. evax** Ulrich and Bassler. (Fig. 1670, *e, f*.) Miocenic.

Similar to preceding, but spinules fine, more numerous, and with occasional coarser nodes.

Chesapeakean of Maryland and Virginia.

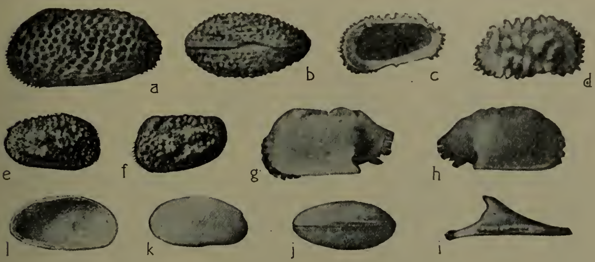

FIG. 1670. *a, b, Cythere clarkana* (127), left and ventral views, × 20; *c, d, C. exanthemata* (128), interior and exterior of right valve, × 20; *e, f, C. evax* (129), right and left, × 20; *g–i, C. cornuta americana* (130), left, right and dorsal of left, × 20; *j–l, Cytheridea subovata* (134), dorsal and exterior and inferior of left valve, × 20. (Ulrich and Bassler, Maryland Survey.)

130. **C. (Cythereis) cornuta** var. **americana** Ulrich and Bassler. (Fig. 1670, *g–i*.) Miocenic.

Margin with coarse spinules; surface of valve elevated into strong, bent, horn-like spine.

Chesapeakean of Maryland and Virginia.

131. **C. (Cythereis) alaris** Ulrich and Bassler. (Fig. 1669, *o–q*.) Miocenic.

Margin spinulose; surface of valve with several irregular spines and nodes.

Chesapeakean of (?) Maryland and Virginia.

132. **C. vaughani** Ulrich and Bassler. (Fig. 1669, *r–t*.) Miocenic.

Surface coarsely reticulated by longitudinal and vertical ridges.

Chesapeakean of Maryland (?) and Virginia.

LII. CYTHERIDEA Bosquet.

Distinguished from *Cythere* by the possession of a row of small teeth in right and socket in left valve, often interrupted in middle. Jurassic–Recent.

133. **C. perarcuata** Ulrich. (Fig. 1669, *u, v.*) Eocenic.
Mytiloid in form but reversed; the rounded anterior margin spinulose; center of surface pitted.
Pamunkey formation of Maryland and Virginia.

134. **C. subovata** Ulrich and Bassler. (Fig. 1670, *j–l.*) Miocenic.
Surface smooth; shell suboval, ends nearly equally rounded.
Chesapeakean of Maryland.

LIII. CYTHEROPTERON G. O. Sars.

Valves tumid, unequal and differing in shape, the right more or less overlapping the left on dorsal margin; surface variously sculptured; ventral surface produced laterally into a prominent, rounded or spinous wing; posterior margin produced into a more or less distinct obtuse beak; hinge with two small terminal teeth on right and minutely crenulated median bar on left valve. Tertiary and Recent.

135. **C. nodosum** Ulrich and Bassler. (Fig. 1669, *w–y.*) Miocenic.
Valve with rounded nodes and pitted surface; wing-like node rounded, the ventral surface pitted.
Chesapeakean of Maryland, rare.

Subclass **Cirripedia** Latreille. (Barnacles.)

The Cirripedes or barnacles differ greatly from other Crustacea, of which they represent a degenerate type. They are attached by

FIG. 1671. *Lepidocoleus sarlei*, right lateral and dorsal, ventral and left lateral views, × 1½. (After Clarke.)

FIG. 1672. *Strobilepis spinigera*, approximate restoration from the side and dorsal view; slightly reduced. (After Clarke.)

direct cementation of the calcareous corona (*Balanus*) or by a fleshy peduncle (*Lepas*) to a variety of substratum, rock, wood, molluscs, other crustacea, marine plants, etc. They are all marine, living abundantly in the shore zone, and extending to the depth of 2,000 fathoms. The fossil genera of America include I., *Lepidocoleus* Faber (Ordovicic–Devonic) of two rows of vertical, overlapping plates; *Examples:* 1. **L. jamesi** (Hall & Whitfield), Cincinnati group of Ohio; 2. **L. sarlei** Clarke, Rochester shale of New York (Fig. 1671) and 3. **L. polypetalus** Clarke, from the Hel-

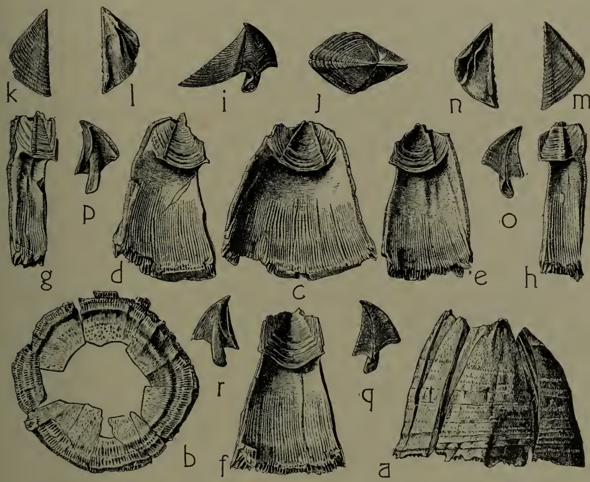

FIG. 1673. *Balanus concavus* Bronn. *a*, lateral view of a complete specimen, × ½; *b*, basis of same; *c*, interior of *rostrum; d*, interior of *left lateral compartment* (*lateralium*); *e*, interior of *right lateral compartment; f*, interior of *carina; g*, interior of *left carino-lateral compartment* (*carino-lateralium*); *h*, interior of *right carino-lateral compartment* (*carino-lateralium*); *i, j*, lateral and end view of *scuta* and *terga*, conjoined; *k, l*, exterior and interior of *left scutum; m, n*, exterior and interior of *right scutum; o, p*, exterior and interior of *right tergum; q, r*, exterior and interior of *left tergum*. All reduced one half. (After Martin, Md. Geol. Surv., Miocene.)

derbergian of New York. II., *Turrilepas* Woodw. (Cambric–Devonic): four to six columns of overlapping scales; *Examples:* 4. **T. devonica** Clarke; 5. **T. squama** Clarke, both of the Hamilton shales of New York. III., *Strobilepis* Clarke (Devonic) of four columns of overlapping plates, two of large and equal size and two others small and unequal; *Examples:* 6. **S. spinigera** Clarke, of the Hamilton shales of New York (Fig. 1672). IV., *Scalpellum* Leach (Cretacic–Recent) of twelve to fifteen variously formed shelly pieces; *Examples:* 7. **S. conradi** Gabb from the Jerseyan beds of New Jersey. V., *Squama* Logan (Cretacic); *Examples:* 8. **S. spissa** Logan, adhering to shells of *Inoceramus* by the entire length, and found in the Coloradoan of Kansas; 9. **S. lata** Logan, from the same beds. VI., *Stramentum* Logan (Cretacic); *Example:* 10. **S. haworthi** Williston, attached to *Ostrea congesta* by the peduncle and found in the Coloradoan of Kansas. VII., *Balanus* Lister (Eocenic–Recent), the true acorn barnacle with six pieces to the corona, and a pair of *scuta* and *terga* closing the aperture, and generally lost in fossil forms; *Examples:* 11. **B. concavus** Bronn (Fig. 1673) (Miocenic–Recent), on both Atlantic and Pacific coasts, and in Europe. VIII., *Protobalanus* Whitfield (Devonic) with twelve plates to the corona, and IX., *Palæocreusia* Clarke (Devonic) a one-piece shell with deep, cylindrical base, and generally embedded in corals (Favosites). *Example:* 12. **P. devonica** Clarke, Onondaga of New York.

Subclass **Malacostraca** Latreille.

Order PHYLLOCARIDA Packard.

Crustacea with the body composed of five cephalic, eight thoracic and two to eight abdominal segments. Head and thorax covered by a thin chitinous or partly calcareous, single or bivalved shell or carapace. When bivalve, the valves are separated by a straight, unarticulated, single or double hinge. In front of the carapace is a narrow movable plate or rostrum. The head bears two pairs of antennæ and stalked compound eyes. Abdomen composed of ring-like segments and often ending in a spine-like tail-plate (telson), provided with lateral spines or *cercopods*. In this order are provisionally placed the two doubtful genera *Stenotheca* and *Ribeiria*, the crustacean character of which is not universally admitted. Only the "carapace" is known in these types.

LITERATURE.

1882–83. **Clarke, J. M.** A. J. S. (3), 23, 25 (Devonic).
1884. **Beecher, C. E.** 2d Geol. Surv. Pa., Rep. PPP (Devonic).
1888. **Hall, James, and Clarke, J. M.** Pal. N. Y., Vol. 7 (Devonic).

I. STENOTHECA Salter.

Univalve, compressed, and transversely corrugated carapaces, without suture along the dorsal margin, and without growth lines. Cambric.

These fossils have generally been placed among the Gastropods, having been considered congeneric with *Metoptoma rugosa* Hall (*Helcionella rugosa* G. and S.). Matthew has referred them to the Crustacea recognizing the character of the shell as that of a folded carapace. They appear to be most nearly related to the Phyllocarida where they are placed for the present.

1. **S. abrupta** Shaler and Foerste. (Fig. 1674, *a–c.*) Cambric.
Slightly curved, rapidly decreasing, with from four to nine strong corrugations decreasing upwards.

FIG. 1674. *a–c, Stenotheca abrupta: a*, interior of half of the carapace, showing thickened ventral margin; *b*, section of this or a related type, the straight side apparently through ventral margin; *c*, exterior; *d, S. curvirostra; e, S. pauper; f, S. levis*, all enlarged. (After Grabau.)

Etcheminian of eastern Massachusetts, and in boulders which probably came from Newfoundland.

2 **S. curvirostra** Shaler and Foerste. (Fig. 1674, *d.*) Cambric.
Very gradually tapering and slightly curved; basal margin almost straight; corrugations numerous, stronger dorsally.

Etcheminian of eastern Massachusetts, and probably Newfoundland.

3. **S. pauper** Billings. (Fig. 1674, *e*.) Cambric.

With strongly incurved posterior portion, and arched dorsum with few coarse corrugations.

Lower Cambric (Etcheminian) of Conception Bay, Newfoundland and eastern Massachusetts.

4. **S. levis** Walcott. (Fig. 1674, *f*.) Cambric.

Elongate, stout, curved through less than a right angle; corrugations irregular, few (about three) of unequal strength, strongest on ventral side.

Lower Cambric (Etcheminian) of Conception Bay, Newfoundland and boulders from eastern Massachusetts.

II. Ribeiria Sharpe.

Arched, univalve shells, without corrugations, with strong beaks, and open at the ends and along the basal margin; a thick, transverse internal plate marks the anterior extremity behind which is a corrugated boss for the attachment of muscles. Ordovicic.

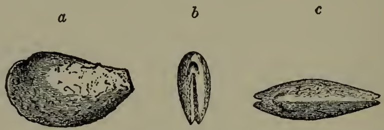

Fig. 1675. *Ribeiria calcifera*, left, anterior and dorsal views of carapace. (After Billings.)

5. **R. calcifera** Billings. (Fig. 1675.) Ordovicic.

Ovate, compressed, narrowed towards the posterior extremity; anterior end broadly rounded; ventral margin curving its entire length; dorsal margin straight behind the beak; a little concave in front; beaks from one fifth to one sixth distance from anterior end.

Beekmantownian of Canada and Pennsylvania.

6. **R. compressa** Whitfield. Ordovicic.

Strongly compressed; valves nearly flat; about three fifths as high as long; both ends gaping; on internal mold is a strongly projecting beak, beneath which is a deep notch; muscular scar narrow, on rounded dorsal edge.

Beekmantownian (Fort Cassin) of Vermont, etc.

7. **R. ventricosa** Whitfield. Ordovicic.

Small (less than three fourths of an inch long), strongly ventricose; venter rounded; dorsum sloping; in internal mold is a strong tubercle on each side of beak; differs from *R. calcifera* in being more gibbous and less elongate behind, with more prominent beaks.

Beekmantownian (Fort Cassin) of Vermont.

III. Ceratiocaris M'Coy.

Carapace consisting of a smooth, pod-shaped, bivalve shell, without eye nodes. Valves of carapace elongate, subovate, or subquadrate, narrow in front, truncated (but not incurved) behind. A free lanceolate rostrum occurs. Body of 14 or more segments, of which from four to seven extend beyond the carapace; some of

Fig. 1676. *Ceratiocaris acuminata*, × ⅓, showing one of the lateral spines. (After Grabau.)

these have obscure branchial appendages. Telson a long-pointed spine, with two smaller lateral spines (*cercopods*) articulated to it. Ordovicic–Siluric.

8. **C. acuminata** Hall. (Fig. 1676.) Siluric.

Carapace large, tapering in front, broad medially, and rather abruptly truncated behind. Surface with fine, raised, longitudinal lines. The next to the last segment long. Telson and lateral spines short.

Waterlime beds (Bertie) of North Buffalo, New York.

IV. Nothozoe Barrande.

Carapace of elongate to subquadrangular or nearly circular valves; both ends and ventral margin rounded, the dorsal margin straight or gently curved; surface smooth. Cambric.

9. **N. vermontana** Whitfield. (Fig. 1677.) Cambric.

Nearly circular; hinge line straight, less than greatest width of shell; sides and base rounded; surface smooth.

Vermont quartzite (Lower Cambric or Georgian) of Vermont.

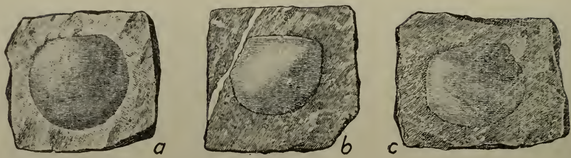

FIG 1677. *Nothozoe vermontana* : *a*, nearly circular valve ; *b*, *c*, right and left valves in quartzite. (After Walcott.)

V. ECHINOCARIS Whitfield.

Hinge short, the bivalve carapace suboval, broad in front, with a free rostrum, not incurved behind, and with no posterolateral spines; a single S-shaped keel on each valve and sometimes a small accessory ridge near the hinge; surface punctate and pustulose; no longitudinal striations; of the body segments, six are exposed and bear small spines on their surface and posterior margins; telson and its lateral spines (cercopods) of unequal size. Devonic.

10. **E. punctata** (Hall). (Fig. 1678.) Devonic.

Large; carapace with short hinge area; oval valves marked by a number of large, rounded nodes in anterior third; with smooth marginal rim and no pustules; abdominal segments rather irregu-

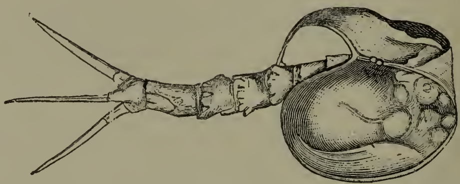

FIG. 1678. *Echinocaris punctata*, complete, with the carapace slightly crushed, × 1. (After Beecher.)

lar, posterior one much longer than others which are roughly nodose on their posterior margins; telson somewhat longer than cercopods.

Hamilton of New York.

11. **E. socialis** Beecher. (Fig. 1679.) Devonic.

Carapace with anterior end rounded, making slightly more than a rectangle with the hinge line; posterior end produced, sharply rounded; marginal rim noded and surface marked with a series of large nodes bearing pustules, besides scattered pustules over the rest of shell; abdominal somites increasing in length posteriorly with two concentric rows of tubercles one posterior and one cen-

FIG. 1679. *Echinocaris socialis*, × ⅓. (After Beecher.)

tral; telson shorter than the lateral spines (cercopods), the latter with a groove on the inside.

Chemung of Warren, Pa., abundant.

12. **E. sublævis** Whitfield. (Fig. 1680, *a, b.*) Devonic.

Length of hinge area about equal to height of carapace; posterior end produced, rounded; anterior end dorsal margins make a

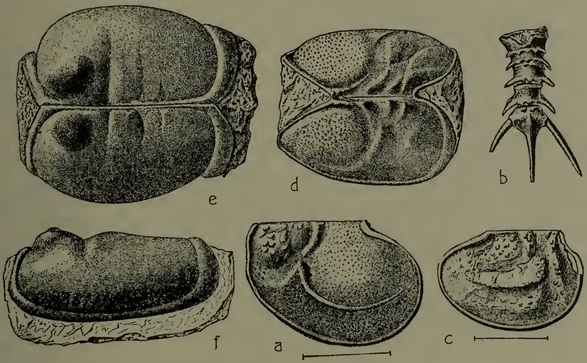

FIG. 1680. *a*, *b*, *Echinocaris sublævis*, left valve, and a few body and caudal segments; *c*, *E. pustulosa*, right valve; *d*, *E. multinodosa*, both valves in conjunction; *e*, *f*, *Aristozoe canadensis*, both valves.

rectangle; surface coarsely pustulose only at anterior end; segments spinose.

Chagrin (Erie) shales of Ohio.

13. **E. pustulosa** Whitfield. (Fig. 1680, *c.*) Devonic.

Hinge area shorter than in preceding; posterior end more sharply rounded, anterior end slightly produced; surface with coarse ridges and pustulose nodes.

Chagrin (Erie) shales of Ohio.

14. **E. multinodosa** Whitfield. (Fig. 1680, *d.*) Devonic.

Posterior end pointed and pustulose; anterior rounded; hinge line short; valves with short folds near hinge and sharp, irregular quadrate nodes in cephalic region.

Chagrin (Erie) shales of Ohio.

VI. Pephricaris Clarke.

Differs from the preceding in the absence of the S-shaped keel, and in a margin with long, curving spines; abdomen with only

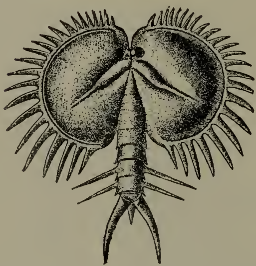

Fig. 1681. *Pephricaris horripilata*, complete, with the carapace spread. (After Clarke.)

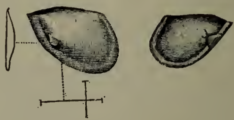

Fig. 1682. *Aristozoe troyensis*, left valve enlarged, and right valve. (After Walcott.)

three or four segments protruding below the carapace, the last two with a long spine on each side. Devonic.

15. **P. horripilata** Clarke. (Fig. 1681.) Devonic.

Spines increasing in length posteriorly, but last four decreasing again; one carapace with a single oblique fold tapering posteriorly; telson short, cercopods several times as long, slightly curved.

Chemung of New York.

VII. Aristozoe Barrande.

Carapace with node on cephalon well developed, but without lateral keels; but one abdominal segment known, and this is very long, cylindrical, with an intricate hinge at the articulation with the tail spines; telson a long spine with a row of small spines on each lateral edge. Cambric–Devonic.

16. **A. troyensis** Ford. (Fig. 1682.) Cambric.

Oblique; anterior end pointed; posterior end rounded, produced, ventral margin grooved and reflected.

Lower Cambric (Georgian) of Troy and Washington County, New York.

17. **A. canadensis** Whitfield. (Fig. 1680, *e, f.*) Ordovicic.

Hinge line slightly less than greatest length, with strong, marginal rim, strong anterior node and several vertical grooves.

Trenton of Ottawa region, Canada.

VIII. Emmelezoe Jones and W.

The two valves of the carapace elongate, narrow, and with distinct eye node; other nodes on cephalon wanting; surface with fine, longitudinal raised striæ. Siluric.

18. **E. decora** Clarke. (Fig. 1683.) Siluric.

Carapace rather broad and bluntly pod-shaped; hinge line straight for two thirds of shell; ends vertical and rectangular; basal margin

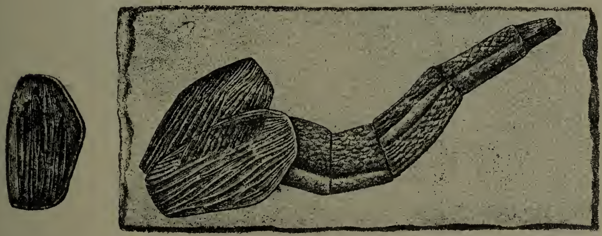

Fig. 1683. *Emmelezoe decora*, a single valve and a nearly complete individual, but with segments of abdomen reversed and thrown forward so as to project from anterior end; width of segments increased by compression, × 3. (After Clarke.)

bluntly triangular; surface ridges sinuous and uniting; abdominal segments of irregular length, longer and narrower posteriorly, pustulose and longitudinally grooved on under surface.

Black Pittsford (Lower Salina) shales of New York.

IX. ELEUTHEROCARIS Clarke.

Carapace elongate, subquadrate, truncated anteriorly, incurved posteriorly; with broad, obscure nodes in the cephalic region; very short, single lateral carinæ in anterior portion; telson slender, cercopods of equal length; surface more or less strongly tuberculated. Devonic.

19. **E. whitfieldi** Clarke. Devonic.

Cephalic region with broad, low nodes, lateral carina very short, oblique and situated anteriorly, both ends truncated. (Type of genus.)

Upper Devonic (Naples shales) of New York.

X. ELYMOCARIS Beecher.

Carapace of two valves with evenly convex and smooth surface, without carina, but with long hinge line, convex posterior margin,

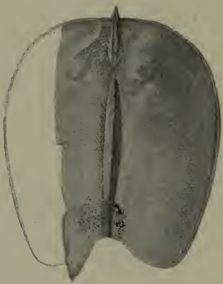

FIG. 1684. *Elymocaris siliqua*, the carapace with valves open, showing median lanceolate plate and rostrum, × 4/3. (After Beecher.)

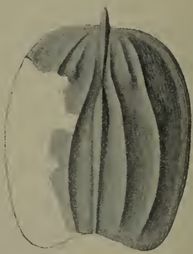

FIG. 1685. *Tropidocaris bicarinata*, the carapace expanded, showing median lanceolate plate and rostrum, × 4/3. (After Beecher.)

and obscure cephalic nodes; median lanceolate plate and rostrum present; two abdominal segments are exposed, with short caudal plate continued in a broad convex and rapidly tapering telson; cercopods bearing setæ on their inner margin. Devonic.

20. **E. siliqua** Beecher. (Fig. 1684.) Devonic.

Rostrum projects slightly beyond the valves and extends backward to optic node; widest at about posterior third of its length, and bearing two longitudinal carinæ; median plate widest just in front of mid-length, with a single carina ornamented by oblique striæ. (Type of genus.)

Chemung of Pennsylvania.

XI. Tropidocaris Beecher.

Bivalve carapace with truncate posterior margins divided by median lanceolate plate and an elongate rostral plate in cephalic region; eye node well defined; other nodes of cephalon obscure; rostrum narrow and ridged; surface of valves with one or more

Fig. 1686. *Tropidocaris bicarinata*, folded carapace with abdomen, telson and cercopods exposed, × 4/3. (After Beecher.)

Fig. 1687. *Tropidocaris alternata*, entire left valve, × 4/3. (After Beecher.)

strong, longitudinal keels; abdomen with two exposed segments, which are subcylindrical and without small spines. Upper Devonic–Mississippic.

21. **T. bicarinata** Beecher. (Figs. 1685, 1686.) Devonic.

With two strong, lateral carinæ, and a shorter intercalated one in cephalic region. (Type of genus.)

Chemung of Pennsylvania.

22. **T. alternata** Beecher. (Fig. 1687.) Mississippic.

Valves elongate with seven alternating longitudinal carinæ, and two spiniform prolongations on the posterior margin, the continuations of the fifth and sixth carina; stronger carinæ with pits on summit; several minor intercalated ones in cephalic region.

Waverly of Pennsylvania.

XII. Rhinocaris Clarke.

Valves in contact at only a single point; divided by median dorsal plate and anterior rostrum; carapace smooth, except for fine, raised longitudinal striæ; ocular nodes well defined; posterior margin concave; abdomen with two or three segments, the last one the longest, all diagonally striated; telson broad; cercopods fimbriated on their margins. Devonic.

23. **R. columbina** Clarke. Devonic.

Rostrum long and slender; median plate spatulate; broadening furrows diverge backwards from the eyes; lateral carinæ very faint.

Hamilton group of New York.

24. **R. scaphoptera** Clarke. (Fig. 1688, *a* and *d*.) Devonic.

More pointed anteriorly than preceding; rostrum strongly curved, rather thick; valves with posterior ventral spinous pro-

Fig. 1688. *a*, *d*, *Rhinocaris scaphoptera*, exterior of left valve and both valves conjoined, the latter × 2; *b*, *c* (center) *R. capsella*, left and right views of two folded carapaces, the first × 2. (After Clarke.)

longation and strong lateral carina; surface with elevated lines parallel to ventral margin, stronger and more frequently interrupted than in *R. columbina*.

Hamilton and Ithaca beds of New York.

25. **R. capsella** Hall and Clarke. (Fig. 1688, *b*, *c*.) Devonic.

Carapace rounded posteriorly; with a few faint ridges near anterobasal margin; longitudinal striæ well marked; no spine on posterior margin.

Hamilton and Ithaca shales of New York.

XIII. Mesothyra Hall and Clarke.

Large; valves of carapace interlocking at contact of two subtriangular projections of dorsal line opposite the eye lobes, leaving

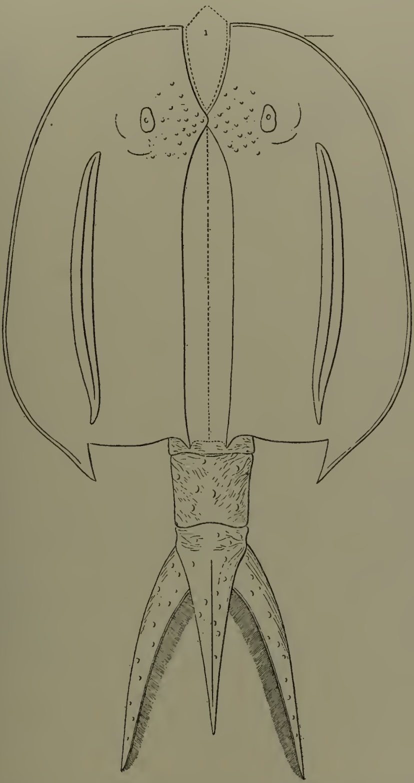

Fig. 1689. *Mesothyra oceani*, outline of carapace, and abdomen and telson, × ½. (After Hall and Clarke.)

a broad anterior and long posterior cleft, closed by median plate; with strong lateral carinæ which are crenulated at the summit; posterior margin produced in a conspicuous spine; two broad segments of abdomen exposed; cercopods setigerous, longer than telson. Devonic.

26. **M. oceani** Hall and Clarke. (Fig. 1689.) Devonic.
Large; lateral carina very strong, its upper surface ornamented by oblique crenulations; cercopods slightly longer than telson; surface of part of abdomen ridged and tubercled.
Portage shales of New York.

XIV. Dipterocaris Clarke.

Carapace chitinous, in one piece; with short, narrow, anterior or rostral, and broad triangular posterior notch, shorter than the anterior one; sides of shield sloping. Siluric–Devonic.

27. **D. procne** Clarke. Devonic.
Cephalic cleft very broad and short, extending one fourth the length of the shield; abdominal cleft narrower and longer; line of connection less than one third length of carapace; surface concentrically striate.
Portage and Chemung of New York.

Order SCHIZOPODA Latreille.

Small, elongate, aquatic forms, superficially resembling macrurous decapods; they have compound eyes borne on movable stalks, a large delicate carapace more or less completely covering the thorax, and eight pairs of thoracic legs similarly formed and consisting of a *protopodite,* with an *exopodite* used for swimming purposes, and an *endopodite.* Five of the abdominal feet or *pleopoda* are biramous swimming feet, the sixth or posterior pair forms with the telson a caudal fin. The genera given below are of doubtful affinities and are placed here tentatively.

XV. Palæopalæmon Whitfield.

Shrimp-like Crustacea with a narrow carpace covering the thoracic region, not rostrated in front, but keeled on back and sides; abdomen of six smooth segments terminating in an elongate triangular telson flanked by caudal flaps composed of five elements, of which the outer four are fused into a triangular plate; legs elongate, smooth, almost thread-like except the upper second joint, which is laterally compressed; antennæ large and strong. Devonic–Mississippic.

28. **P. newberryi** Whitfield. (Fig. 1690, *a–c*.) Devonic–Mississippic.

A sharp carina extends along the axis of cephalothorax and

FIG. 1690. *a*, *Palæopalæmon newberryi*, × 4/3; *b*, caudal fin and last thoracic segment; *c*, same from impression in matrix. (After Whitfield.)

bifurcates near anterior extremity; abdomen tapering rapidly to telson. (Type of genus.)

Chagrin (Erie) shales of Ohio; Kinderhook of Iowa.

XVI. ANTHRAPALÆMON Salter.

Carapace longer than wide, simple, convex, with the sides arched outwards; front margin serrate; antennæ with wide, square basal joints and slender outer joints, the inner pair of flagellæ biramous;

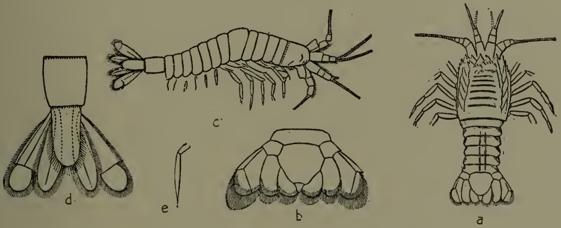

FIG. 1691. *a*, *Anthrapalæmon gracilis*, × 2/3, upper surface of carapace removed; *b*, enlargement of caudal fin and last segment; *c*, *Palæocaris typus*, × 2; *d*, caudal portion enlarged; *e*, a single abdominal foot enlarged. (Ind. Survey.)

abdomen of six segments; telson broad, lateral flaps much subdivided. Carbonic.

29. **A. gracilis** Meek and Worthen. (Fig. 1691, *a, b*.) Carbonic.

Joints of flagella of outer antennæ short; segments of peduncles articulate obliquely; lateral margins of carapace in front of middle finely serrate.

Coal Measures of Illinois.

XVII. PALÆOCARIS Meek and Worthen.

Shrimp-like, with the two pairs of antennæ of nearly equal length, inner biramous; head as long as first two abdominal segments; thoracic legs long, slender, anterior pair without chelæ; telson long and flat; last pairs of pleopoda flattened, with short first joint. Carbonic.

30. **P. typus** Meek and Worthen. (Fig. 1691, *c–e.*) Carbonic.

Thorax slightly wider in middle than the abdomen; telson nearly as broad at base as penultinate segment; both telson and stylets setaceous. (Type of genus.)

Coal Measures of Illinois.

Order DECAPODA Latreille.

Crustacea with the cephalon and thorax united into a *cephalothorax,* of thirteen segments, each with a pair of appendages, and the whole completely covered by a single *carapace,* or with one segment free. Anteriorly the carapace is commonly prolonged into a median spine or *rostrum,* which may be continued backward in a median *dorsal ridge* or *keel.* The surface of the carapace is commonly divided by grooves or depressions into a number of *regions,* corresponding in a general way to the grouping of the organs lying below it. A transverse *neck furrow* (*cervical sulcus*) generally divides the carapace into "cephalic" and "scapular" region, the latter being commonly the larger. The anterior region is divided by vertical or oblique furrows into a median *gastric region,* and lateral *hepatic regions.* The posterior region is similarly divided into the median *cardiac region,* and the lateral *branchial regions.* The grooves vary greatly, and are often obsolete. The anterior pair has been designated the *gastro-hepatic grooves,* and the posterior pair as the *branchio-cardiac* grooves.

The ventral surface of the carapace commonly shows a more or less well-developed *sternum,* which occupies the inner field between the thoracic legs, and varies in width according to the distance between the inner leg-bases. It is especially well developed in the Brachiura, where it shows more or less strongly, the original seven-partite structure.

The *abdomen* (*post-abdomen*) is free and distinct though not visible from above in the Brachiura, where it is bent under. It consists of seven joints, of which the terminal one is the tail-piece or *telson*. The first six abdominal segments are commonly supplied with appendages.

Appendages.—The cephalothoracic appendages fall into two groups, the pre-oral, and the post-oral. The former comprise three pair, the stalked *eyes,* and the two pair of *antennæ,* which vary greatly in length. The antennæ consist of a three-jointed *shaft* (*scapus*) and a *flagellum* (*funiculus*) which in the first or inner (anterior) pair (*antennules*), is double or even triple, while in the second or outer (posterior) pair it is single. Attached to the first joint of the shaft of the outer antenna, or to a distinct outer division of it, is the *antennal scale,* which is variously formed, and has independent motion.

The post-oral appendages of the cephalothorax, comprise six masticatory and five locomotor pairs. In its typical development, the crustacean limb is biramous, consisting of an inner branch (*endopodite*), and an outer branch (*exopodite*), both many jointed, and arising from a common shaft or stem (*protopodite*) composed of two segments. Many modifications occur, and one or the other branch may be entirely wanting.

The first pair of post-oral appendages form the hard chewing jaws, or *mandibles,* each with a masticatory edge. These edges meet between the upper lip (*labrum*), and the lower lip (*labium, paragnathæ*). The next two pairs are the *maxillæ* (anterior and posterior), and the three remaining ones the *maxillipeds* (inner or first, middle or second, and outer or third). The second and third maxillipeds carry gills and in that respect resemble the locomotor appendages. The first pair of maxillæ is small, compared with the mandibles, and of a delicate membranaceous character, hence not likely to be preserved. The second pair generally shows the biramous character more clearly than the first. The first maxilliped is still furnished with a masticatory edge, as in the preceding parts, but the second and third maxillipeds are without this edge. The three maxillipeds agree in having the exopodite feeler-like, while the endopodite is well developed and leg-like in the second and third maxilliped.

The locomotor appendages or legs proper (*pereiopoda*) are in five pairs (hence the name Decapoda), and with few exceptions each consists of seven parts or joints. The exopodite is absent or rudimentary, the leg consisting of the two joints of the protopodite, and the five-jointed endopodite. Named from the base outward, the joints are: 1, *coxopodite* (*coxus*); 2, *basipodite* (*trochanter primus*); 3, *ischiopodite* (*trochanter secundus*); 4, *meropodite* (*merus*); 5, *carpopodite* (*carpus*); 6, *propodite* (*hand, manus*); and 7, *dactylopodite* (*free finger, dactylus pollex*). The first two are generally short, while the last two often constitute the shears or *chela*. The carpus may be many jointed (Fig. 1692). The chelæ are generally best developed on the first pair of thoracic legs (*chelopods*), which are commonly larger, though often unequal in the two legs. The succeeding legs are generally claw-like and serve for walking purposes, though one or more pairs may be modified into flat *paddles* for swimming purposes. Not infrequently, however, one or more pairs of the succeeding legs may be chelate, though these are commonly much smaller than the anterior.

The abdomen is typically furnished with six pairs of abdominal legs (*pleopoda*), corresponding to the first six segments. Each consists of a two-jointed stem or protopodite, and two branches (exopodite and endopodite). In the Brachiura generally only a few of the pleopoda are present. In the Macrura the exopodite and endopodite of the sixth segment are leaf-like and flat, and form with the telson the *caudal fin*.

Typical Decapod Crustacea appear first in the Triassic, are not uncommon in the Jurassic and Cretacic, and abound in the Tertiary and modern faunas. American fossil forms are known from the Cretacic and the Tertiaries.

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See also in faunal works, section on Crustacea (Cretacic and Tertiary), viz.: California Pal., I.–II.; Maryland Survey reports, Pliocene and Pleistocene; New Jersey Palæontology, Vol. IV., Weller; Proc. U. S. Nat. Museum, White; Wilkes Exploring Expedition, Dana; and for structural and systematic detail: Bronn's Klassen und Ordnungen des Thierreichs. Crustacea, by Gerstaecker and Ortmann.

Suborder Macrura Latreille.

(*Prawns, Shrimps, Lobsters, Crayfish,* etc.)

Abdomen at least as long as the cephalothorax; last pair of pleopoda forming with the telson a powerful five-bladed caudal fin. Antennæ mostly very long. Third pair of maxillipeds long and slender, not completely covering the preceding ones (Fig. 1692).

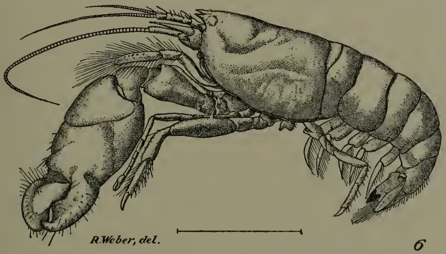

Fig. 1692. *Alpheus nigro-spinatus* Rankin. A modern prawn from the Bahamas. The figure shows the external organs of one side, *i. e.*, the inner antenna with double flagellum, the outer with a single flagellum, the long third maxilliped, the large claw, or first pereiopod, the slender chelate second pereiopod, with the carpus five-jointed (one long and four shorter joints); the third, fourth and fifth pereiopods ending in spines (4th one missing); the first five pleopoda, and the caudal fin. (After Rankin, New York Acad. Science Annals.)

XVIII. Linuparus Gray.

Cephalothorax cylindrical; carapace thick and rigid; without rostrum, and with three longitudinal ridges; pereiopods of six segments only and non-chelate. Cretacic–Recent.

31. **L. vancouverensis** Whiteaves. Cretacic.

Longitudinal ridges low, angular and tuberculous or spinose, the median one thicker and more obtuse than the lateral ones;

carapace divided by shallow, broad, obtusely subangular cervical sulcus at about one third the distance from the front; lateral ridges more spinose in front of this groove, and sharp, but median one becomes obsolete, and replaced by an ovate-lanceolate or pear-shaped area, elevated anteriorly, and margined by tubercles; surface of carapace minutely granulose.

Nanaimo group of Vancouver, B. C.

32. **L. canadensis** Whiteaves. Cretacic.

More prismatic in form than the preceding species, median ridge of post-abdomen sharp, with rounded tubercles; marginal ridges also tuberculate.

Nanaimo group of Vancouver; Benton of Alberta; Niobrara of Dakota.

XIX. Callianassa Leach.

Abdomen much elongated; cephalothorax small, compressed; first, second and last thoracic legs chelate, the first pair the largest; chelæ smooth or with serrated margins; carpopodite joined to the propodite by a straight suture; nearly of the same shape and width as the latter, but shorter and somewhat contracted behind; remaining joints much smaller; entire body except the outer leg joints soft-skinned, and hence the latter alone are commonly preserved. Readily distinguished by the similarity of the carpopodite and propodite. Jurassic–Recent.

33. **C. whiteavesi** Woodward. Cretacic.

Fixed finger of propodite rudimentary and stout, only half as long as the movable finger (dactylopodite), which is straighter than in other species.

Pierre-Fox Hills of Assiniboia, and Nanaimo of Vancouver Island, B. C.

34. **C. conradi** Pilsbry. (Fig. 1693, *a–c*.) Cretacic.

Claws shorter and broader than in *C. mortoni* and more evenly convex on the two sides, posterior margin of outer side and keel along upper edge not abruptly deflected behind; fixed finger of propodite without the median tooth on grasping face, found in *C. mortoni*.

Ripleyan of New Jersey (Tinton beds).

35. **C. mortoni** Pilsbry. (Fig. 1693, *d–f*.) Cretacic.

Known by chelæ; the abrupt deflection of the hind margin of the more convex face of propodite and the downward bend posteriorly of its upper margin are characteristic.

Nearly throughout the Ripleyan of New Jersey.

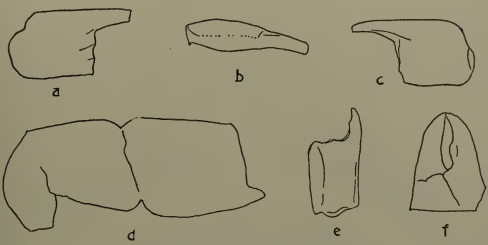

FIG. 1693. *a–c, Callianassa conradi: a*, right propodite; *b*, profile of left propodite; *c*, inner face of same; *d–f, C. mortoni: d*, outside view of specimen retaining propodite, carpopodite and mesopodite in rostrum; *e*, outside view of right propodite; *f*, outside view of extremity of right propodite with dactylopodite, × ¾. (After Weller.)

36. **C. stimpsoni** Gabb. Cretacic?–Eocenic.

Fixed finger nearly as long as hand, not toothed, very slightly curved on inner edge; surface minutely wrinkled, and marked along upper edge by a row of about seven foramina, and by pustules, largest and most crowded in the upper half.

Upper Chico? and Tejon formations of California.

37. **C. ulrichi** White. Eocenic.

Hand quadrate, flattened, inner face less convex than outer, both upper and lower edges acute, the lower one mainly so and finely crenulate; fixed finger shorter than the hand, and gently curved, slender; movable finger larger and stronger, with a moderately strong inner ridge, sometimes with a tooth; surface smooth or granulated along the middle, several small foramina occur in the upper margin of the movable finger.

Lower Eocenic (Midwayan) of Arkansas.

38. **C. oregonensis** Dana. Oligocenic.

Lower margin of hand and fixed finger straight, and denticulate; finger narrow, arcuate, inner edge and sometimes upper surface strongly denticulate; length of propodite nearly twice the width; length of carpus similar, width a little greater.

Abundant in nodules of Astoria shales of Oregon.

XX. Astacus Fabricius.

Body cylindroidal; cephalothorax with strong neck furrow; rostrum triangular, narrow; inner antennæ with short shaft, and short double flagella; outer antennæ with longer shaft, and long flagella, with pronounced scale; sternum narrow; last thoracic seg-

Fig. 1694. *Cancer antennarius* Stimpson (male). A recent species from the California coast. Distinguished by its long outer antennæ and its hairiness, × ⅔. The regions of the cephalothorax are faintly outlined. (After Stimpson, Bost. Soc. Nat. Hist. Proc., VI.)

ment not fused with the preceding; three anterior thoracic legs chelate, the first one very large, with dactylus on the inside, whereas in the other two it is on the outside.

The fresh water crayfish of America include the genera *Cambarus* and *Astacus* (= *Potamobius* according to Ortmann). The distinction between the two genera lies in the character of the gills, features not preserved in the fossil forms known. They will hence be included under the older genus. *Cambarus* is living today east of the Rocky Mountains, and *Astacus* (*Potamobius*) on the west side, and in Europe.

39. **A. (Cambarus?) primævus** Packard. Eocenic.

Similar to the modern *C. affinis* Say, with a similar long narrow pointed rostrum; first pair of thoracic legs shorter and stouter than in the living form, and chelæ rather shorter; surface of carapace, post-abdomen, and legs coarsely tuberculated; telson and broad rami of last pair of pleopoda spined as in living species of Cambarus.

Green River beds of Wyoming.

40. **A. subgrundialis** Cope. Pliocenic.

Surface of cephalothorax smooth or obsoletely wrinkled; two tubercles on each side of rostrum, which is narrow, medially grooved and acute, with five spinous points on each side, and a terminal recurved spinelet; chelæ not granulate, superior edge spiniferous; margins of segments of post-abdomen produced into acuminate plates.

Fresh-water Pliocenic of Idaho.

Suborder Brachiura Latreille.

Body flattened, round oval, triangular or quadrangular, generally transverse, never much elongated. Regions of the cephalothorax generally strongly outlined; sternum mostly well-developed, often showing seven-partite character. Abdomen reduced, without caudal fin, and bent round on ventral side; in the male it is narrow and pointed, with one to two pairs of abdominal feet; in the female it is broad with four pairs. Anterior thoracic legs alone furnished with chelæ in the typical divisions; antennæ short, sometimes not visible from above. The principal external characters are shown in the accompanying figure of a recent crab (Fig. 1694).

Ortmann restricts the Brachiüra so as to include only the superfamilies *Oxyrhyncha* or triangular crabs, *Cyclometopa* or bow crabs, and *Catometopa* or quadrangular crabs. The *Oxystomata* or round crabs, and the *Ranioidea* and *Dromiacea* he separates and places into distinct divisions of equal rank with the Brachiura, the first two under *Oxystomata,* and the last under *Dromiidæ.*

Superfamily Oxystomata Milne Edwards.

XXI. Palæocorystes Bell.

Carapace longer than broad, slightly arched, narrowing posteriorly, latero-anterior border dentated; rostrum-short; orbits moderately broad, oval, with two fissures; neck furrow strong; abdomen of seven segments, the first five short, the sixth quadrangular, the seventh semiovate; chelæ of first pereiopods equal, posterior feet much smaller. Cretacic–Recent.

41. **P. harveyi** Woodward. Cretacic.

Carapace very finely and minutely granulated, with a faint median longitudinal ridge, and two pairs of curved lateral furrows.

Nanaimo group of Vancouver Islands, B. C.

Superfamily Oxyrhyncha Latreille.

XXII. Loxorhynchus Stimpson.

Large; carapace pyriform and subglobose, narrowing forward, broadly rounded behind; surface more or less spinose; rostrum bifid, horns generally strongly deflected downwards, and outwards; orbits slightly excavated, with a single supraorbital fissure; external antennæ not concealed, with a broad basal portion. Miocenic–Recent.

42. **L. grande** Simpson. Miocenic–Recent.

Surface of carapace covered with small warts of nearly uniform size, blunt and rounded near the middle, but sharp and spine-like anteriorly and on the sides, where they are also more crowded; hepatic region with seven spines, two of them large; rostrum longer than wide, slit for a little more than half its length, and deflected downwards to almost at right angles to the horizontal axis; first pair of feet shorter than second, inner margins of chelæ in contact throughout, and denticulate. Length of carapace of type 5.55 inches, greatest width 4.54 inches.

Upper Miocenic (Etchegoin formation) of Fresno County, California. Living off coast of California.

Superfamily Cyclometopa Milne-Edwards.

XXIII. Cancer Leach.

Cephalothorax very broad, moderately convex, arcuate in front, and narrowed behind, without prominent rostrum. Antero-lateral margins notched, forming a regular curve with the frontal margin, which is also marked by several notches; postero-lateral margins straight and rapidly converging; posterior margin short; regions of the cephalothorax faintly outlined. Eocenic–Recent. (Fig. 1694.)

43. **C. fissus** Rathbun. Miocenic.

Anterior angle of each lateral tooth scarcely projecting sideways beyond the tooth immediately in front of it; teeth subtruncate, separated by V-shaped notches and long closed fissures, eight on each side; postero-lateral borders formed by thick granulated line, which is continued across the posterior margin. Length to width, as 1 to 1.45; cardiac region more distinctly divided in the middle into two elevations.

Etchegoin (Lower Miocenic) formation of California.

XXIV. Callinectes Stimpson.

Carapace twice as wide as long; antero-lateral margin forming with the front a regular curve, and marked by nine strong spines, the last a pronounced lateral spine; chelæ with long narrow toothed claws; posterior pair of pereiopods with last joint (dactylus) flattened into a paddle and used in swimming; second, third and fourth pair of legs for walking; first abdominal segment entirely concealed, first and second with appendages; in female second, third, fourth and fifth segments bear appendages. Pleistocenic–Recent.

44. **C. sapidus** M. J. Rathbun. Pleistocenic–Recent.

Carapace moderately convex, with granules of medium size, scattered and faintly marked on anterior half of carapace, but crowded on the inner branchial and cardiac regions; two frontal or interantennal teeth, triangular acute, and with faint indications of two others on their oblique inner margins; lateral spines in males from 3 to 4 times the length of preceding tooth; merus of first pair of pereiopods with three sharp oblique spines on its anterior edge; chelæ with 12 to 14 unequal teeth on each finger.

Pleistocenic of Sankaty Head, Mass., and of New Jersey, and Maryland; Recent: Cape Cod to Florida.

Subfamily Catometopa Milne-Edwards.

XXV. Plagiolophus Bell.

Cephalothorax small, transversely ovate-quadrangular, broader than long; anterior border curved, slightly rostrate, not dentate and with median longitudinal furrow; orbits deep and wide; regions of the cephalothorax outlined by deep furrows, arched and granulose. The four ambulatory legs are similar to one another. Cretacic–Eocenic.

45. **P. vancouverensis** Woodward. Cretacic.

Frontal border straight; rostrum bifid, with two small elevations divided by a groove; lateral borders gently rounded; posterior border nearly straight; lobes of carapace marked, forming three transverse lines across the carapace. (Hind feet unknown, and generic reference provisional.)

Nanaimo of Vancouver Islands, B. C.

XXVI. Archæopus Rathbun.

Differs from *Plagiolophus* in having the last pair of thoracic legs very small, and the orbits much deeper and wider. Cretacic.

46. **A. antennatum** Rathbun. Cretacic.

Differs from *P. vancouverensis* in its slender acuminate, non-bifid and obliquely-inclined rostrum, and in having each orbit occupying about one fourth of the anterior border of the carapace, with a prominent outer, and fainter inner triangular tooth or spine on the dorsal border, and one each on the inner ventral border of the orbit. The carapace is about one and three fifths times as broad as long; antero-lateral margins straight and converging forwards, with five unequal and irregularly disposed tubercles; postero-lateral margins rounded to the bilobed hinder end; cervical sulcus well-developed, cardiac and branchial regions with transverse ridges; central depressions of carapace form a broad H. Chelipeds (of female) of moderate size, subequal, with thick merus and narrow, strongly arcuate chelæ, the fingers somewhat longer than the palm, very slender, grooved, opposed edges meeting and finely dentate.

Chico of San Mateo County, Cal.

XXVII. ARCHÆOPLAX Stimpson.

Subquadrangular; posterior portion very broad, strongly convex, antero-lateral margin with four teeth, the first of which is the largest, and forms the outer angle of the wide orbit; rostrum broad (one fourth the width of the front), truncate, frontal margin with median notched lobe; chelipeds moderate with slender fingers; sternum rather broad; expanded anteriorly, and rather flat; abdomen of male rather broad. Miocenic.

47. **A. signifera** Stimpson. (Fig. 1695.) Miocenic.

Length of type 1.6 inches; greatest width 2 inches; posterior end 1.5 inches; longitudinal curvature forming a regular arc, as

FIG. 1695. *Archæoplax signifera*, dorsal view of a carapace (drawn so as to show anterior end and with posterior end foreshortened), ventral view of a male showing sternum and broad post abdomen. (After Stimpson, Bost. Soc. Nat. Hist. Proc., VII.)

seen in side view the middle height of which is nearly half an inch; surface smooth, covered with minute punctures, granulated anteriorly, and at the margins; central region defined by two lunate smooth marks; last tooth of antero-lateral margin small.

Abundant in the Miocenic deposits of Gay Head, Mass.

Superorder **Edriopthalma** Leach.

Order AMPHIPODA Latreille.

Body laterally compressed. Abdomen elongate. The three anterior feet for swimming, the rest directed posteriorly and used for jumping, at least in modern species. Mostly small, aquatic and generally marine.

Fossil forms are derived chiefly from fresh-water strata.

XXVIII. ACANTHOTELSON Meek and Worthen.

Elongate, slender crustacea with many-ringed body, the rings of the thorax and abdomen of about the same length; head about the length of two thoracic segments; antennæ of equal length, the inner pair biramous, flagella longer than peduncle; anterior thoracic legs longer than others; telson long, simple, spine-like, laterally compressed; stylets with second segment longer than first and similar to telson, and all setigerous. Carbonic.

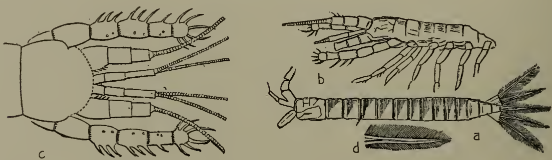

FIG. 1696. *Acanthotelson stimpsoni: a*, dorsal view; *b*, side view; *c*, anterior portion enlarged, showing antennæ and anterior thoracic legs; *d*, stylet enlarged. (Ind. Surv.)

48. **A. stimpsoni** Meek and Worthen. (Fig. 1696.) Carbonic.

Both pairs of antennæ very long; 14 thoracic and abdominal segments. (Type of genus.)

Coal Measures of Illinois.

Order ISOPODA Latreille.

Vertically flattened, elongate crustacea, inhabiting salt and more rarely fresh water, while a number of them are terrestrial; body flat below, rounded above; seven free thoracic segments; carapace scarcely developed; abdomen of short, ringed and often reduced, partially fused segments; caudal segment comparatively large and shield-shaped.

XXIX. AMPHIPELTIS Salter.

Carapace oblong, oval, rounded anteriorly, truncated behind; thorax with nine segments, five of which project behind the carapace, while four are concealed beneath it; caudal segment semicircular, of same width as abdomen and equal in length to the last three segments.

49. **A. paradoxus** Salter. Devonic? or Carbonic.

Length of carapace fully three fourths of an inch; breadth somewhat less; surface without ornamentation; margins minutely serrate; thoracic rings narrow beneath carpace, but attain full width when exposed; pleuræ scarcely distinguishable from axis. (Type of genus.)

Upper Devonic(?) (Fern Ledges) of New Brunswick. Regarded by some as Carbonic.

Class **ACERATA** Kingsley.

Subclass **Merostomata** Dana.

Order XIPHOSURA Gronovius.

Crustacea-like forms; body in mature types distinctly triolobed longitudinally; cephalothorax depressed, large, semicircular; the pair of compound eyes situated laterally and the pair of ocelli in the center in front; six pairs of walking legs about the mouth, the first pair and sometimes several succeeding pairs bearing chelæ; abdomen with seven to ten segments, which dorsally may be either free or united; the six anterior ones are provided with five pairs of lamellar appendages on the under side, the so-called "gill-books" for respiration, covered by the enlarged first pair (operculum); telson long or short, sword-shaped, movable.

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1885. **Williams, H. S.** A. J. S. (3), 30 (Devonic).

1888. **Hall, James, and Clarke, J. M.** Pal. N. Y., 7 (Devonic).

1902. **Rogers, Austin F.** Some new American species of Cyclus from the Coal Measures, Kansas Univ. Sci. Bulletin I, No. 10, pp. 269–275, pl. XIV.

(See also, Palæontology of Illinois.)

I. Cyclus deKoninck.

Cephalothorax small, orbicular, discoidal, or convex, calcareous or chitinous, bounded by a distinct border; the imperfectly preserved appendages seem to be simple swimming legs; their enlarged joints cover the ventral surface of the carapace everywhere except in the center, which is occupied by a V-shaped plate, towards the pointed extremity of which all the basal joints of the limbs converge; Cyclus is known almost solely by its cephalothorax and its poorly preserved appendages. Carbonic.

1. **C. americanus** Packard. (Fig. 1697.) Carbonic.

Nearly circular (about one inch in diameter), low, with extended rim.

Coal Measures of Illinois.

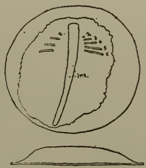

FIG. 1697. *Cyclus americanus*, with side view, × ⅔. (After Packard.)

2. **C. limbatus** Rogers. (Fig. 1698, *a*.) Carbonic.

Differs from the preceding in its spinose margin, lobed and noded surface and small size.

Upper Coal Measures (Iola limestone) of Kansas City, Missouri.

3. **C. minutus** Rogers. (Fig. 1698, *b*.) Carbonic.

Distinguished by its small size (18 mm. long), elliptical outline, median and marginal ridges and nodes.

Coal Measures (Iola limestone) of Kansas City, Missouri.

FIG. 1698. *a*, *Cyclus limbatus*, × 7; *b*, *C. minutus*, × 7; *c*, *C. communis*, diagrammatic profile showing position of facetted eye, and slight groove separating margin from carapace proper, × 7. (After Rogers.)

4. **C. communis** Rogers. (Fig. 1698, *c*.) Carbonic.

Subhemispheric, with narrow, nearly vertical margin.

Upper Coal Measures of Kansas (Lower Garnett limestone) and Missouri (Iola limestone).

II. BELINURUS König.

Cephalothorax horseshoe-shaped, its central portion subquadrate and surrounded by a broad, flat, marginal area; long, slender, genal spines present; abdomen with eight segments besides the very long, slender tail spine (telson); seventh and eighth segments consolidated. Devonic–Carbonic.

5. **B. lacoei** Packard. (Fig. 1699.) Carbonic.

Genal spines parallel to median axis; pleura of abdomen of nearly equal length.

Coal Measures of Illinois.

III. Prestwichia Woodward.

Differs from *Belinurus* in having seven abdominal segments, all united, besides a short tail spine (telson). Carbonic.

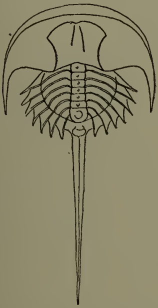

Fig. 1699. *Belinurus lacoëi*, × 1. (After Packard.)

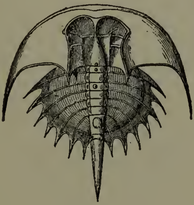

Fig. 1700. *Prestwichia danæ*. (Ill. Survey.)

6. **P. danæ** M. and W. (Fig. 1700.) Carbonic.

Lateral angles of cephalothorax produced into long, slender spines; flattened border of abdomen with strong spines.

Coal Measures of Mazon Creek, Illinois.

7. **P. longispina** Packard. Carbonic.

Median lobe of cephalic shield larger than in preceding, and eyes much nearer lateral margin; lateral spines much longer, extending nearly or quite to base of caudal spine.

Coal Measures of Pennsylvania.

IV. Protolimulus Packard.

Cephalothorax large, with small appendages, its genal angles less produced than in *Belinurus;* abdomen with six (seven?

Packard) segments besides a large, thick tail spine or telson. Devonic.

8. **P. eriensis** (Williams). (Fig. 1701.) Devonic.

Axial length 100 mm., width of axis five to eight mm., length of telson 32 mm.; genal spines scarcely protruding. (Type of genus.)

Chemung of Pennsylvania.

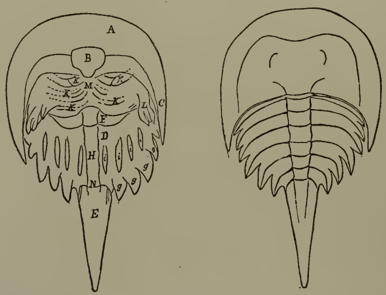

FIG. 1701. *Protolimulus eriensis.* Diagrams of lower and upper (theoretical) sides: *A*, cephalic shield; *B*, ? hypostoma; *C*, genal spine; *D*, thoracico-abdominal buckler; *E*, telson; *g*, marginal abdominal spines; *ii*, longitudinal ridges of buckler; *KK*, portions of the gnathopodes; *L*, ? foliaceous terminations of the last gnathopodes; *M*, position of the mouth, × ½. (After Simpson.)

Order SYNXIPHOSURA Packard.

Cephalothorax semicircular, median axis more or less well-defined; compound eyes generally present; abdomen trilobed, its segments free, resembling the thorax of a trilobite; pleura flat and extended, and generally terminating in lateral spines.

V. Aglaspis Hall.

Cephalothorax large, trilobed, central portion short, conical, with two compressed eyes in front of it; no facial suture; pleura not grooved. Cambric.

9. **A. eatoni** Whitfield. (Fig. 1702.) Cambric.

Head-shield lobed, subsemicircular, conate central portion about half the length of cephalothorax; telson long and slender.

St. Croix (Upper Cambric) of Wisconsin.

VI. Pseudoniscus Nieszk.

Oval crustacea with relatively short cephalothorax, characterized by a broad central and more or less ill-defined lateral portion; eyes apparently absent; abdominal segments ten, the last often in form of short spine; pleura flat; telson strong. Siluric.

10. **P. roosevelti** Clarke. (Fig. 1703.) Siluric.

Subovate, broadest in front; head shield evenly convex, about as long as the abdomen, apparently undivided, and without eyes;

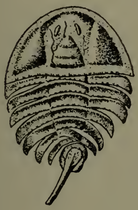

Fig. 1702. *Aglaspis eatoni.* (After Whitfield.)

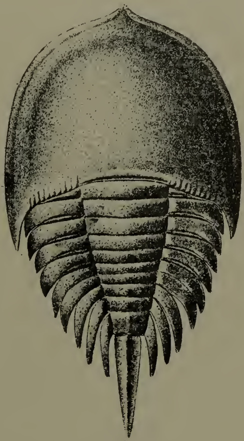

Fig. 1703. *Pseudoniscus roosevelti*, × 3. (After Clarke.)

margin narrow, flat, anteriorly produced in blunt point, posteriorly crenulated on either side of axis, and produced into short, genal spines; telson with strong median angulation.

Pittsford shales (basal Salina) and Bertie waterlime of New York.

Order EURYPTERIDA Burmeister.

Large, Crustacea-like forms, with an elongate body composed of *cephalothorax*, a ringed *abdomen*, and a tail-piece (*telson*); the body is covered by a chitinous skeleton which could be shed as in the modern horseshoe crab. The cephalothorax is usually furnished dorsally with two large, compound (facetted) *lateral eyes* and a pair of *median ocelli,* and ventrally with six pairs of legs, the first preoral and chelate, the others non-chelate. Abdomen of thirteen joints, the six anterior segments bearing on their under side, five pairs of broad, leaf-like appendages probably comparable to the "gill-books" and operculum of the Xiphosura. The posterior seven segments, including the telson, are without appendages. The inner margins of the legs are furnished with stout spines which serve as teeth. The last pair of legs is usually large and somewhat flattened, and ends in an oval plate. This *"paddle"* may have been used for swimming or for burying in the mud or for purpose of anchoring. On the under or ventral surface of the first two abdominal segments, is the genital *operculum,* a pair of plates meeting medially, with a median lobe attached which differs in the two sexes. Eurypterids were probably mostly fresh or brackish water animals, their remains being relatively rare in typical marine strata.

Literature.

1859–1888. **Hall, J., and Hall, J., & Clarke, J. M.** Pal. N. Y., vols. 3 and 7.

1900. **Beecher, C. E.** Restoration of *Stylonurus lacoanus*, etc., Am. Journ. Sci., Vol. X., pp. 145–150, pl. 1.

1901. **Beecher, C. E.** Discovery of Eurypterid Remains in the Cambrian of Mo., A. J. S., 4th Ser. vol. 12, pp. 364–66, pl. VII.

1903. **Sarle, C. J.** A New Eurypterid Fauna from the Base of the Salina of Western N. Y., N. Y. State Mus. Bull., 69, pp. 1080–1108.

1907. **Clarke, J. M.** The Eurypterus Shales of the Shawangunk Mountains in Eastern N. Y., N. Y. State Mus. Bull., 107, pp. 295–310, pls. 1–8.

1909. **Clarke, J. M., and Ruedemann, R.** Monograph of the Eurypterida Memoir, N. Y. State Museum (in preparation) abstract N. Y. State Mus. Bull., 133, p. 35.

VII. Strabops Beecher.

Cephalothorax comparatively larger and wider than in *Eurypterus,* the eyes further forward, nearer together and more oblique; twelve abdominal somites besides the telson as in *Eurypterus.* (Clarke and Ruedemann, only 11 shown in figure.) Cambric.

11. **S. thatcheri** Beecher. (Fig. 1702.) Cambric.

Large, length of cephalothorax less than half the width; eyes of medium size, oblique and connected by a distinct arched line or fold; abdomen of convex segments, which slope outwards into nearly flat pleuræ with rounded anterior ends; telson broad and flat; length of type 110 mm., width 49 mm. (Type of genus.)

Potosi limestone of Missouri.

FIG. 1704. *Strabops thatcheri*, the type specimen, × ½. (After Beecher.)

VIII. EURYPTERUS Dekay.

Body elongate and narrow, often of great size; cephalothorax one fifth or one sixth of the whole length including the telson; depressed-convex, subquadrate in outline, with the anterior angles rounded and the posterior margin slightly concave. Entire margin bordered by a narrow, marginal furrow; eyes reniform, situated somewhat in front of the middle of the cephalothorax; ocelli close to the median line; mouth a ventral

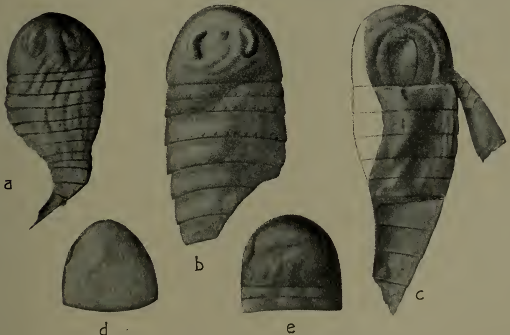

FIG. 1705. *a–c*, *Eurypterus maria*, *a*, an entire individual, 5.5 mm. long; *b*, a specimen 8 mm. long; *c*, an incomplete individual 20 mm. long, ventral aspect; *d*, *e*, *Hughmilleria shawangunk*; cephala, *d*, nat. size; *e* × 4. (After Clarke.)

cleft; legs progressively increasing in length backward, the anterior pair small with pincers or chelæ; second, third and fourth pairs six- to seven-jointed, and covered with fine spines; fifth pair eight-jointed; posterior (sixth) pair consisting of eight segments, large and powerful, with a large, subquadrate basal joint in each and a broad terminal "paddle." Anterior six segments of abdomen occu-

FIG. 1706. *Eurypterus pittsfordensis*, anterior portion of a specimen, × ⅔. (After Sarle.)

FIG. 1707. *Eurypterus eriensis*. (After Whitfield.)

pying together about one fourth of the entire body length; they are short, broad and of nearly uniform shape; the succeeding segments are ring-like, and progressively decrease in diameter, thus causing a tapering of the body; telson long and slender. Siluric–Permic.

12. **E. maria** Clarke (Figs. 1705, *a–c*; 1713, *d, e*.) Siluric.

Small; with large, crescentic eyes; abdomen very little expanded; young strongly contracted in lower part of abdomen.

Shawangunk conglomerate (black shale layers) of New York.

13. **E. myops** Clarke. (Fig. 1713, *f, g*.) Siluric.

Small; head subquadrate, nearly as square in front as behind; eyes large, semicircular.

Shawangunk conglomerate of New York.

14. **E. pittsfordensis** Sarle. (Fig. 1706.) Siluric.

Large, cephalon rather square, with rounded anterior ends; eyes large, reniform; ocelli on faint swellings between the compound eyes; abdomen increases slightly in width to third segment,

FIG. 1708. *Eurypterus lacustris*, a nearly complete individual, but with only one appendage preserved, × ½. (Pal. N. Y., III.)

then tapers to very long telson; body covered with coarse, imbricating, crescentric scales; length 20–30 cm.

Pittsford shale (Lower Salina) of New York.

15. **E. eriensis** Whitfield. (Fig. 1707.) Siluric.

Cephalothorax semioval, regularly rounded; eyes small, rather close together; abdomen scarcely widening to the fourth somite, after which it tapers rapidly; last three segments of nearly equal width.

Put-in-Bay dolomites (Lower Monroe) of Ohio, Canada, etc.

16. **E. lacustris** Harlan. (Fig. 1708.) Siluric.

Stout; anterior portion of abdomen very broad, abruptly tapering beyond the sixth segment; next to the last segment quadrate, without lateral flanges.

Very abundant in the waterlime of North Buffalo, New York.

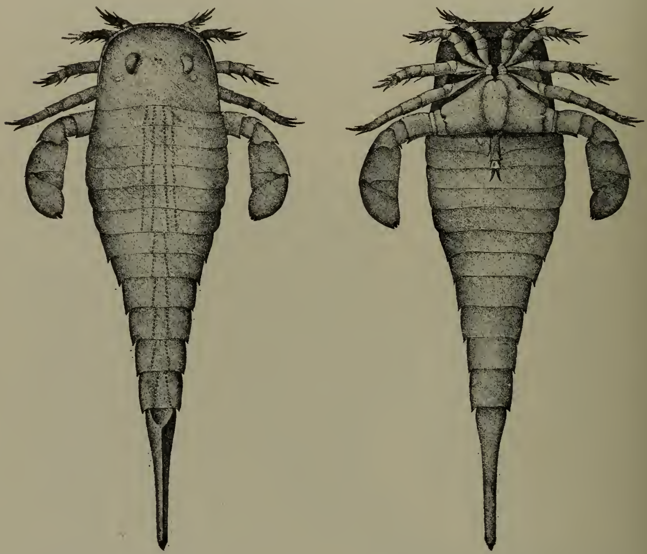

FIG. 1709. *Eurypterus remipes*, upper and under side of an individual, restored; the first pair of appendages omitted. Reduced. (Pal. N. Y., III.)

17. **E. remipes** Dekay. (Fig. 1709.) Siluric.

Animal small, with the lateral margins of the body making broad outward curves and tapering very gradually backwards. The next to the last segment slightly, if at all, flanged. (Type of genus.)

Occasionally in the waterlime of North Buffalo, New York.

18. **E. robustus** Hall. (Fig. 1710.) Siluric.

Like *E. lacustris* but larger and more robust, and proportionately narrower over the anterior abdominal region.

Common in the waterlime at North Buffalo, New York.

19. **E. dekayi** Hall. Siluric.

Body proportionately short, with broad, short carapace; anterior part of abdomen very broad, with posterior part very much contracted; next to last segment with lateral flanges.

Occasionally in the waterlime at North Buffalo, New York.

20. **E. mansfieldi** Hall. Carbonic.

Cephalothorax sloping forward and abruptly rounded anteriorly; eyes reniform, with two broad, rounded elevations between; ab-

FIG. 1710. *Eurypterus robustus*, under side of two individuals, × ⅓. (Pal. N. Y., III.)

domen gently increasing to fourth segment then decreasing to seventh, then abruptly narrowing at the eighth, which is about half as wide as the fourth; sixth and seventh somites with acute, produced lateral angles; five posterior ones with strong, angular ventral spines; telson long, narrow, extremely acuminate; length 228 mm., greatest width 53 mm.

Alleghany series of Pennsylvania, etc.

IX. EUSARCUS Grote and Pitt.

Eurypterids with the six anterior abdominal segments greatly expanded and the succeeding ones abruptly contracted; the terminal joint of the sixth pair of legs not expanded. Siluric.

21. **E. grandis** Grote and Pitt. Siluric.

Large, attaining a length of two or three feet; posterior abdominal segments subcylindric.

Waterlime at North Buffalo, New York.

22. **E. scorpionis** Grote and Pitt. Siluric.

Smaller than *E. grandis;* average length about one foot; appearance strikingly like that of a scorpion; telson strongly curved.

Waterlime at North Buffalo, New York.

X. Dolichopterus Hall.

Differs from *Eurypterus* in having the swimming legs with elongate joints, the seventh and eighth joints little dilated; but the terminal piece or palette, extremely developed; postoral plate lyrate or cardiform-lyrate; central thoracic appendage strong, thick and

Fig. 1711. *Dolichopterus macrocheirus*, a specimen with posterior portion incomplete and some appendages missing, × ½. (Pal. N. Y., III.)

simple in its posterior part. (This and the preceding feature are shown only in ventral aspect.) Siluric.

23. **D. macrocheirus** Hall. (Fig. 1711.) Siluric.

Large; cephalothorax subquadrangular with nearly parallel sides, rounded anterolateral margins, and straight or slightly concave anterior eyes, large, and near the front; body tapering in both directions from third segment.

Bertie waterlime of Buffalo, New York.

XI. Pterygotus Agassiz.

Large, often gigantic Eurypterids, with a semiovate cephalothorax, anterior marginal eyes and central ocelli; the first pair of cephalothoracic legs (preoral) very long and slender, terminating in large pincers or chelæ, very probably prehensible in function; behind the mouth are four pairs of slender, walking legs and behind these are the large swimming feet, which differ from those of *Eurypterus* in being less broadly expanded at the ends; telson an oval plate, either terminating in a short, projecting point, or bilobed. Siluric–Devonic.

24. **P. macrophthalmus** Hall. Siluric.

Cephalothorax subquadrate or tapering anteriorly; eyes very large and high, with a circular base; chelæ (pincers) with angular front end; the posterior teeth on the larger division of the pincers are inclined and saw-like.

Bertie waterlime of North Buffalo, New York.

XII. Eurypterella Matthew.

Very small, elongated Eurypterids with small, triangular cephalothorax; first four abdominal segments together subquadrate; posterior end tuberculated. Devonic (or Carbonic?).

25. **E. ornata** Matthew. ?Devonic or Carbonic.

Minute; length 8 mm., width 4 mm. Length of limb 4 mm. Segments increasing to the third one, then gradually decreasing; a row of tubercles along the posterior margin.

Little River Group; plant bed No. 2, New Brunswick.

XIII. Anthraconectes Meek and Worthen.

Differs from *Eurypterus* in absence of spines on the joints of the cephalothoracic appendages, which terminate in single points, in the great length and the simple extremity of the median appendage of its operculum, and in the presence of two little spatulate supplementary pieces. Carbonic.

26. **A. mazonensis** Meek and Worthen. (Fig. 1712.) Carbonic.
Large, abdomen abruptly contracted after the fifth segment; cephalothorax semioval. (Type of genus.)

Coal Measures of Mazon Creek, Illinois.

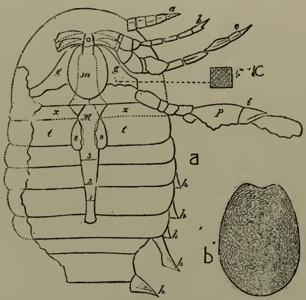

FIG. 1712. *Anthraconectes mazonensis*, an outline of the ventral side, × ½.
a, *b*, *c*, crushed and broken legs, as they appear in the specimens; the divisions shown are not all natural articulations. *gg*, basal segments of the swimming feet. *h*, *h*, *h*, *h*, *h*, impressions of the angular ends of the dorsal half of the body segments. *m*, hypostoma, in place. *M*, mesial appendage of the operculum; 1, 2, 3, are its apparent articulations; *x*, *x*, and *t*, *t*, are lateral alæ of the operculum. *o*, position of the mouth. *p*, one of the paddles or swimming feet, imperfect. The division at *i* seems to be a natural joint.
b, hypostoma enlarged, to show surface sculpturing.
c, a portion of basal segment of swimming-foot enlarged to show surface sculpturing.

XIV. HUGHMILLERIA Sarle.

Cephalon rounded, triangular, or elliptical, with marginal compound eyes; body slender with slight constriction; appendages similar to *Pterygotus;* preoral appendages stout, three-jointed and chelate, barely half the length of cephalothoracic shield when extended; pincers edentulous; spiniform walking legs of seven joints, proportionally more robust than in *Pterygotus,* and each joint from third to sixth, inclusive, carries a pair of ventrally and distantly articulated, slender curved spines; abdomen without marked contraction, of twelve segments exclusive of telson. Siluric.

27. **H. shawangunk** Clarke. (Figs. 1713, *a–c*; 1705, *d, e*.) Siluric.
Similar to *H. socialis* but much smaller; the young with abrupt constrictions after fifth abdominal segment; telson broad, stouter and more triangular than in type.

In the dark shales of the Shawangunk conglomerate (Lower Salina) of eastern New York and Pennsylvania (?).

28. **H. socialis** Sarle. (Fig. 1714.) Siluric.

Telson comparatively long and pointed; surface of entire specimen covered with imbricating, crescentic or angular scales, sometimes carrying smaller ones of same pattern. (Type of genus.)

Pittsford shales (Lower Salina) of New York.

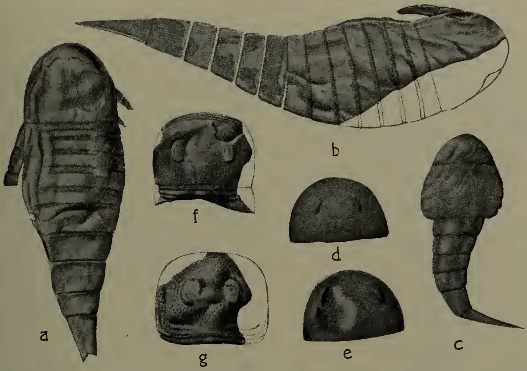

FIG. 1713. *a–c*, *Hughmilleria shawangunk*; *a*, nearly entire, 40 mm. long; *b*, average mature individual, × 4/3; *c*, youngest individual, 2.5 mm. long; *d*, *e*, *Eurypterus maria*, × 3/2 and × 2; *f*, *g*, *E. myops*, head shields, × 1 and × 2/3. (After Clarke.)

XV. Stylonurus Page.

Body similar in general proportions to *Pterygotus*, and often exceeding three feet in length; cephalothorax quadrate or five-sided, its margins bent under so as to cover more than one half of the ventral surface; eyes large, close together, sometimes surrounded by strong ridges; ocelli on the slope of a median ridge; appendages from before the mouth known only by fragments of small chelæ. Of the five pairs of appendages behind the mouth the first bears chelæ, the next two are short and each joint bears a pair of lamellar processes; the last two pairs are enormously elongated, nine-jointed, extending almost to the end of the telson and terminating in sharp claws; number of abdominal segments probably the same as in *Eurypterus*; telson long and slender. Siluric and Devonic.

29. **S. lacoanus** Claypole. (*S. excelsior* Hall.) (Fig. 1715.) Devonic. Form as shown in figure; surface of cephalon covered with conspicuous squamiform tubercles, elongated and much elevated over anterior part of cephalon, broader and more triangular posteriorly.

Catskill of New York; Chemung of Pennsylvania.

FIG. 1714. *Hughmilleria socialis*, dorsal view of a specimen below average size. (After Sarle.)

FIG. 1715. *Stylonurus lacoanus*, from a model by C. E. Beecher, of a specimen nearly five feet long. (After Beecher.)

Subclass **Arachnida.** (Spiders, Scorpions, etc.)

The Arachnida are terrestrial animals, their respiration being carried on by lung-books or tracheæ. The cephalothorax is usually without dorsal indications of segments, but there are six pairs of cephalothoracic legs surrounding the mouth, at least four of which are used for walking purposes. The abdomen is unsegmented and anchylosed with the cephalothorax in the mites and ticks (*Acari*, Tertiary–Recent), but segmented in the false scorpions (*Che-*

lonethi, Tertiary and Recent). An example of the first order is **Ixodes tertiarius** Scudder of the Oligocenic Green River beds of Wyoming, the other is unknown in America. In the Carbonic order

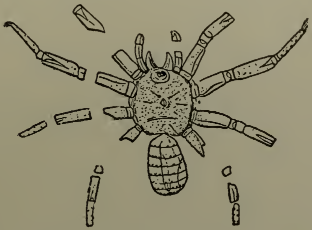

FIG. 1716. *Arthrolycosa antiqua.* Nat. size. (After Beecher.)

Anthracomarti the cephalothorax and abdomen are distinct, the latter being segmented. (*Examples:* **Arthrolycosa antiqua** Harger (Fig. 1716); **Geraphrynus carbonarius** Scudder; **Architarbus rotundatus** Scudder, and **Anthracomartus pustulatus** Scudder of the Coal Measures of Mazon Creek, Illinois, and **A. trilobitus** Scudder (Fig. 1717*a*) of the Fayetteville shale of Arkansas. In the order *Pedipalpi,* the cephalothorax and abdomen are distinct, the latter is segmented and sometimes continued in a slender postabdomen;

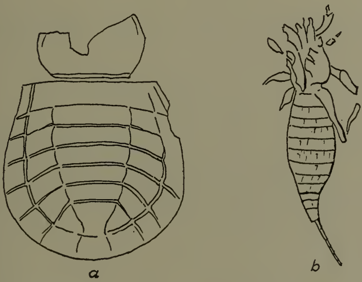

FIG. 1717. *a, Anthracomartus trilobitus,* $\times \frac{8}{3}$; *b, Geralinura carbonaria.* (After Scudder.)

the first pair of legs are exceptionally long. They range from the Devonic to the Present. *Examples:* **Geralinura carbonaria** Scudder (Fig. 1717*b*) of the Coal Measures of Mazon Creek, Illinois. The scorpions (*Scorpiones*) have the abdomen of two parts, a *preabdomen* of seven broad segments and a *postabdomen* of six long slender segments, the last of which forms a hollow spine or sting. **Proscorpius osborni** Whitfield has been considered the oldest American scorpion—occurring with the Eurypterids

FIG. 1718. *Eoscorpius carbonarius*. *A*, natural size; *B*, comb (pecten), enlarged; *C*, body segment, enlarged. (After Meek & Worthen.)

in the Bertie waterlimes of New York. **Eoscorpius carbonarius** Meek and Worthen (Fig. 1718) and **E. (Mazonia) woodanus** M. & W. from the Coal Measures of Illinois are American Carbonic species. The false spiders, of the order *Opiliones* (unknown in American deposits), have cephalothorax and abdomen fused, whereas they are distinct in the true spiders or *Araneæ*. The latter go back to the Carbonic, but are more characteristic of the Tertiary. **Parattus evocatus** Scudder, **P. latitatus** Scudder and **P. resurrectus** Scudder and **Titanœca hesterna, T. ingenua** Scudder, and **Linyphia retensa** Scudder, **Tethnæus hentzii** Scudder, etc., and **Epeira abscondita** Scudder, etc., from the Oligocenic beds of Florissant, Colorado, are American examples.

Class **MYRIOPODA** Ruthe.

The Myriopods (thousand-legs, centipedes) are air-breathing (tracheate) arthropods, of worm-like appearance, with a distinct head furnished with one pair of antennæ and three pairs of jaws,

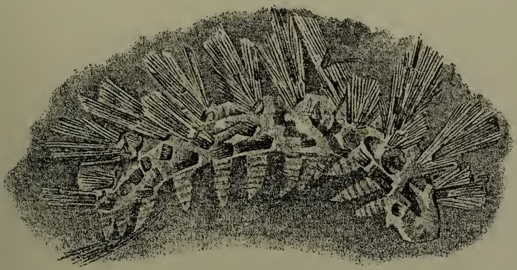

FIG. 1719. *Palæocampa anthrax.* A myriopod from the coal measure nodules a Mazon Creek, Ill., showing legs and bristles, × 2. (After Scudder.)

and with numerous similar body segments, each of which is furnished with a pair of legs (*Chilopoda*) or with two pairs of legs (*Diplopoda*).

The Palæozoic Myriopods (*Archipolypoda* and *Protosyngnatha*) begin, so far as known, in the Devonic, having been found in the Old Red sandstone of Scotland and the Devonic (?) sandstones of New Brunswick (Matthew). They are not uncommon in the

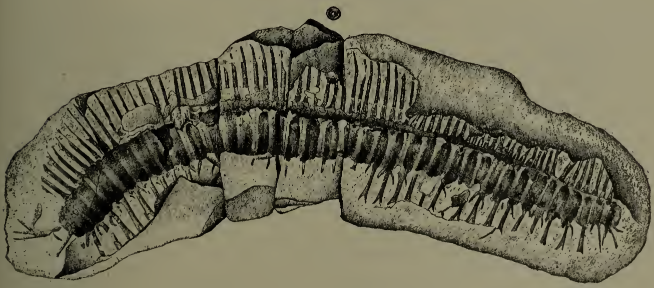

FIG. 1720. *Acantherpestes major.* An almost complete individual, showing legs on upper side of fossil and the branching spines on the lower, one half natural size. Above is shown one of the small disks which cover the surface of the whole fossil excepting the legs, × $\frac{5}{2}$. (After Scudder.)

Coal Measures, especially in the Mazon Creek beds of Illinois. Here occurs the primitive caterpillar-like **Palæocampa anthrax** Meek and Worthen (Fig. 1719), the only representative of the *Protosyngnatha,* while the *Archipolypoda* are represented by a

FIG. 1721. *Euphoberia granosa.* A nearly complete individual, showing both legs (above) and spines, × 2. (After Scudder.)

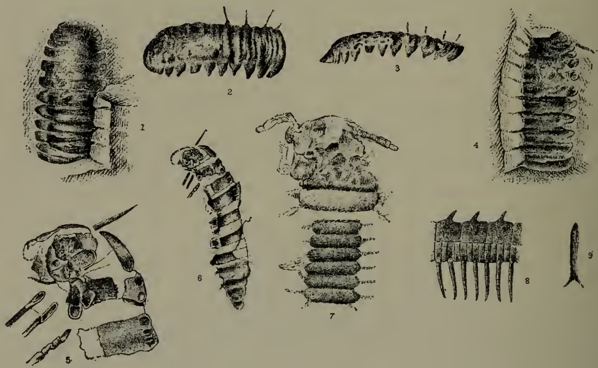

FIG. 1722. Myriopods from the coal measures: (1) *Amynilispes wortheni,* dorsal view, × $\frac{4}{3}$; (2) dorsolateral view of same, × $\frac{4}{3}$; (3) lateral view of same, × $\frac{4}{3}$; (4) view of rock mold of the same, × $\frac{4}{3}$; (5) *Eileticus anthracinus,* anterior portion of figure 6 enlarged, × 2; (6) entire specimen, × ⅔; (7) *Euphoberia armigera,* anterior portion showing head and antennæ, × $\frac{8}{3}$, and the succeeding segments of anterior part of body, × $\frac{4}{3}$; front segment of less magnified part, same as hinder segment of more magnified part; (8) segments from stouter part of body of same showing spines, legs and stigmata, × 2; (9) *Amynilispes wortheni,* front spine of specimen, Figs. 1–3, × 2.

number of genera and species. *Examples:* **Acantherpestes major** Meek and Worthen (Fig. 1720) ; **Euphoberia armigera** Meek and Worthen (Fig. 1722, 7, 8) ; **E. granosa** Scudder (Fig. 1721) and other species; **Amynilispes wortheni** Scudder (Fig. 1722, 1–4 and 9) ; **Eileticus anthracinus** Scudder (Fig. 1722, 5, 6). **Trichiulus**

FIG. 1723. *Xylobius sigillariæ.* *a*, natural size ; *b*, anterior portion, enlarged ; *c*, posterior portion, enlarged. (After Dawson.)

villosus Scudder and other species (all from Mazon Creek), and **Archiulus xylobioides** Scudder, etc., and **Xylobius sigillariæ** Dawson (Fig. 1723) and other species from the Coal Measures of Joggins, Nova Scotia.

The *Chilopoda* are Tertiary and extra American, but the *Diplopoda,* which first appear in the Cretacic of Greenland (**Julopsis cretacea** Heer) are represented in the American Oligocenic by **Julus telluster** Scudder from the Green River beds of Wyoming, and another species from the "lake beds" of Florissant Colorado.

Class INSECTA (*Hexapoda,* Insects).

Insects are air-breathing Arthropoda with the body separated into *head, thorax,* and *abdomen,* covered by a chitinous exoskeleton capable of preservation. The hard integument is in reality composed of a number of plates or *sclerites* connected by delicate membrane, the dividing line being often indicated by sutures. Respiration is by means of air tubes or *tracheæ* which penetrate the body and wings. The head consists of four fused segments with a pair of appendages corresponding to each. These are, from before backwards: a single pair of *antennæ,* attached to the main part of the head (*epicranium*) ; a pair of *mandibles,* one of *maxillæ* (anterior maxillæ), and the under lip or *labium* (posterior maxilla), the basal segments of the opposite members of which are more or less attached to the *clypeus* or front sclerite of the head. There is also an upper lip or *labrum.* Both maxillæ and labium often carry jointed appendages or palpi. The mouth parts may be greatly modified in the various orders for biting, for sucking, lapping, etc. The head further carries the compound eyes and may bear simple ocelli.

The thorax consists of three segments, *prothorax, mesothorax,* and *matathorax,* each with a pair of legs, and the last two typically with a pair of *wings* each. The last pair of wings may be rudimentary or wanting (Diptera). Each thoracic segment consists of an upper region or *tergum* (*notum* or *dorsum*); of a lateral region or *pleuron* on each side, and a ventral region or *sternum* (*tergite, pleurite* and *sternite*). Each region is further designated according to the segment of the thorax to which it belongs: *pronotum, propleuron, prosternum, mesonotum, mesopleuron,* etc.

The pleuron is further divisible into an anterior and a posterior portion (*episternum* and *epimeron*). The episternum rests on the sternum. The mesonotum and metanotum are each divisible into an anterior portion or *scutum,* which extends across the back, and a posterior part or *scutellum,* often smaller and shield-like. A *præscutum* and a *postscutellum* often occur before and behind these two divisions, but they are usually very small and may be obsolete. In the prothorax, these are not differentiated. The wings are inserted between tergum and pleuron and the legs between pleuron and sternum.

The legs consist of five joints each; named from the body outward these are: (1) *coxa,* or basal segment; (2) *trochanter;* (3) *femur;* (4) *tibia* and (5) *tarsus,* or foot. The last consists generally of five members, of which the outer may end in a claw. The coxa connects the trochanter with the episternum while an additional joint, the *trochantin,* exists in some cases, and this may connect the trochanter and epimeron.

The wings are among the most important organs from a systematic point of view, and they are generally the best preserved part of the animal. They consist typically of a thin expanded membrane, including a network of *wing-veins* (*nervures*) and ribs, the arrangement of which is of the highest systematic importance. These veins or nervures are hollow tubes, more or less branching and anastomosing and contain tracheæ or air-tubes and circulating fluid. The principal veins arise by cuticular thickening around the principal tracheæ which lie almost free within the simple sac-like wings of the immature insect. In some cases, however, the nervures are formed before they become tracheated (*Hymenoptera, Coleoptera?*).*

The principal veins or nervures have received distinct names, those most generally adopted being from before backwards (see

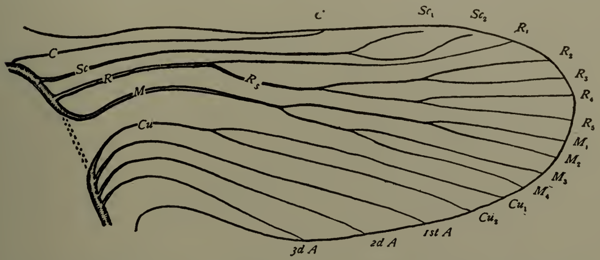

FIG. 1724. Diagram of the tracheation of a primitive insect wing. (Hypothetic. After Comstock and Needham.) *C*, costa; *Sc*, subcosta; Sc_1, Sc_2, first and second subcostal branches; *Rs*, radial sector; R_1–R_5, branches of radial groups; *M*, media; M_1–M_4, branches of media; *Cu*, cubitus; Cu_1, Cu_2, branches of cubitus; *1stA–3dA*, first, second and third anal veins.

Fig. 1724): (1) *costa—C,* (2) *subcosta—Sc,* (3) *radius—R,* (4) *media—M,* (5) *cubitus—Cu,* (6) *anal veins—A.* The costa generally forms the front margin of the wing, and has also been called the *marginal vein.* The subcosta is more or less parallel to the costa, and in much-veined wings gives off numerous small branches to the costa. This vein has also been called the *mediastinal* (Fig. 1737). The radial group, also known as the *scapular veins* (Fig. 1737), is the most prominent of the wing-veins. Typically it is five-branched, the main vein separating into two divisions, the *radius proper, R,* and the *radial sector,* R_s. The latter is four-branched (R_2 to R_5, from before backwards, Fig. 1724), in primitive groups, though the number of branches may be modified by the development of new ones (generally between R_2 and R_4), and by the reduction of the number through coalescence of the older ones. The first radial vein or radius proper may also be-

*See the important papers "The Wings of Insects," by J. H. Comstock, and J. G. Needham, *American Naturalist*, Vol. XXXII., 1898, and XXXIII., 1899.

come wholly atrophied as in the Hemiptera. The preceding three veins constitute the *costo-radial group*, arising from a distinct trunk (Fig. 1724). The cubitus and anal veins constitute the *cubito-anal group*. The media (*M*), also called the *externo-median* (Fig. 1737), is a member of the costo-radial group in the primitive or retarded forms, but migrates to the cubito-anal group, or arises from a transverse basal connecting trachea in all the more specialized groups. This connecting trachea, as well as the bases of the wing trachea are within the thorax of the adult insect, and do not appear in the veining of fossil wings.

The media is usually four-branched in the generalized members of widely separated orders, though in some primitive forms it is only three-branched. The branches are numbered from before backwards. In certain specialized forms, the number of branches is much greater, there being repeated furcations, while in others a reduction takes place which may be caused by the disappearance of the main stem of the media, as in many Lepidoptera.

The cubitus or fifth principal vein (also called *internomedian*, Fig. 1737) separates into two branches in the primitive type. This number may, however, become greatly increased as in the cockroach wing (Fig. 1737) where there are twelve.

The posterior group of veins comprises the anal veins (*A*). They lie between the cubitus and the posterior margin of the wing. In primitive or immature types, there are three, which may arise independently from the cubito-anal stem. In specialized forms they are increased by furcation, or decreased by coalescence, or by atrophy of one or more of the veins, accompanied by a decrease of the anal area.

Besides disappearance of veins through atrophy, there often results a reduction of the number of veins as a whole by coalescence, the point of furcation migrating towards the margin of the wing, until it disappears, or the veins unite at their tips, this coalescence then extending backwards. Veins may also coalesce for part of their extent, and be free at both extremities.

Cross-veins often connect the longitudinal ones. They arise as a rule secondarily, and are not preceded by tracheæ. A few of these cross-veins appear sufficiently constant to receive distinct names (Fig. 1725). These are: (1) *humeral cross-vein*, extending from the subcosta to the costa near the humeral angle of the wing; (2) the *radio-medial cross-vein* (Fig. 1725, *r–m*) connecting radius and media, usually near the center of the wing; (3) *medio-cubital cross-vein* (Fig. 1725, *m–cu*) connecting the media and cubitus usually near the center of the wing; (4) the *medial cross-vein* (Fig. 1725, *m*), connecting the second and third medial branches, and (5) the arculus (Fig. 1725, *ar*), connecting radius and cubitus near the base of the wing, the media appearing to arise from it but in reality forming the anterior part of it, the remainder being formed by a strong cross-vein from the cubitus to the angle in the bent media (ex. Odonata, Fig. 1752, *b*).

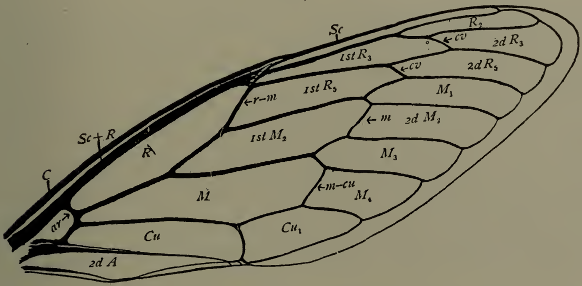

FIG. 1725. Diagram of veins and cells of the fore-wing of an adult *Cicada*. *C*, costa; *Sc*, subcosta; *R*, radius; *M*, media; *Cu*, cubitus; *A*, anal vein. The cells are named according to the veins bounding them in front. *cv*, cross veins; *ar*, arculus; *r-m*, radio-medial cross vein; *m*, medial cross vein; *m-cu*, medio-cubital cross vein. (After Comstock and Needham.)

The *cells* formed by the bounding veins are designated according to the principal vein which bounds them anteriorly. In the basal part of the wing, the cells are bounded by the stems of the principal veins, and are designated accordingly, cells *R, M, Cu, A,* etc. (see Fig. 1725). In the anterior part of the wing, however, where the bounding veins are the branches, these give their names to the cells. Thus we have cells M_1, M_2, M_3, M_4, Cu_1, etc. When cross-veins unite branches, as in the case of the median cross-vein, Fig. 1725, *m*, we may have 1st M_2, and 2d, M_2. In the cicada wing (Fig. 1725) the radial cells are also divided into 1st R_3, 2d R_3, etc. When two branches coalesce, the cells between them disappear. Thus in the Cicada wing (Fig. 1725) cell R_4 has disappeared by the coalescence of veins R_4 and R_5. Such disappearance can usually only be determined by a study of immature stages, or primitive types. In the strongly veined insect wings, the simple cells are subdivided by numerous longitudinal and cross veins, and the names of the original cells are then applied to the corresponding areas of the much divided wing.

A series of folds or furrows further exist on many wings. These serve either for strengthening the wing, or are the result of folding of the wing when at rest. The *subcostal furrow* lies between costa and radius, with the subcostal vein at its bottom. It is a strengthening furrow. Other furrows are: the *anal furrow,* usually between the cubitus and first anal vein (Fig. 1737), and the *nodal furrow,* extending from the costa to the inner margin.

The wings themselves are frequently more or less modified. Thus in the great order COLEOPTERA or beetles, the anterior wings are replaced by, or modified into, a pair of horny sheaths or *elytra* which close together over the back of the insect, concealing the hind wings (Figs. 1747–49). According to some authors, these are not the homologues of the front wings, but of the *tegulæ* or *paraptera* of other insects (*i. e.,* the small sclerites at the base of the wing so well developed in the Hemiptera). Comstock and Needham however conclude from their study of the tracheation of the elytra, that they are modified wings. In the DIPTERA (flies), the posterior wings are wanting entirely while in the STREPSIPTERA, the anterior wings are replaced by small appendages, the posterior wings being large.

The abdomen is typically composed of ten segments, though one or more of the terminal segments is commonly much modified, or even wholly withdrawn into the interior of the body. The anterior segment may be more intimately related to the metathorax than to the rest of the abdomen, becoming a *median* segment. The unequal enlargement of one of the segments as in the ants, may also greatly modify the abdomen. Each segment is typically provided with a dorsal and a ventral plate, while a *stigma* or breathing pore is generally present on each side. These latter may however be greatly reduced in number, or even disappear altogether.

The last abdominal segment is often supplied with appendages (*cerci*).

The development of insects is generally through metamorphosis.

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A. Palæozoic Insects.

Classification. Handlirsch divides Palæozoic insects into the following sixteen orders; those marked with an anterisk (*) have American representatives: 1.* Palæodictyoptera. 2.* Mixotermitoidea. 3. Reculoidea. 4.* Protorthoptera. 5.* Protoblattoidea. 6. Mantoidea. 7.* Blattoidea. 8.* Hadentomoidea. 9.* Hapalopteroidea. 10. Perloidea. 11.* Protodonata. 12. Protephemeroidea. 13. Plectoptera. 14.* Megasecoptera. 15. Protohemiptera. 16. Palæohemiptera.

The Palæodictyoptera are considered to be the stem group, from which all others are derived. This order appears first in the Pottsville in America, and in the Little River Group of New Brunswick. This group is placed in the Kanawha series, though many Canadian geologists regard it as Devonic. All the orders became extinct at the end of the Palæozoic with the exception of the Blattoidea and Plectoptera.

Order PALÆODICTYOPTERA* Goldenberg.

Slenderly built insects with four similar membranous wings, independent of each other, not capable of folding, and moving only

* The characterizations of the orders are taken almost directly from Handlirsch, 1906, and 1906–08.

in a vertical direction. Head rounded, of moderate size, eyes distinct; antennæ not very long, and simple; mouth parts fitted for chewing; thorax of three similar segments, the first mostly with

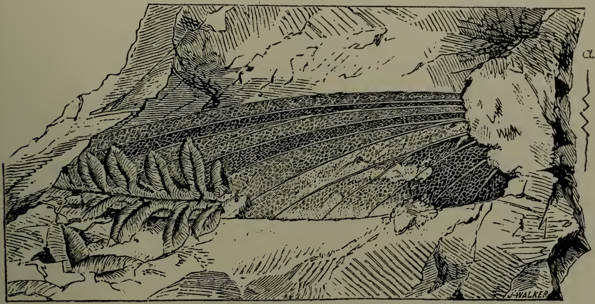

FIG. 1726. *Haplophlebium barnesii*, wing embedded in rock, with frond of fern; *a*, profile of base of wing. (After Dawson.)

small wing-like appendages. Wing-veins almost exactly corresponding to the hypothetic type (Fig. 1724). *C* marginal not branched; *Sc* independent, not far removed from *C*, not furcate; *R* simple, preserved to the tip; *Rs* separating from *R* near the base of the wing, its branches mainly oblique to the apical border; *M* and *Cu* each generally with a simple or slightly dichotomous anterior branch, and a more strongly branching inferior one, their branchlets always more or less arcuate, and directed backward; anal veins always well developed, more or less branched and curved back to inner margin; cross-veins generally abundant and irregularly distributed; no anal fold or fan-like plaitings. Legs

FIG. 1727. *Homothetus fossilis*, $\times \frac{4}{3}$. (After Scudder.)

similar, moderately long and strong, fitted for running; tarsus of several joints. Abdomen moderately slender, never very thin or very broad, uniformly segmented; eleventh segment with several jointed, and often long, cerci. Larva similar to imago.

Of the 115 known species of Palæodictyoptera, 28 have been found in North America. Six of these are known from the Pottsville, ten from the Kanawha and Little River groups, 11 from the

FIG. 1728. *Eubleptus danielsi* Handlirsch, Mazon Creek, Ill. (*Rs*, radial sector; *M*, media; *Cu*, cubitus.) (After Handlirsch.)

Allegheny, and 1 from the Conemaugh. *Examples:* **Haplophlebium barnesii** Scudder (Fig. 1726), from the Allegheny? of Sydney, Cape Breton; **Titanodictya jucunda** (Scudder) from the

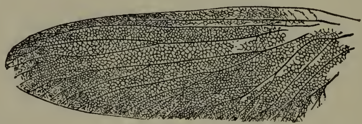

FIG. 1729. *Paolia vetusta*, left anterior (?) wing, natural size. (After Smith.)

upper Kanawha group of Pennsylvania; **Homothetus fossilis** Scudder (Fig. 1727) from the Little River Group of St. John, N. B.; **Eubleptus danielsi** Handlirsch (Fig. 1728) from the Coal Measures of Mazon Creek, Ill., and **Paolia vetusta** Smith (Fig. 1729), characterized by an abundance of cross-veins, from the Mansfield of Indiana.

Order MIXOTERMITOIDEA Handlirsch.

Wings with broadly rounded apical border, with neuration closely approaching that of the preceding type; branches of *M* few, they, the cubitus and the anal veins extending obliquely to the lower margin; anal area feebly developed; *Sc* reduced; *R* simple; *Rs* feebly branched; cross-veins straight and numerous.

Only one European and one American species are known, the latter being **Geroneura wilsoni** Matthew of the Little River Group of St. John, N. B.

Order PROTORTHOPTERA Handlirsch.

Wings more highly specialized than in preceding types; folded over the abdomen when at rest; front wings with more complicated venation than in PALÆODICTYOPTERA, the veins no longer extending in regular curves to the inner margin. Hind wings similar to the front wings, but with larger anal area, marked off by a fold. Body more or less strongly built, prothorax large, often much elongated; head large, mouth parts strong, fitted for chewing; antennæ long, slender; legs similar in form, fitted for running;

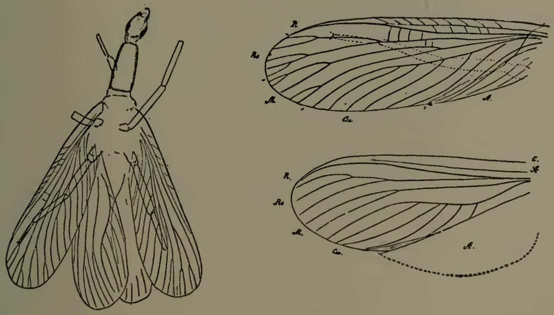

FIG. 1730. *Spaniodera ambulans* Handl., Mazon Creek, Ill. Carbonic; crushed specimen, and front and hind wings; *C*, costa; *Sc*, subcosta; *R*, radius; *Rs*, radial sector; *M*, media; *Cu*, cubitus; *A*, anal area. (After Handlirsch.)

or the posterior ones adapted for jumping. The order apparently connects the ORTHOPTERA proper with the PALÆODICTYOPTERA. Of the 88 or more described species of this order, 62 are American,

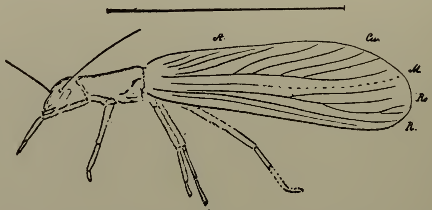

FIG. 1731. *Gyrophlebia longicollis* Handl., Mazon Creek, Ill. Carbonic. *R* = radius; *Rs*, radial sector; *M*, media; *Cu*, cubitus; *A*, anal area. (After Handlirsch.)

18 are known from the Allegheny, one each from the Kanawha and the Conemaugh, and 42 from the Permic of Kansas. *Examples:* **Spaniodera ambulans** Handl. (Fig. 1730), and **Gyrophlebia longicollis** Handl. (Fig. 1731), both from Mazon Creek, Ill., and

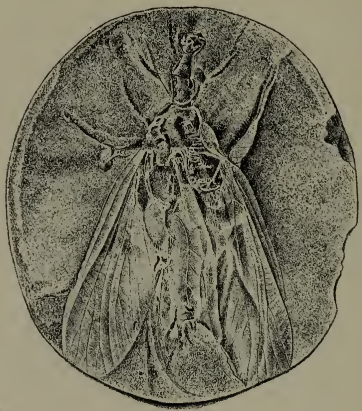

FIG. 1732. *Propteticus infernus*, × $\frac{4}{3}$, coal measures of Ill. (After Scudder.)

both characterized by having the *Sc* abridged, the *R* simple, with the *Rs* branching off near the base. In the last mentioned form the *M* appears also to be simple. Other examples of closely related forms are: **Propteticus infernus** Scudder (Fig. 1732) from the Alleghanian of Vermilion County, Ill., **Dieconeura arcuta** Scudder (Fig. 1733–4) and **Genentomum validum** Scudder (Fig. 1733, 2, 3), both from the Alleghanian of Mazon Creek, Ill., the last representing a family, in which the superior branch of the *M* of the front wing coalesces with the *Rs* and later again separates. In the Permic occur: **Lepium elongatum** Sellards; *Stoichus* Sellards,

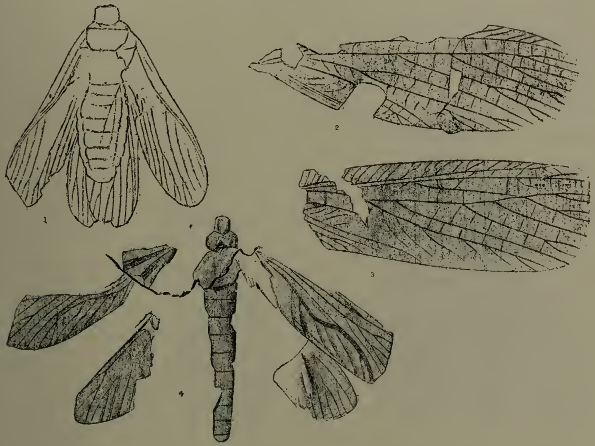

FIG. 1733. Protorthopterous insects from coal measures of Mazon Creek, Ill. 1, *Anthracothremma robusta*, × 4/3; 2, *Genentomum validum*, front wing, × 4/3; 3, hind wing of same, × 4/3; 4, *Dieconeura arcuta*, × 4/3. (All after Scudder.)

several species; *Lemmatophora* Sellards, 5 species; *Artinska* Sellards, 6 species, etc.

Order PROTOBLATTOIDEA Handlirsch.

Head distinct, rounded; prothorax either not expanded, or only moderately so; wings intermediate in character between the palæodictyopteran and the blattæform type, laid back over the abdomen when at rest; front wings with anal area fairly well defined, and filled up with arcuate or oblique veins descending to the posterior margin; hing wing with enlarged anal area, defined by fold.

Of the 44 or more known species, 27 are American, 19 occurring in the Alleghany horizon, 6 in the Conemaugh and two in the Lower Permic of Kansas. The family *Oryctoblattidæ* has 8 described species in America, all but three in the Conemaugh. It is characterized by its well defined anal area, a strongly compound radial sector, a less copiously divided media, and a large number of delicate veins, running out obliquely from the cubitus. The costal area further is broad, filled with numerous branches from the subcosta, similar veins extending forward from the radius, while intercalary veins abound. *Examples:* **Oryctoblattina laqueata** Scudder, from the Chanute shales of Kansas City, Mo.; **Blattinopsis anthracina** Handl. from the Conemaugh of Ohio, and **Pursa ovata** Sellards and **Sindon speciosa** Sellards from the Permic of Kansas.

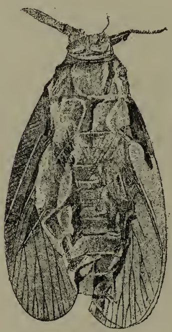

FIG. 1734. *Eucænus ovalis* Scudder, × 2, Mazon Creek, Ill. Carb. (After Scudder.)

FIG. 1735. *Gerapompus blattinoides* Scudder, Mazon Creek, Ill. Carbonic, × 2. (After Scudder.)

The family *Eucænidæ* contains 4 species. The costal area of the wing is broad, attaining about two thirds the length of the wing, the radius is reduced to few branches, while the cubital area is expanded and the anal area reduced, and marked off by a curved furrow. *Example:* **Eucænus ovalis** Scudder (Fig. 1734), from Mazon Creek, Ill.

The family *Gerapompidæ* with three species has the costal area of the front wing more reduced and supplanted by a great number of branches extending forward from the radius, which together with the media is crowded back by the strongly developed cubitus. *Example:* **Gerapompus blattinoides** Scudder (Fig. 1735), from Mazon Creek, Ill.

The family *Adiphlebidæ* with 2 species is characterized by an enlarged shield-shaped pronotum, and by having the branches of *Sc, R, M,* and *Cu,* run off almost ray-like from the base of the wing, separated by numerous intercalary veins, and many cross-veins. *Example:* **Adiphlebia lacoana** Scudder (Fig. 1736) from the Mazon Creek beds of Illinois.

Finally in the family *Anthracothremmidæ,* with only one species. **Anthracothremma robusta** Scudder (Fig. 1733, 1), from Mazon Creek, the wings differ from all other Carbonic insects hitherto known. The front wings are slender, four times as long as wide, with strongly arcuate anterior border, a very narrow costal area, extending about two thirds the length of the wing, and a short anal area, marked off by a bow-shaped furrow; *R* simple, reaching nearly to the tip of the wing; *Rs* emerging near the base of the wing, with four or five simple branches which extend in a curve to the apical border; branches of *M* and *Cu* nearly parallel; hind wings similar, but with subcosta extending farther towards the tip. The body is robust; prothorax enlarged, disk-shaped; front legs somewhat elongated as in *Eucænus.*

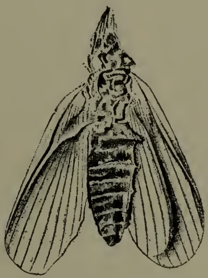

FIG. 1736. *Adiphlebia lacoana* Scudder, × 4/3, Mazon Creek, Ill. Carb. (After Scudder.)

Order BLATTOIDEA Handlirsch. (Cockroaches.)

This order includes the majority of Palæozoic insects, a total of more than 620 species being known, of which approximately 289 are North American. These are distributed as follows: Kanawha horizon 4, Kittanning 56, Freeport 37, Conemaugh and higher coal measures 92, Lower Permic 100. Scudder separates the Palæozoic cockroaches from the Mesozoic and later species as PALÆO-

BLATTARIÆ (Family *Palæoblattidæ* Sellards), but Handlirsch and others do not favor such a separation.

Head often entirely concealed by the large shield-like pronotum. In the winged cockroaches the front wings or tegmina are more coriaceous than the hind wings and more generally preserved. The marked veins of the tegmen and wings are (Fig. 1737): the *subcostal* or *mediastinal,* the *radial* (including radial sector) or *scapular;* the *media* or *externomedian;* the *cubitus* or *internomedian,* and the *anal veins* separated from the rest by the anal furrow.

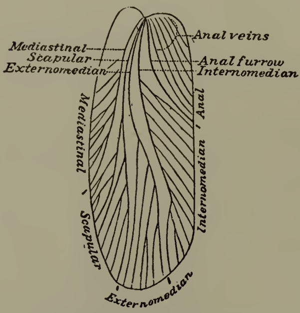

FIG. 1737. One of the tegmina of *Etoblattina* (*Asemoblatta*) *mazona*, × 2, with the parts named. The areas are marked along the margin, the veins are named at the base of the tegmina. (After Scudder.)

In the family *Archimylacridæ,* which includes more than one third of the American species, the neuration still resembles in the main the palæodictyopteran type. The subcosta or mediastinal of the tegmen is always preserved as an independent vein sending off a large number of branches to the costal margin, either pectinate or united into groups, but never issuing ray-like from the base of the wing; radius (scapular) more or less copiously branched, separable into radius and radial sector only in the most primitive forms; radial group divided into clusters of twigs or branches all of which arise apparently on the superior side of the principal vein; media (externomedian) separated into two main compound offshoots, or it forms one vein with branches running off backwards, or finally, one such, with the branches ramifying anteriorly; cubitus (internomedian) with numerous branches to the inner margin, more rarely with an isolated widely furcating superior offshoot; anal area always marked off by a bow-shaped furrow, and containing a number of veins which fuse on the posterior margin; irregularly reticulate or delicately regular cross-veins occur. *Examples:* **Adeloblatta columbiana** (Scudder) (Fig. 1738, *b*), and **Asemoblatta mazona** (Scudder) (Fig. 1737,

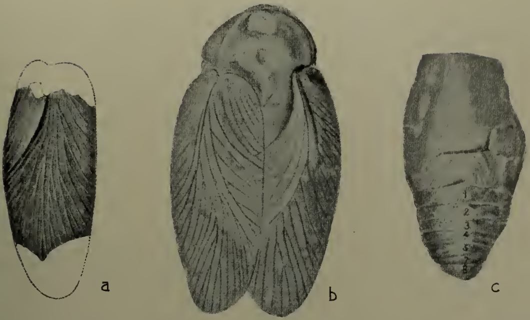

FIG. 1738. Palæozoic cockroaches. *a*, *Hemimylacris clintoniana* (Scudder), × 2; *b*, *Adeloblatta columbiana* (Scudder), × 2; *c*, body of cockroach enlarged. (After Scudder.)

1739, *a*), both from Mazon Creek, Ill. **Phyloblatta dichotoma** Handlirsch (Fig. 1739, *d*), and **P. arcuata** Handl. (Fig. 1739, *e*) (both referred by Scudder to *Etoblattina communis*); and **Bradyblatta sagittaria** (Scudder) (Fig. 1739, *c*), this and the two preceding from the Dunkard formation (Permic) of Cassville, W. Va.

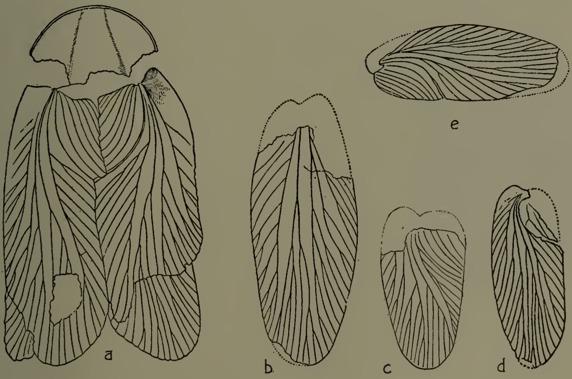

FIG. 1739. Palæozoic cockroaches (referred to *Etoblattina* by Scudder). *a*, *Asemoblatta mazona* (Scudder), Mazon Creek, Ill.; *b*, *Dicladoblatta tenuis* (Scudder), Conemaugh of Ohio; *c*, *Bradyblatta sagittaria* (Scudder); *d*, *Phyloblatta dichotoma* Handl.; *e*, *P. arcuata* Handl.; *c*, *d* and *e*, from Dunkard of W. Va.

In the family *Spiloblattinidæ*, with about 40 species from the Conemaugh, and less than half that number from the Dunkard formation, the interspaces between the main veins are remarkably broad in the central portion of the tegmen, the costal area is always band-shaped, and the branches of the subcosta arise successively in a pectinate manner; the radius separates either into two widely compound main branches, or it sends out forward a large number

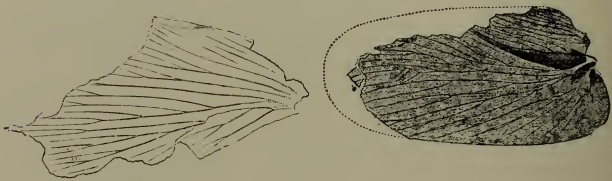

FIG. 1740. *Mylacris anthracophila* Scudder, × $\frac{4}{3}$, and *Orthomylacris antiqua* Scudder, both from the coal measures (Allegheny) of Ill.

of feebly compound offshoots; the media rarely divides into two equally branched principal stems, but mostly forms a series of branches running out forward; cubitus and anal area as in preceding family. *Examples:* **Etoblattina (Dicladoblatta) tenuis** Scudder (Fig. 1739, *b*), from the Conemaugh formation of Ohio. **Spiloblattina gardineri** Scudder, from the Permic of Fairplay, Colorado.

FIG. 1741. *Mylacris anthracophila.* (After Scudder.)

In the family *Mylacridæ* which is represented by about 50 species in the Alleghany, and perhaps half a dozen or more in the Conemaugh and higher Coal Measures, the front wing is of variable shape, but generally broad and short, nearly always widest at the base. Costal area always more or less triangular in form, never band-shaped; branches never pectinately arranged on subcosta but main ones always radial from one point; the radius as a rule sends numerous branches anteriorly, or it divides into two widely branched principal off-shoots; the media gives off its branches either serially from one stem backwards, or it forms two compound main branches, or (more rarely) the offshoots are directed forward; *Cu* with a variable number of veinlets, branching off posteriorly; anal area chiefly rather large, its veins never or quite exceptionally ending in the anal fold, but generally in the posterior border. *Examples:* **Hemimylacris clintoniana** Scudder (Fig. 1738, *a*), from the Cherokee shales of Missouri, **Orthomylacris antiqua** (Scudder) (Fig. 1740, *b*), from Mazon Creek, Ill.; and **Mylacris anthracophila** Scudder (Figs. 1740, *a*; 1741), from the Alleghany of Colchester, Ill.

Of the remaining families of the Palæozoic Blattoidea, the majority are represented in North America, but generally only by a few species.

Order HADENTOMOIDEA Handlirsch.

This order is represented by only one species **Hadentomum americanum** Handl. (Fig. 1742), from the Kittanning horizon

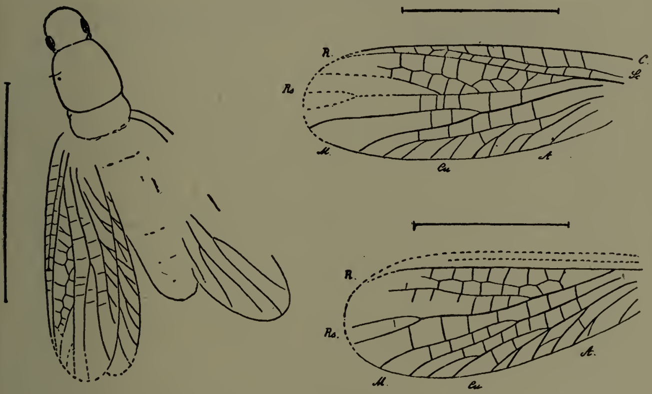

FIG. 1742. *Hadentomum americanum* Handl., Mazon Creek, Ill. Carbonic. A nearly entire individual and hind and fore wings. (*C*, costa; *Sc*, subcosta; *R*, radius; *Rs*, radial sector; *M*, media; *Cu*, cubitus; *A*, anal area. (After Handlirsch).

of Mazon Creek, Ill. It has a large head, very elongate prothorax, and rather simply veined wings. *R* simple, the radial sector three-branched, and arising near the base; *M* forked once, *Cu* with four posterior branchlets, partly furcate; first anal forked, second simple; anal area small, not defined; the wide space between *R* and *Rs* filled by polygonal cells; cross-veins in other interspaces simple and distant.

Order PROTODONATA Brongniart.

This order includes 10 described species of which only 3 are American; one from the Kanawha of Pennsylvania, **Palæotherates pennsylvanicus** Handl., another from the Freeport horizon of Rhode Island, **Paralogus æschnoides** Scudder, and the third, the remarkable **Tupus permianus** Sellards (Fig. 1743), from the Permic of Kansas. The members of this order represent connecting links between the Odonata and the Palæodictyoptera. The neuration of

FIG. 1743. *Tupus permianus* Sellards, a Permic dragonfly from Kansas. The type specimen about × ½. Specimen viewed from under side, the base of the wings passing under the body. The strongly outlined structures, on the under side of the head are apparently the mandibles; the distal end of the femur, the tibia and a part of the tarsus of the left front leg are preserved, also a small part of the tibia of the second pair of legs. (After Sellards.)

the four equal wings is more highly specialized by coalescence of several longitudinal veins in the basal portion of the wing, by conversion of longitudinal veins into "accessory sectors" and by the regular arrangement of cross-veins. Many of the characteristic wing structures of the Odonata, such as the pterostigma, wing triangle, and quadrangle, and the reduction of anal veins, are still wanting in this order. As shown by Sellards, however, the intersection of longitudinal veins, *i. e.,* the crossing of $M_{1,2}$ by the radial sector, indicated in the adult by the oblique cross-vein at, or just beyond, the separation of $M_{1,2}$, and a similar, but faint oblique vein (*subnodus*), uniting *R* and M_1, features so characteristic of modern Odonates is also found in *Tupus permianus* Sellards, and thus indicates a closer relationship between the Palæozoic and later Odonates than before recognized.

Order MEGASECOPTERA Brongniart.

This order, with 22 known species, is represented by two species in the Kittanning horizon and 1 species in the Lower Permic of Kansas. They are especially distinguished by the tendency toward degeneration shown by the specialization of the anal part of the wing, as well as the reduction in number of the cross-veins, their regular arrangement, and the partial coalescence of the media and cubitus with the base of the radius. There is further a differentiation of the thoracic segments by the diminution of the prothorax.

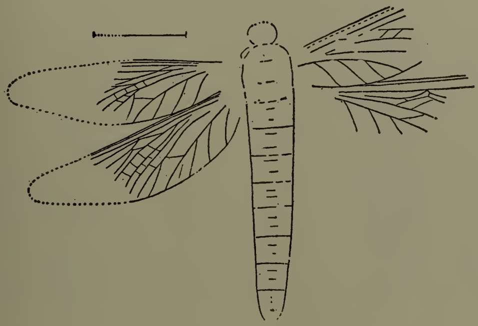

FIG. 1744. *Adiaphtharsia ferrea* Handl., Mazon Creek, Ill. Carbonic.

Examples: **Adiaphtharsia ferrea** Handl. (Fig. 1744), from Mazon Creek, Ill. (Alleghany), and **Opter brongniarti** Sellards, from the Permic of Kansas.

Order PLECTOPTERA Packard.

True Ephemera, or May Flies, have, until recently, been known from the Palæozoic only through examples from the Russian Permic, but the recent discoveries in the Permic of Kansas have added 14 new American species to this group. They are included by Sellards (1907) in his new family *Protereismephemeridæ*. The prothorax and head are of medium size, the thorax as a whole large and arched, the mesothorax and metathorax being of equal size or nearly so; abdomen long and slender, terminating in streamers; wings elongate, with rounded inner border, the two pairs equal or nearly so; *Sc* close to border and extending to apex of wing; *R* strong at the base, and extending parallel to *Sc* to the apex; *Rs* very uniform throughout the family, its divisions are by sets of threes, three sets of three each being the most typical; the first division commonly somewhat in front of the middle line of the wing, the upper of the three trifurcates, and later the lower of this new set of three also trifurcates. The middle veins of these sets of three are weak, lie on the folds, and appear like intercalations; the attachment is either to the upper or the lower vein of the group, or more rarely directly between them. *M* simple to or beyond the middle of the wing, then breaking into a set of three veins all of which remain simple. The interpolated vein lies in a furrow, the outer branches and the media itself lie on folds. The media, usually carrying the sector, is fused at the base with the radius; Cu_1 and Cu_2 separate, just at their basal origin, each typically three-branched; first anal strong with abrupt downward curve, *C* short, a few mm. long, dividing, its stronger branch turning with uniform curvature across the *Sc*, ending on *R*, and forming a costal brace (Sellards); the weaker part turns toward and joins the costal margin. *Examples:* **Protereisma permianum** Sellards (Fig. 1745), **Prodromus rectus** Sellards, **Scopus gracilis** Sellards, and others from the Permic of Kansas.

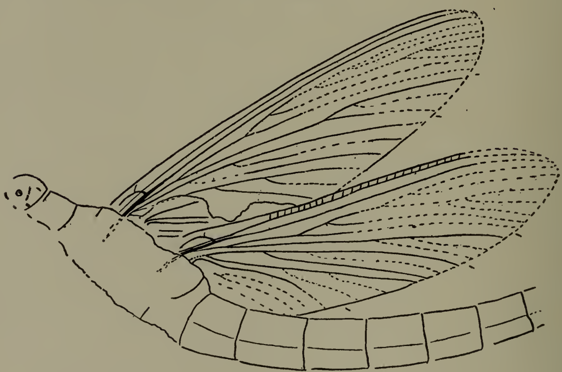

FIG. 1745. *Protereisma permianum* Sellards, a Permic mayfly from Kansas, × 4, showing head, thorax and first seven segments of abdomen, and wings partly restored. (After Sellards.)

B. Mesozoic Insects.

The only Triassic insect remains so far found in America (exclusive of the Fairplay, Col., species now regarded as more probably Permic), are tracks, and the remarkable larva **Mormolucoides articulatus** Hitchcock (Fig. 1746) from the dark shales in the Connecticut Valley red sandstone. This is believed to be the aquatic larva of perhaps a Neuropterous insect. A head, a thorax of three segments, and an abdomen of nine segments are recognizable. Short cerci occur at the end of the abdomen. Numerous tracks in the Connecticut Valley Triassic shale have been described by Hitchcock, and referred to insects, among them being ten species of *Acanthichnus,* five of *Bifurculapes,* two of *Conopsoides,* four of *Copeza,* two of *Hexapodichnus,* and a number of others of more doubtful character. (Ichnology of New England, 1858–65.)

Fig. 1746. *Mormolucoides articulatus* Hitchcock, an insect larva from the Triassic shales of the Connecticut Valley; a specimen with dissociated segments, and a nearly perfect individual, × 2. (After Scudder.)

In the Cretacic of North America few insect remains have so far been found. A cockroach (*Blattoidea*) **Stantoniella cretacea** Handlirsch has been obtained from the Judith River beds of Montana. From the Lower Cretacic (Comanchic?) beds of northern Greenland, Heer has described three Coleoptera **Archiorhynchus angusticollis** Heer, **Curculiopsis cretacea** (Heer) Handl. and **Ely-**

trulum multipunctatum (Heer) Handl., while Scudder has described one from the Pierre shales of Manitoba (**Hylobiites cretaceus** Scudder). Besides these, what has been regarded as oötheca of gigantic Sialidæ, **Corydalites fecundus** Scudder, has been obtained from the Laramie of Colorado, and "larval mines" of *Tineidæ, Tortricidæ* or Diptera, and insect "galls" from the Dakota group of Kansas and Nebraska.

C. Cenozoic or Tertiary Insects.

Tertiary insects are closely related to modern types, falling into the same orders and families. Numerous systems of classification have been proposed, of which the recent elaborate one of Handlirsch, based on phyletic principles is here adopted. Handlirsch divides insects into four classes: I. Collembola (Lubbock), II. Campodeoidea Handl. (*Archinsecta* Haeckel), III. Thysanura (Latr.), IV. Pterygogenea Brauer. The last comprises the true winged insects (though there are many wingless ones among them), and is divided into the following subclasses:

I. ORTHOPTEROIDEA, with the orders 1, Orthoptera; 2, Phasmoidea; 3, Dermaptera; 4, Diploglossata; 5, Thysanoptera.

II. BLATTÆFORMIA, with the orders 6, Mantoidea; 7, Blattoidea; 8, Isoptera; 9, Corrodentia; 10, Mallophaga, and 11, Siphunculata.

III. COLEOPTEROIDEA, with the orders 12, Coleoptera, and 13, Strepsiptera.

IV. HYMENOPTEROIDEA, with the order 14, Hymenoptera.

V. EMBIDARIA, with the order 15, Embioidea.

VI. PERLOIDEA, with the order 16, Perlaria.

VII. LIBELLULOIDEA, with the order 17, Odonata.

VIII. EPHEMEROIDEA, with the order 18, Plectoptera.

IX. NEUROPTEROIDEA, with the orders 19, Megaloptera; 20, Raphidioidea, and 21, Neuroptera.

X. PANORPOIDEA, with the orders 22, Panorpatæ; 23, Phryganoidea; 24, Lepidoptera; 25, Diptera, and 26, Suctoria.

XI. HEMIPTEROIDEA, with the orders 27, Hemiptera, and 28, Homoptera.

According to this author, the total number of known Tertiary and Quaternary species of insects (including all four classes) is something over 5,800, while the number of known recent species is over 384,000. In the following synopsis of the orders represented in the American Tertiary and Quaternary deposits, the diagnoses as given by Handlirsch are closely followed.

THYSANURA Latr.

(*Aptera, Springtails.*)

Order LEPISMOIDEA Handlirsch.

Small wingless insects developing without metamorphosis; head with broad basis joined to thorax, which consists of three divisions; tergite not well developed, pleurite and sternite strongly so; prothorax as large as, or larger than, mesothorax; legs ambulatory, not modified for springing; abdomen of 11 segments and a telson. The only American species is **Lepisma platymera** Scudder, from the Oligocenic "lake beds" of Florissant, Col.

PTERYGOGENEA Brauer.

Order ORTHOPTERA (Oliv.) Handl.

(*Grasshoppers, locusts, crickets,* etc.)

With coriaceous fore wings and delicately veined thinner hind wings; the five principal veins of the wings with all their furcations extending to the outer margin of the wing. Anal area large in hind wings, often small in front wings and modified in the male locust into musical organs; *C* of front wings separated from anterior margins, *Sc* and *R* simple, the *Sc* as well as the *C* may have forward directed branches; *Rs* with oblique backward directed branches; *M* simple or branched, abundantly so in fore wings of *Acridioidea; Cu* often much reduced; anal veins generally branched or fan-shaped; cross-veins abundant. Of the 75 known Tertiary and Quaternary species, 17 are American, 10 from Florissant, Col. (Oligocenic), 6 from the Green River beds of Wyoming (Eocenic), and 1 from the Eocenic of Greenland. The number of recent species is about 6,300.

American Tertiary locusts (*Locustidæ*) are known from Florissant, **Locusta silens** Scudder, **Lithymnetes guttatus** Scudder, etc., while locust legs have also been found in the Green River beds of Wyoming. Crickets (*Grillidæ*) are known from the Green River beds of Wyoming (**Pronemobius tertiarius** Scudder, etc.), where grasshoppers (*Acridii*) are also found (**Tyrbula multispinosa** Scudder). These latter are also found at Florissant (**T. russelli** Scudder, **Nanthacia torpida** Scudder and others).

Order PHASMOIDEA Handl.

(*Walking-sticks,* etc.)

Mostly with long slender bodies, often wingless; when present, front wings are generally smaller, rarely larger, than the hind wings, which are large; *C* reduced, separated from anterior margin; *Sc* moderate; *R* and *Rs* irregularly branched; *M* moderately branching; *C* and *Cu* not strongly developed; anal area not defined; cross-veins forming irregular network. 2,500 recent and 4 Tertiary species, one of these (**Agathemera reclusa** Scudder) in the Oligocenic of Florissant, Col.

Order DERMAPTERA (Deg.) Kirby.

(*Ear-wigs,* etc.)

Flat-bodied running insects with poorly developed wings. Front wings hard, without marked neuration, hind wings doubly folded, largely composed of the fan-like anal area.

Ear-wigs (*Forficulidæ*) are fairly well represented in the Oligocenic of Florissant, Colorado (**Labiduromma exsulatum** Scudder and ten other species).

Order THYSANOPTERA Halid.

Small sucking insects, with slender furrowed wings, ill adapted for flight, often rudimentary or wanting; legs for running. Representatives (**Palæothrips fossilis** Scudder, and two other species) are found in the White River beds of Colorado.

Order BLATTOIDEA Handl.

(*Cockroaches.*)

(For the characterization of the order see *ante,* p. 433.)

Tertiary species have been obtained from the Oligocenic of Colorado and Wyoming (**Homœogamia ventriosa** Scudder, **Zetobora brunneri** Scudder), from Florissant, and **Paralatindia saussurei** Scudder from the Green River beds of Wyoming.

Order ISOPTERA Brullé.

(*Termites, white ants.*)

Small or moderately sized insects, integument slightly chitinized, power of flight small or wanting; wings when present delicate, almost alike, with small rudimentary but defined anal area. *C* and *Sc* shortened, simple, often fused; *R* originating near the base, with more or less pronounced branching; *M* independent throughout, more or less branched; *Cu* with numerous branches directed towards the posterior border; regular cross-veins absent, but a very delicate net-like supplementary neuration wrinkles the surface. 350 Recent, 6 Quaternary and 61 Tertiary species are known.

The termites (*Termitidæ*) have numerous American representatives in the Oligocenic of Colorado (*Parotermes,* three species; *Eutermes,* four species; *Hodotermes,* two species, etc.).

Order COLEOPTERA (Linn.) Degeer.

(*Beetles.*)

With thick chitinous fore wings, the nervation of which is obsolete; these are the *elytra,* which cover the thinner folded hind wings, the nerves of which are connected only at intervals. *C* faint, *M* generally much reduced, *Sc, R* and *Cu* always well developed but slightly or not at all branched; secondary ribs prominent. In the hind wing, *M* is not strongly developed, *R* and *Cu* are well developed and mostly forked; anal veins generally well developed.

The total number of Recent species of Coleoptera is about 172,500; of Quaternary 373, 95 of which are American, 75 of these having been obtained from the interglacial and post-glacial beds of the Scarboro Heights region in Ontario; of Tertiary species 2,285 have been described, 340 of these being American.

The division of the *Rhynchophora* is represented in the Cretacic (Comanchic?) of Greenland (**Curculiopsis cretacea** Heer, **Archio-**

rhynchus angusticollis Heer) and abundantly so in the Oligocenic of Florissant, Colorado, where in the neighborhood of one hundred species or more (*Curculionidæ* and others) are

FIG. 1747. *Cremastorhynchus stabilis*, × 8. (After Scudder.)

FIG. 1748. *Acalyptus obtusus*, × 12. (After Scudder.)

FIG. 1749. *Cryptorrhynchus profusus*, × 12. (After Scudder.)

FIG. 1750. *Anthonomus reventus*, × 12. (After Scudder.)

recorded. *Examples:* **Cremastorhynchus stabilis** Scudder (Fig. 1747); **Acalyptus obtusus** Scudder (Fig. 1748); **Cryptorrhynchus profusus** Scudder (Fig. 1749); and **Anthonomus reventus** Scudder (Fig. 1750). Other species occur in the White River beds of Colorado and Utah (Oligocenic) (**Entimnus primordialis** Scudder, etc.) and in the Green River beds of Wyoming (Eocenic) (**Brachytarsus pristinus** Scudder, *Cratoparis,* two species; **Dryocœtes carbonarius** Scudder; **Trypodendron impressum** Scudder; *Epicærus,* three species; *Eugnamptus,* two species, etc.).

The division of the *Heteromera* is less abundantly represented in America, a number of species of *Meloidæ, Rhipiphoridæ* and *Mordellidæ* occurring in the Oligocenic of Florissant, of *Cistelidæ* in the Miocenic of Greenland (**Cistelites minor** Heer and **C. punctulatus** Heer); of *Tenebrionidæ* in the Oligocenic of Florissant, Colorado (about twenty species); in the Miocenic of British Columbia (**Tenebrio primigenius** Scudder), and in the Eocenic of Greenland (**Helops wetteravicus** Heyd.).

The division of the *Phytophaga* is well represented in the American Tertiary, the *Bruchidæ* in the Oligocenic of Florissant, Colorado (**Spermophagus vivificatus** Scudder and others), and the White River of Colorado (**Bruchus anilis** Scudder), the *Chrysomelidæ* at Florissant (**Oryctoscirtetes protogæum** Scudder, and more than twenty other species); in the Green River beds of Wyoming (**Cryptocephalus vetustus** Scudder); in British Columbia (**Galerucella picea** Scudder); in Alaska (**Chrysomelites alaskanus** Heer), and in north Greenland (**C. fabricii** Heer) and the *Cerambycidæ* in the Oligocenic of Florissant, Colorado (**Parolamia rudis** Scudder, and perhaps twenty other species).

The division *Lamellicornia* is sparingly represented in American deposits by the family *Scarabæidæ,* occurring in the Oligocenic of Florissant, Colorado (thirty or more species), the Green River beds of Wyoming (**Ægialia rupta** Scudder), the Tertiary of British Columbia (**Trox oustaleti** Scudder), and in the Post-Pliocenic of Pennsylvania (**Aphodius præcursor** Horn, **Chœridium(?) ebeninum** Horn and **Phanæus antiquus** Horn).

The division *Serricornia* is known from the Eocenic Green River beds of Wyoming (*Anobium,* three species; **Corymbites velatus** Scudder, etc.); in the Florissant beds of Colorado (several hundred species, including the fire-fly, **Chauliognathus pristinus** Scudder); the White River beds of Utah and Colorado (**Epiphanis deletus** Scudder; **Oxygonus mortuus** Scudder, and others); the Eocenic of Greenland (**Buprestites heeri** Scudder); and the Miocenic of Nicola River, British Columbia (*Buprestis,* three species).

The division *Clavicornia* is likewise most abundantly represented in the Oligocenic beds of Florissant, Colorado, though the number of species is much less than in the preceding division. Most of the species belong to the family *Staphylinidæ.* Other Tertiary localities in which these insects have been found are British Columbia (**Prometopia depilis** Scudder, **Cercyon(?) terrigena** Scudder), the Green River beds of Wyoming (**Antherophagus priscus** Scudder, **Lathrobium abscessum** Scudder, *Berosus,* two species; *Hydrobius,* two species; *Tropisternus,* two species; **Hydrochus relictus**), the Miocenic of Greenland (**Hydrophilites naujatensis** Heer), and the Pleistocenic beds of Scarboro Heights, Ontario (**Hydrochus amictus** Scudder, and **Cymbiodyta extincta** Scudder).

The division *Adephaga* finally has American representatives of the family *Carabidæ* or running beetles. In the Oligocenic beds of Florissant, Colorado, there are more than thirty species (**Nomaretus serus** Scudder, **Myas rigefactus** Scudder, **Amara powelli** Scudder, etc.); the Green River beds of Wyoming and the White River beds of Colorado and Utah have several species (**Bembidium exoletum** Scudder, *Platynus,* two species); the Tertiary of British Columbia has its species (**Nebria paleomelas** Scudder) and so has the Miocenic of Greenland (**Carabites feildenianus** Heer). The Pleistocenic and interglacial beds of Scarboro Heights, Ontario, have a number of species (**Bembidium fragmentum** Scudder, **B. glaciatum** Scudder, and six other species, **Loricera(?) lutosa** Scudder, **L. glacialis** Scudder, **L. exita** Scudder, **Loxandrus gelidus** (interglacial), *Platynus,* eleven species, *Pterostichus,* eight species, *Patrobus,* three species), and the Post-Pliocenic cave deposits of Port Kennedy, Pennsylvania, have a number of species (**Chlænius punctulatus** Horn, **Cymindis aurora** Horn, *Dicælus,* two species, *Pterostichus,* two species, *Cychrus,* two species).

Order HYMENOPTERA Linnæus.

(*Ants, bees, wasps.*)

With thin, membranous, sparsely and distantly veined fore wings, which are larger than the hind pair; *C* marginal, moderately developed and short; *Sc* simple, *R* strong, with *Rs* splitting off about the middle; *M* reduced, included in basal part of *R*; *Cu* well developed, divided into two branches; anal area defined by furrow with, at the most, only two veins; cross-veins few; cells large; hind wings with veining more reduced; anal region somewhat larger; reduction of veins frequent; both wings sometimes reduced or even wanting; prothorax well developed, pronotum fused with large mesothorax; mouth parts adapted for biting and licking; legs mostly for running. This order goes back to the Lias, but is best represented in the Tertiary. American examples are most abundantly obtained from the Oligocenic "lake beds" of Florissant, Colorado. Here half a hundred species of wasps (*Terebrantia*) are represented by hundreds of individuals. They include the leaf-wasps or saw flies (*Tenthredinidæ*), of which **Atocus defessus** Scudder (Fig. 1751), is an example, the ichneumon flies (*Ichneumonidæ* ex.: **Protostephanus ashmeadi** Cockerell), the gall flies (*Cynipidæ*), etc. The ants (*Formicidæ*) are exceedingly abundant here, thousands of individuals having been obtained, while the true wasps (*Vespidæ*) and the bees (*Apidæ*) are not uncommon.

FIG. 1751. *Atocus defessus*, complete, ×3, and antenna much enlarged. Oligocenic, Florissant, Col. (After Scudder.)

Other American localities where Hymenoptera have been found are the Green River beds of Wyoming (**Decatoma antiqua** Scudder, White River of Colorado (**Ichneumon petrinum** Scudder) and the Tertiary beds of British Columbia (**Aphænogaster longæva** Scudder, **Dolichoderus obliteratus** (Scudder) and **Formica arcana** Scudder).

Order ODONATA Fabricius.

(*Dragon-flies.*)

Often large insects (length of wing in one form 122 mm., in another 378 mm., with a spread of wings of 750 mm.), slender, with highly developed compound wings, a free movable head, with large and highly developed compound eyes; wings nearly equal, very delicate and transparent, a *nodus* or faint contraction of the costal area marks the end of the subcosta at the oblique cross-vein or *subnodus*, uniting R and M_1, C marginal, R simple, Rs crossing anterior branches of media ($M_{1,2}$) and ending on posterior margin, generally between M_2 and M_3. In the adult the crossing is indicated by an oblique cross-vein originating below and more or less in front of the fork between M_1 and M_2. The backward continuation of the Rs, behind the oblique cross-vein in the adult, is a later addition and forms the "*bridge*." This obscures the course of the Rs, Cu often making an abrupt bend, just behind the arculus, this bend forming the base of the "*wing-triangle*" (*Anisoptera*). Cu_2, immediately after leaving Cu_1, fuses with the first anal; anal groove absent; anterior costal cell of both wing pairs darkened to a wing-spot or *pterostigma;* cross-veins forming mostly a regular network; arculus well developed.

A. Triangle formed by cubitus and two cross veins from *Cu* to *M*............*Anisoptera.*
B. Quadrangle formed through less abrupt bending of *Cu*........................*Zygoptera.*

FIG. 1752. Odonata wings from Florissant, Colorado. *a*, *Stenogomphus carletoni* Scudder, left forewing, × $\frac{3}{2}$; *b*, *Trichocnemis aliena* Scudder, right wing, × 2. (After Scudder.)

There are about 2,300 Recent and 92 Tertiary species known; of the latter, 16 are American. As an example of *Anisoptera* may be mentioned **Stenogomphus carletoni** Scudder (Fig. 1752, *a*), from the Oligocene of Roan Mt., Colorado, and of the *Zygoptera,* **Trichocnemis aliena** Scudder (Fig. 1752, *b*), and three species of *Agrion* from Florissant, Colorado. Five species have been obtained from the Green River beds of Wyoming (*Dysagrion,* three species, **Podagrion abortivum** Scudder, and others).

Order PLECTOPTERA Packard.

(*Ephemeridæ or May flies.*)

Delicate insects, with the mouth parts small and more or less atrophied, the antennæ short, the abdomen with two or three very long slender cerci. Wings delicate, anterior pair always much larger than posterior pair; venation variable, generally fan-like, with a number of auxiliary sectors or longitudinal veins and numerous cross-veins; anal furrow wanting. *C* marginal; *Sc* and *R* always simple; *Rs* originating near the base, and generally divided into a number of branches; *M* isolated, not much branched; *Cu* with one or several forks; anal veins variable in number, often repeatedly branching. 400 Recent, 18 Tertiary and 1 Quaternary species are known; 7 species of *Ephemera* occur at Florissant, 5 of them larvæ. (*Example:* **Ephemera howarthi** Cockerell.)

Order RHAPHIDIOIDEA Handlirsch.

(*Snake flies,* etc.)

Neuropterous insects with slender abdomen, large head, and greatly prolonged prothorax, which, with the contracted back of the head, forms a long neck. Wings similar, of nearly equal size; *C* marginal, *Sc* extending to the prominent pterostigma, *R* and *Rs* divided distally into several branches; *M* confluent basally with *R*, much branched; *Cu* repeatedly forked. Anal veins forming several irregular cells, of moderate size, and never fan-shaped in arrangement. Forty Recent and seven Tertiary species are known, five of them from Florissant. *Examples:* **Inocellia veterana** Scudder, and three other species; **Rhaphidia? tranquilla** (Scudder).

Order NEUROPTERA (Linnæus) Handlirsch.

(*Lace wings, ant-lions,* etc.)

In the emended sense, the term Neuroptera includes only a limited number of species (1,300 Recent, 27 Tertiary and Quaternary). The American fossil forms belong to the *Osmylidæ* (**Osmylus requietus** Scudder, from Florissant), the *Hemerobidæ* (**Bothromicromus lachlani** Scudder, from Quesnel, British Columbia, Oligocenic), *Chrysopidæ* or lace-wing flies (**Palæochrysa stricta** Scudder, and *Tribochrysa,* 3 species, from Florissant, Colorado).

Mostly slender, often very small insects, with the power of flight well developed; wings mostly similar, delicate; *C* marginal, *Sc* extending nearly to apex of wing, generally with numerous branches or cross-veins towards the costa; *R* close to *Sc,* forked near the apex of the wing; *Rs* beginning generally near the base of the wing nearly always with oblique backward directed branches, which fork distally; *M* generally less strongly branched, *Cu* generally more strongly so; anal area not defined, with few irregular veins; cross-veins generally numerous; pterostigma seldom developed.

Order PHRYGANOIDEA Handl.

(*Caddis flies.*)

Moderately sized insects, with well developed similar, delicate but hairy wings; logitudinal veins moderately branched, cross-veins few; anal area generally well defined by anal furrow, and with few veins; *C* marginal, *Sc* nearly reaching to apex of wing; *R* simple, *Rs* originating near the base and dividing into several branches; *M* generally forking several times; *Cu* with simple fork only; legs similar; 1,400 Recent and about 100 Tertiary species are known, of which 24 occur at Florissant (**Setodes abbreviata** Scudder, **Hydropsyche marcens** Scudder, *Mesobrochus,* 2 species, *Derobrochus,* 7 species, **Neuronia evanescens** Scudder, **Phryganea labefacta** Scudder, **Limnophilus soporatus** Scudder, and others); from the Green River beds of Wyoming, masses of tubes composed of rock fragments and known as **Indusia calculosa** Scudder, have been obtained; they are believed to belong to Phryganoid larvæ.

Order LEPIDOPTERA Linn.

(*Butterflies and moths.*)

With similar fore and hind wings, covered with scales and usually highly colored; with suctorial mouth parts, in the form of a spirally

FIG. 1753. *Jupiteria charon,* entire individual with overlapping wings. (After Scudder.)

FIG. 1754. *Jupiteria charon,* showing venation and margins of separated wings, × 4/3. (After Scudder.)

coiled proboscis. *C* marginal; *Sc* and *R* simple; *Rs* generally with 4 branches in front wings, and less in the hind wings; *M* divided into three, more rarely into two branches, or unbranched; *Cu* generally simple, anal veins 1 or 2. About 60,000 Recent species; the number of Tertiary species is just over 75. Fossil Lepidoptera are known from the Jurassic on, but in America the order is only repre-

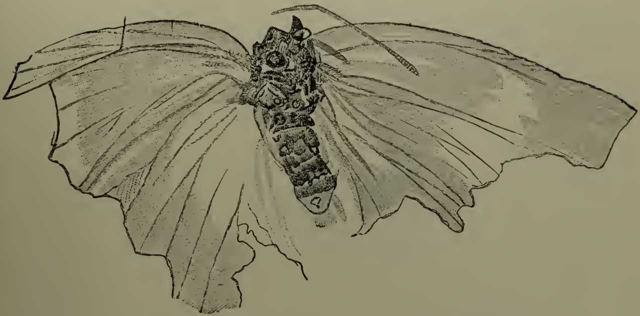

FIG. 1755. *Nymphalites obscurus*, × 2. (After Scudder.)

FIG. 1756. *Prodryas persephone*, the entire butterfly, natural size. (After Scudder.)

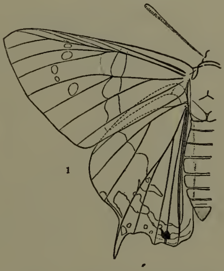

FIG. 1757. *Prodryas persephone*, left half of body in outline with venation and position of markings; the wings being separated slightly more than in Fig. 1756, × $\frac{4}{3}$. (After Scudder.)

FIG. 1758. *Prolibythea vagabunda*, natural size. (After Scudder.)

FIG. 1759. *Stolopsyche libytheoides*, × 2. (After Scudder.)

sented in the Oligocenic beds of Florissant, Colorado. Here occur **Jupiteria charon** Scudder (Fig. 1753–1754), **Lithopsyche styx** Scudder, **Nymphalites obscurus** Scudder (Fig. 1755), **Prodryas perse-**

FIG. 1760. *Barbarothea florissanti*, general appearance of the fossil; Oligocenic, Florissant, Col., natural size. (After Scudder.)

phone Scudder (Figs. 1756–1757), **Prolibythea vagabunda** Scudder (Fig. 1758), **Psecadia mortuella** Scudder, **Stolopsyche libytheoides** Scudder (Fig. 1759), and **Barbarothea florissanti** Scudder (Figs. 1760–1761).

FIG. 1761. *Barbarothea florissanti*. Oligocenic, Florissant, Col. *a*, outline, $\times \frac{4}{3}$; *b*, head enlarged, $\times \frac{8}{3}$. (After Scudder.)

Order DIPTERA Linnæus.

(*Flies.*)

With the fore wings only prominent, membranous, narrow and veined, while the hinder wings are reduced to clubbed filaments. Longitudinal veins of wings sparingly branched, cross-veins few; *C* marginal, *Sc* simple, *Rs* forked, *M* forked once or twice, *Cu* forked singly; anal furrow seldom developed, anal veins 1 to 2, often rudimentary. About 44,000 Recent and 1,550 Tertiary species are known, 125 of them American. Flies have been found as far back as the Lias. In America the division *Cyclorrhapha* is best represented in the Oligocenic beds of Florissant, Colorado, where numerous species occur. They are also found in British Columbia (**Lithortalis picta** Scudder, **Sciomyza revelata** Scudder, **Heteromyza senilis** Scudder, *Anthomya,* two species, etc.), in the Green River beds of Wyoming (*Sciomyza* three species, *Chilosia* three species, **Milesia quadrata** Scudder), the White River of Colorado (**Heteromyza detecta** Scudder). The division *Orthorrhapha* is likewise abundantly represented in America, especially in the Florissant beds, where thousands of individuals and more than a hundred species have been found. *Examples:* **Palombolus florigerus** Scudder, *Tipula* sixteen species, **Mycetophætus intermedius** Scudder (Fig. 1762); in the Green River beds of Wyoming (*Stenocinclis* two species, *Tipula* two species, **Chironomus septus** Scudder, **Sciara scopuli** Scudder, **Diadocidia (?) terricola** Scudder, *Boletina* two species); the White River beds of Colorado and Utah (**Pronophlebia rediviva** Scudder, *Tipula* two species, *Chironomus* two species, **Mycetophila occultata** Scudder, **Sackenia arcuata** Scudder, etc., **Gnoriste dentoni** Scudder, **Lasioptera recessa** Scudder, **Lithomyza condita** Scudder), and the Tertiary of British Columbia (**Sciara deperdita** Scudder, *Brachypeza* two species, **Boletina sepulta** Scudder and **Trichonta dawsoni** Scudder).

FIG. 1762. *Mycetophætus intermedius,* × 5⅓. Florissant, Col., Oligocenic. (After Scudder.)

Order HEMIPTERA (Linn.) Handl.

(*Heteroptera—Bugs.*)

With fore wings more coriaceous in the basal portion, and more coarsely veined than hind wings; anal field of wings generally well developed, but with never more than two veins; more strongly developed in hind wings; anal furrow in front of *Cu*; the veins are much reduced; *R* replaced by or coalescing with *Sc*; cross-veins few or absent. Front of head not touching coxæ; mouth with a sucking proboscis.

About 19,000 living and 450 Tertiary species are known, 150 of these being from North America; the order begins in the Lias. The capsids or soft bugs (*Capsidæ*), are represented by about 14 species at Florissant (**Carmelus gravatus** Scudder, **Closterocoris elegans** Scudder, **Capsus obsolefactus** Scudder, etc.); the *Reduviidæ* by several species (**Eothes elegans** Scudder, etc.); the water bugs (*Hydrometridæ*) by **Stenovelia nigra** Scudder, and others; the *Lygæidæ*, or long bugs (chinch bugs, etc.), by about 60 species,

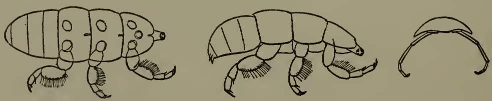

FIG. 1763. *Planocephalus aselloides*, dorsal, lateral and sectional view of a restoration, × 3. (After Scudder.)

at Florissant (**Lygæus obsolescens** Scudder, **Trapezonotus exterminatus** Scudder, **Linnæa evoluta** Scudder, **Lithocromus gardneri** Scudder, etc.), and others, in the White River beds of Colorado. The *Coreidæ* (squash-bugs, etc.) are represented by about a dozen species at Florissant (**Heeria gulosa** Scudder, **H. lapidosa** Scudder, etc.); the *Tingitidæ* only by a few (**Eotingis antennata** Scudder); the *Pentatomidæ* are found at Florissant (**Procydnus divexus** Scudder, and six other species, *Thlibomenus* six species, *Necrocydnus* seven species, etc.); and in the Green River beds of Wyoming (**Procydnus mamillanus** Scudder, etc.). The *Corixidæ* finally are represented by **Corixa immersa** Scudder, and other species at Florissant. Here also has been placed the remarkable **Planocephalus aselloides** Scudder (Fig. 1763), originally placed by Scudder among the Thysanura but regarded by Handlirsch as the larva of an Hemipterous insect.

Order HOMOPTERA Leach.

(*Plant lice, wax-bugs, harvest-flies,* etc.)

Front of the head much inflexed, so as to be in contact with the coxæ, scarcely movable; wings similar, front wings seldom denser and more coriaceous than hind wings; anal field well developed, with four veins or less, sometimes rudimentary or wanting; *C* marginal; *Sc* and *R* often united; *M* and *Cu* free; branching of longitudinal veins very variable; cross-veins seldom numerous.

In the neighborhood of 14,000 species occur in the present fauna, while only about 250 Tertiary species are known. The order is first observed in the Lias; about 120 American species are known.

The plant-lice (*Aphididæ*) occur in the Florissant beds (**Schizoneuroides scudderi** Buckton, *Pterostigma,* two species; *Siphonophoroides,* three species), and the *Fulgoridæ* are also well represented in this formation (**Florissantia elegans** Scudder, **Fulgora obticescens** Scudder, etc.). This family also occurs in the Green River beds of Wyoming (**Oliarites terrentulus** (Scudder); *Lystra,* two species; *Fulgora,* two species; **Lithopsis fimbriata** Scudder, etc.) and the White River of Colorado (**Aphana atava** Scudder, **Delphax senilis** Scudder, etc.). The *Jassidæ* likewise occur in the Tertiaries of Utah, Wyoming, British Columbia and Florissant, Colorado (*Acocephalus,* two species; *Tettigonia,* four species, etc.). The harvest-flies (*Cercopidæ* and *Cicadidæ*) are well represented at Florissant. *Examples:* **Cicada grandiosa** Scudder (Fig. 1764), *Aphrophora,* **Petrolystra gigantea** Scudder, etc.

FIG. 1764. *Cicada grandiosa*, hind wing, $\times \frac{4}{3}$. Oligocenic of Florissant, Col. (After Scudder.)

Phylum VIII. ECHINODERMATA.

Branch Pelmatozoa.

Class **Cystoidea** von Buch.

The cystoids are entirely extinct marine invertebrates which flourished only during Palæozoic time. Most of them lived during the Ordovicic or Siluric eras, but Cambric and Carbonic forms are also known. They were mostly stemmed organisms with a *calyx* like the crinoids, but the *arms* were imperfect and a few of them were stemless. The *calyx,* which varies in form, is composed of polygonal plates which are united by close sutures. The *plates* vary in number in different species, from thirteen to several hundred, and only exceptionally exhibit a regular arrangement. A radial arrangement of plates, like that of the crinoids, occurs rarely, and the side plates pass insensibly into the plates of the ventral (upper) side. In the center of the dorsal (under) side, however, a regular series of *basal plates* exists, which rest on the *stem* or *column.*

The *mouth* is indicated by a central or nearly central aperture on the upper (*ventral*) surface and is sometimes covered by small plates. From it radiate two or more simple or branching *ambulacral grooves* or *ambulacra,* which are also frequently roofed over by plates (Fig. 1776). From the distal end of the ambulacra arise the *arms.* These are feebly developed in the cystoids and are often entirely absent. When present, they are unbranched, consisting of a single (uniserial) or a double (biserial) row of plates, and possess a ventral groove, protected by covering plates. Just beneath the mouth is often a small porous plate, the *madreporite.*

More excentrically situated than the mouth is the *anal opening;* this is frequently closed by a valvular *pyramid.*

The calyx plates in most cystoids are perforated by *pores* or fissures. These are often arranged to form lozenge-shaped or rhombic figures, the *pore-rhombs,* which are disposed one half on each of two adjoining plates, while the line of suture between the plates forms either the longer or shorter diagonal of the rhomb

(Fig. 1774). The pores on opposite sides of the rhombs are united by perfectly closed straight ducts which pass horizontally through the plates, vertically across the line of suture, and produce a transversely striated appearance (*Caryocrinus*, Fig. 1772). These striate rhombs are thus generally visible only in weathered specimens. They may be present on all plates or only on a few. In *Callocystites* (Fig. 1779) and other related genera, the pore-rhombs are reduced to comb-like rhombs, *pectinate-rhombs*, which are few in number, lying on contiguous plates as do the pore-rhombs, but the two parts of each are often separated externally by an interval; often the two parts are of different form or size, or one of them may become obsolescent (Fig. 1776). These structures had probably a respiratory function.

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Artificial Key to the Genera.

A. Arms present...I.
- I. Outer surface of plates deeply excavated ....XV. *Comarocystites*.
- I. Outer surface of plates not excavated...1.
  - 1. Pores in rhombic figures, each one confined to two plates.......................a.
    - a. Pore-rhombs three (calyx flattened).....................VIII. *Pleurocystites*.
    - a. Pore-rhombs many ....11.
      - 11. Calyx subglobular...VII. *Caryocrinus*.
      - 11. Calyx pear-shaped, with broad end above...........IV. *Paleocystites*.
  - 1. Pores in spherical triangles, each one divided among three plates. XVIII. *Porocrinus*.
  - 1. Pores simple or in pairs but not arranged in rhombs or triangles..............b.
    - b. Sides of calyx with edges of plates only pierced by pores.................22.
      - 22. Calyx with seven plates besides those of tegmen..XIX. *Zophocrinus*.
      - 22. Calyx with very numerous plates.............................I. *Eocystites*.
    - b. Sides of calyx with entire plate pierced by pores...........II. *Holocystites*.

B. Arms absent...II.
- II. Calyx attached by its entire under surface...2.
  - 2. Ambulacra straight...XVII. *Hemicystites*.
  - 2. Ambulacra curved...XVI. *Agelacrinus*.
- II. Calyx attached by column...3.

3. Ambulacra spiral, at broad end of an elongated, pear-shaped calyx.
III. *Gomphocystites.*
3. Ambulacra not spiral ....c.
c. Pores absent..33.
33. Calyx flattened..V. *Amygdalocystites.*
33. Calyx subglobose..XIV. *Malocystites.*
c. Pores present ....44.
44. Pores piercing plates, without definite arrangement..II. *Holocystites.*
44. Pores piercing plates, with definite arrangement.......................aa.
aa. Pore-rhombs very numerous..........................IV. *Paleocystites.*
aa. Pectinate rhombs 10–15................................VI. *Glyptocystites.*
aa. Pectinate rhombs 3...†.
†. Ambulacra two...XI. *Pseudocrinites.*
†. Ambulacra three to five...*
*. Ambulacra undivided..1″.
1″. Ambulacra about half the length of the calyx; distal portion of column fused.......................IX. *Lepocrinites.*
1″. Ambulacra usually extending to column.
X. *Jækelocystis.*
*. Ambulacra branching...2″.
2″. Calyx plates 25; ambulacra branching slightly, rarely simple ....XII. *Callocystites.*
2″. Calyx plates 18; ambulacra branching extensively.
XIII. *Sphærocystites.*

I. Eocystites Billings.

Calyx plates numerous, varying in size, form and ornamentation. Cambric.

1. **E.(?) longidactylus** Walcott. (Fig. 1765, *a.*) Cambric.
Calyx plates without apparent order, and varying in form, size and surface characters on the same specimens. Plates smooth to somewhat radiately sculptured, their margins indented, probably indicating pores. Arms several, long, slender, biserial, with one or two (?) pinnule-like plates arranged upon the one side of each arm plates; stem of numerous irregular small plates.
Lower(?) Cambric (Pioche formation) of Nevada and Utah.

2. **E. primævus** Billings. (Fig. 1765, *b.*) Cambric.
Known only from calyx plates; these are polygonal, with strong ridges radiating from the elevated center. (Type of genus.)
Middle Cambric of New Brunswick.

II. Holocystites Hall.

Calyx elongated to subcylindrical, short stemmed or stemless, composed of large plates in quite regularly alternating series, pierced by pores which are united in pairs. Mouth nearly central. Minute arms or spines spring from the ends of the ambulacral grooves. Siluric.

3. **H. cylindricus** Hall. (Fig. 1766.) Siluric.

Calyx ovate; plates large and of nearly equal size. (Type of genus.)

Niagaran of Wisconsin.

4. **H. alternatus** Hall. (Fig. 1767.) Siluric.

Calyx composed of twelve series of plates alternating in size. Surface strongly granulose.

Niagaran of Wisconsin.

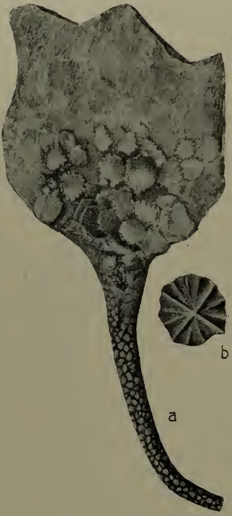

FIG. 1765. *a*, *Eocystites longidactylus*. (After Pack.) *b*, *E. primævus*, a plate enlarged. (After Walcott.)

III. GOMPHOCYSTITES Hall.

Elongate pear-shaped, composed of many ranges of granulose, closely applied, polygonal plates. Openings upon outer surface, mouth subcentral and anus excentric. Arms sessile, lying in grooves curving spirally outward from the mouth to the greatest diameter of the calyx. Siluric.

FIG. 1766. *Holocystites cylindricus*, × ⅔. (After Hall, 20th Mus. Rep.)

FIG. 1767. *Holocystites alternatus*, × ⅔. (After Hall, 20th Mus. Rep.)

5. **G. glans** Hall. (Fig. 1768.) Siluric.

Elongate, abruptly expanding at summit. Length of calyx one to three inches. (Type of genus.)

Niagaran of Wisconsin.

IV. Paleocystites Billings.

Calyx oval or pear-shaped. Plates numerous and furnished with pore-rhombs; the pores penetrate the margins of the plates

Fig. 1768. *Gomphocystites glans*, internal mold, × ⅔. (After Hall, 20th Museum Report.)

Fig. 1769. *Amygdalocystites florealis*; *m*, mouth, left and posterior views. (After Billings.)

and extend to the center but do not open on the exterior surface; this gives the edges of the plates when viewed from within, a notched appearance. The ducts pass vertically across the sutures. Ordovicic.

6. **P. tenuiradiatus** (Hall). Ordovicic.

Calyx pear-shaped, with upper part largest. Length about two inches. Plates somewhat hexagonal, depressed conical; when slightly worn they are covered with deep striæ—the cut edges of the pore ducts. (Type of genus.)

Chazy of New York and Quebec.

V. Amygdalocystites Billings.

Calyx flattened laterally. Plates without pores, numerous, and irregularly arranged. Ambulacra large, recumbent, composed of a large and a small series of plates, the small being situated on the edge and below the large series. Ambulacral opening at apex, rear the mouth. Ambulacral groove not in the middle of the upper surface of each arm but on one side. Column round and smooth. Ordovicic.

7. **A. florealis** Billings. (Fig. 1769.) Ordovicic.

Each calyx plate with low ridges radiating from a centrally placed tubercle to the angles. Arm much longer upon posterior side than upon anterior. Calyx about one and one half inches long. (Type of genus.)

Trenton of Ontario.

VI. Glyptocystites Billings.

Calyx elongate cylindrical, with four series of plates; four plates in the basal and five in each succeeding series. Anal opening in one of the plates of the second series. Mouth at center of summit where it receives the five ambulacra. Ambulacra bordered with small plates. Pectinate rhombs 10 to 15. Column short, tapering to a point. Ordovicic.

8. **G. forbesi** Billings. Ordovicic.

Surface of plates with four to six large ridges which radiate from the center of the plate to the center of each straight side of the plate. In the angular spaces formed by these large ridges are smaller parallel ones. The entire surface of each plate is also covered with sharp concentric striæ. Length about two inches; diameter three fourths inch.

Chazy of Quebec.

9. **G. multiporus** Billings. (Fig. 1770.) Ordovicic.

Four of the ambulacra extending to base of calyx, the fifth but

Fig. 1770. *Glyptocystites multiporus*, anterior and dorsal views of two specimens; *a*, analysis of calyx, showing pore-rhombs and place for arms. (After Billings, Can. Org. Rem. Dec., III.)

a short distance. Column with alternately wide and narrow joints. Pore-rhombs irregularly placed. (Type of genus.)

Trenton of Ontario and Quebec.

10. **G. logani** Billings. Ordovicic.

Summit abruptly truncated, base slightly rounded. Ambulacral grooves extending only to the angles of the truncated apex and each bearing at the end several long pinnules bordered with side plates. Each plate ornamented with three to seven very much elevated, sharp ridges which radiate from the center to the sides; spaces between the ridges smooth. Small plates of column pentagonal, their angles forming five spiral lines around the column throughout its length. Length one and one fourth inches; diameter two thirds inch.

Trenton of Quebec.

Fig. 1771. *Caryocrinus ornatus*, with stem. (After Hall.)

VII. Caryocrinus Say.

Calyx ovoid or subglobose. Base dicyclic, *i. e.*, lowest plates (infrabasals) four, unequal, followed by a second row of six basals which alternate in position with those of the preceding and succeeding cycles. Third cycle consisting of eight plates of which six are regarded as radials and the others as interradials. Ventral surface formed of six or more small pieces. All plates of the calyx furnished with pore-rhombs. Summit plates without perforations. Mouth and ambulacral grooves situated below the ventral plates or tegmen. Anal opening protected by a valvular pyramid and situated on the outer margin of the ventral surface. Arms six to thirteen, situated on the ventral margin, and relatively feeble. Stem long, composed of cylindrical joints. Siluric.

11. **C. ornatus** Say. (Figs. 1771–1773.) Siluric.

Greatest diameter of calyx usually below the middle. Summit slightly convex, with arms sometimes several inches long. Upper margins of radial and interradial plates indented for the arm plates. Pores represented on the exterior of the plates by single or double

FIG. 1772. *Caryocrinus ornatus.* (After Hall.)

FIG. 1773. *Caryocrinus ornatus*, basal view. (After Hall.)

rows of tubercles radiating from the center of the plates to their angles; between these are numerous rows of smaller tubercles parallel to the sides of the plates. (Type of genus.)

Rochester shale of New York and Ontario.

12. **C. bulbulus** Miller and Gurley. Siluric.

Smaller than *C. ornatus* and with smooth surface. Calyx hexagonal in the middle by reason of the central protuberances on each of the six plates of the second row.

Niagaran of Tennessee.

VIII. PLEUROCYSTITES Billings.

Calyx compressed laterally; convex side composed of large plates arranged in cycles; flattened side covered with very minute plates. Arms two. Pectinated rhombs three, borne on the convex side. Anal opening at side of base. Column round, short, tapering distally to a point. Ordovicic.

13. **P. squamosus** Billings. (Fig. 1774.) Ordovicic.

Large plates smooth; rhombs small; the longer axes of the upper two are transverse to the length of the calyx. (Type of genus.)

Trenton of Ottawa.

14. **P. filitextus** Billings. Ordovicic.

Longer axes of rhombs in same direction as length of calyx. Plates on flat side ten times larger than in *P. squamosus*. Plates on convex side with strong ridges radiating from the center to the angles; between these are often other ridges crossing the sides of the plates at right angles, giving the plates a striated appearance. Calyx about the size and shape of *P. squamosus*.

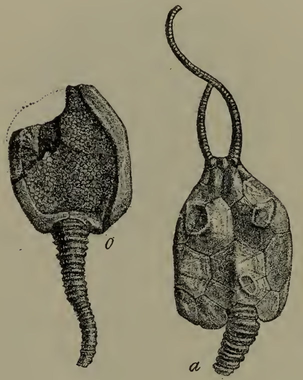

FIG. 1774. *Pleurocystites squamosus*, two specimens showing opposite sides. *O*, anal opening. (After Billings, Can. Org. Rem. Dec., III.)

FIG. 1775. *Lepocrinites gebhardi*, showing a pectinated rhomb and ambulacra. (After Hall.)

Trenton of Ottawa.

15. **P. elegans** Billings. Ordovicic.

Differs from *P. filitextus* in its smaller size, shorter rhombs, and much stronger surface striation. Size of calyx about one half that of *P. filitextus*.

Trenton of Ottawa.

IX. LEPOCRINITES Conrad. (*Lepadocrinus* Hall.)

Calyx oval or pear-shaped, composed of 20 plates arranged in circular rows of four cycles. First or basal cycle consisting of four plates; the second, third and fourth each of five plates; the twentieth plate is very small and situated on top of the fourth cycle or between it and the third cycle. Anal area consisting of a pyramid of six pieces surrounded by a complete circle of many small pieces. Pectinated rhombs three, one basal and two upper. Ambulacra four, undivided, and usually not longer than one half the length of the calyx. Anal area small, placed between the second and third cycles of plates. Column tapering, composed of an upper portion of about 15 plates and a thick distal portion composed of many anchylosed plates coated on the outside by a nodose calcareous layer. Siluric and Devonic.

16. **L. gebhardi** Conrad. (Fig. 1775.) Devonic.

Column composed of two distinct parts. Surface of calyx plates granular. (Type of genus.)

Coeymans of New York and Maryland?

X. JÆKELOCYSTIS Schuchert.

Calyx pear-shaped or globular, composed of 19 plates arranged in circular series. First or basal series consisting of four plates,

FIG. 1776. *Jækelocystis hartleyi*, the holotype, and enlargement of two plates, showing discrete, pectinirhombs (× 8), and of the oral end, × 8. (After Schuchert.)

the second of five plates, the third of four, the fourth of five; upon the last row is situated the nineteenth plate. Anal area protruding, consisting of a pyramid of six pieces. Pectinate rhombs three, one basal and two upper. Ambulacra four, rarely three or five, depressed, continued to or nearly to the column. Siluric.

17. **J. hartleyi** Schuchert. (Fig. 1776.) Siluric.
Calyx pear-shaped, strongly sculptured. (Type of genus.)
Manlius of West Virginia.

XI. Pseudocrinites Pearce.

Calyx laterally compressed, circular to subquadrate, composed of four cycles (basal cycle of four plates, the succeeding of five, four

Fig. 1777. *Pseudocrinites gordoni*, an elongate specimen, with ambulacra drawn over on anal side more than usual, and two views of the holotype. (After Schuchert.)

and six plates) and a very small plate above these. The laterally placed anal area is composed of a pyramid of seven pieces surrounded by an incomplete circle of six to eight pieces. Pectinate rhombs three, one basal and two upper. Ambulacra two, extending along the narrow periphery of the calyx and usually to the column, and beset with biserial jointed pinnules. Siluric.

18. **P. gordoni** Schuchert. (Fig. 1777.) Siluric.
Outline circular. Ambulacra extending to the column. Each ambulacrum with about 80 pinnules.
Manlius of West Virginia.

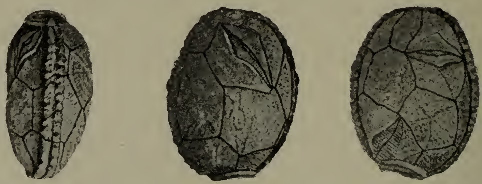

Fig. 1778. *Pseudocrinites clarki*, three views of holotype. (After Schuchert.)

19. **P. clarki** Schuchert. (Fig. 1778.) Siluric.

Elongate in outline. Ambulacra extending to the column. Each ambulacrum with about 44 pinnules.

Manlius of West Virginia.

XII. Callocystites Hall.

Calyx ovoid, composed of 25 plates arranged in four cycles, with a partial telescoping of the second and third cycles. Pectinate

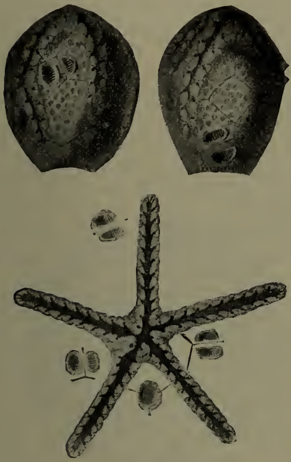

Fig. 1779. *Callocystites jewetti*, with enlargement of ambulacra and rhombs. (After Hall.)

Fig. 1780. *Callocystites canadensis*. (After Schuchert.)

rhombs three, one basal and two upper, component halves on bordering plates and usually separated by an interval, and generally surrounded by an elevated margin. Mouth slit-like and forming center of radiation for the arms. Ambulacra five, slightly excavated, sometimes bifurcating. Stem well developed, tapering distally to a point. Siluric.

20. **C. jewetti** Hall. (Fig. 1779.) Siluric.

Each rhomb surrounded by a high wall. Anal opening between second and third cycles of plates, excavated in two plates of the former and one of the latter. Ambulacra five, simple, or more usually one or more of them branching once; plates ornamented with polygonal depressions, a more or less defined border and granulose surface. (Type of genus.)

Rochester shale of New York.

21. **C. canadensis** (Billings). (Fig. 1780.) Siluric.

The two halves of each pectinate rhomb closely adjoin and are not separated by a high wall as in *C. jewetti.*

Rochester shale of New York and Ontario.

XIII. Sphærocystites Hall.

Calyx spheroidal, wider than high, with 18 plates in four cycles and a partial telescoping of the second and third cycles. Ambulacra four, bifurcating many times. Pinnules widely separated, slender, short, club-shaped. Pectinate rhombs three, one basal and

Fig. 1781. *Sphærocystites multifasciatus*, a large specimen, anal and top views. (After Schuchert.)

two upper, with the two halves separated by an interval. Anal area composed of a pyramid of six to eight pieces and an outer circle of 10 to 14 pieces. Column stout, terminating basally in a few "roots." Siluric.

22. **S. multifasciatus** Hall. (Fig. 1781.) Siluric.

Base of calyx more or less excavated. Branches of ambulacra varying from 14 to 27, obscuring the suture lines. (Type of genus.)

Manlius of Maryland and West Virginia.

23. **S. bloomfieldensis** Schuchert. Siluric.

Calyx depressed globular; length 14 mm.; diameter 15 to 16 mm. Base not excavated.

Manlius of Pennsylvania.

XIV. Malocystites Billings.

Calyx globular, composed of 40 or 50 thick and solid plates. Arms recumbent, in two groups, varying in number, connected by a short groove. Pores and pore-rhombs absent. Ordovicic.

24. **M. murchisoni** Billings. (Fig. 1782.) Ordovicic.

Plates covered with small tubercles. Arms in two groups of four each, connected by a short groove. Usual diameter about one inch. (Type of genus.)

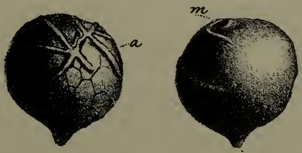

Fig. 1782. *Malocystites murchisoni*, right and left side. *a*, ambulacra; *m*, mouth. (After Billings.)

Chazy of Quebec.

25. **M. barrandii** Billings. Ordovicic.

Plates smooth or very minutely granulated. Arms two and very short, connected by the ambulacral groove.

Chazy of Quebec.

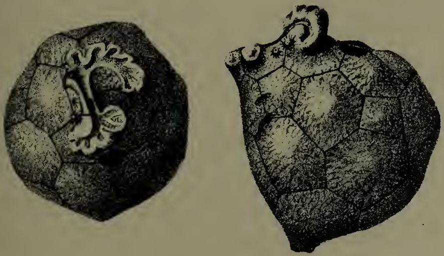

Fig. 1783. *Malocystites emmonsi*, oral and side view of type, $\times$ 4. (After Hudson.)

26. **M. emmonsi** Hudson. (Fig. 1783.) Ordovicic.

Smaller than the preceding species and with the globular calyx irregularly angular. Arms two, connected in the form of a sigma.

Chazy of New York.

XV. Comarocystites Billings.

Calyx ovate or pyriform, with three basal plates; above these are 8 to 11 cycles of mostly hexagonal plates in irregular order. Ambulacrum at apex, short, straight, unbranched; from each end rises a pair of uniserial arms, bearing long, cylindrical pinnules. Anal area near apex composed of a pyramid of five pieces and an outer circle of about five plates. Column round, smooth; its plates very thin. Ordovicic.

27. **C. punctatus** Billings. Ordovicic.

Length of calyx about one and one half inches; diameter one inch. Each plate with a deep depression occupying nearly its entire area, and usually with thin, erect lamellæ at right angles to the sides of the plates; these lamellæ are occasionally crossed by others, parallel with the sides of the plates. (Type of genus.)

Trenton of Ottawa.

XVI. Agelacrinus Vanuxem.

Calyx in the form of a depressed or convex disc, without column, and attached by the entire under surface; composed of numerous small, polygonal, sometimes imbricating plates which are perforated by fine pores which, for the most part, are united in pairs. Mouth central, surrounded by four oral plates; radiating from this are five small, more or less curved ambulacra, which are protected by a double row of covering plates. Anus eccentric, provided with a valvular pyramid. Ordovicic–Mississippic.

28. **A. (Lepidodiscus) cincinnatiensis** Roemer. (Fig. 1784, *b*.) Ordovicic.

Circular, depressed-convex above. Ambulacra sunk nearly to the level of the disc; four sinistral and one dextral. Disc plates imbricating. Usually found on *Rafinesquina alternata*.

Cincinnatian of Cincinnati region.

29. **A. hamiltonensis** Vanuxem. Devonic.

Disc plates sculptured, not imbricating.

Hamilton of New York.

30. **A. (Lepidodiscus) alleganius** Clarke. Devonic.

Disc plates imbricating. Ambulacra very slender and all pointing dextrally.

Chemung of New York and Pennsylvania.

31. **A. (Lepidodiscus) squamosus** Meek and Worthen. Mississippic.
Disc plates imbricating. Ambulacra, four sinistral and one dextral. Differs from *A. cincinnatiensis* in its larger size and in the lateral position of the anal aperture in its interradius.
Keokuk of Indiana.

32. **A. (Discocystis) kaskaskiensis** Hall. Mississippic.
Disc plates not imbricating, smooth. Ambulacra very long and narrow.
Kaskaskia of Missouri and Illinois.

XVII. HEMICYSTITES Hall.

Like *Agelacrinus* but differs in its much smaller size and straight and proportionally wider ambulacra. Ordovicic–Siluric.

FIG 1784. *a*, *Hemicystites stellatus*, top view, × 2 ; *c*, *H. granulatus*, side view, × 2 ; *b* (center), *Agelacrinus cincinnatiensis*, × 2. (After Meek, Pal. Ohio.)

33. **H. stellatus** Hall. (Fig. 1784, *a*.) Ordovicic.
Discoidal, subpentagonal.
Cincinnatian of Cincinnati region.

34. **H. granulatus** Hall. (Fig. 1784, *c*.) Ordovicic.
Calyx elevated into a cylindrical form and covered by numerous grain-like pieces. Usually grows on *Strophomena*.
Cincinnatian of Cincinnati region.

XVIII. POROCRINUS Billings.

Calyx conical, with five pentagonal plates in the basal cycle (infrabasals) ; three hexagonal and two heptagonal in the second cycle (basals) ; six in the third row (five radials and one interradial). One small plate is interpolated between the second and third cycles below the interradial. Arms five, feeble, uniserial, rising from the five radials. Pore-rhombs about 22, at the intersection of three (not two as usual in cystoids) plates, in the form of equilateral spherical triangles; their diameter about 2 mm., the ducts passing obliquely across the margin of the plates. Ordovicic. (Sometimes classed with crinoids.)

35. **P. conicus** Billings. Ordovicic.

Length of calyx 11 mm.; diameter at base 3 mm.; diameter at top 8 mm. (Type of genus.)

Trenton of Ottawa.

XIX. Zophocrinus S. A. Miller.

Calyx ovate or pear-shaped, consisting of two circles of plates, the three basals and four plates of the second circle, and the ventral disk. The distal margins of each plate of the second circle are pierced by five pores. Ventral disk consists of a circle of 20 minute plates through each of which a pore passes perpendicularly, connecting with the pores that pierce the beveled edges of the plates below. Within this circle of 20 plates are other smaller plates which comprise the central portion of the tegmen. The pores piercing the plates seem to ally the genus to the cystoids more closely than to the crinoids. Siluric.

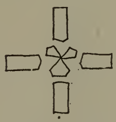

Fig. 1785. *Zophocrinus howardi*, analysis of calyx. (After Weller.)

36. **Z. howardi** S. A. Miller. (Fig. 1785.) Siluric.

Small, less than one half inch long. (Type of genus.)

Niagaran of Indiana and Illinois.

Class **BLASTOIDEA** Say.

The Blastoids are an entirely extinct group of marine echinoderms. They are confined to Palæozoic time, being found from the Ordovicic to the Carbonic, but reaching their climax in the Mississippic.

They had an ovate or bud-like body (*calyx*), no arms, and were short-stalked or stemless. They differ in general appearance from the Crinoids in the total absence of arms.

The *calyx* is usually composed of 13 principal plates, firmly united to one another, and arranged in three successive cycles, represented by the three *basals,* five *radials* and five *deltoids* or

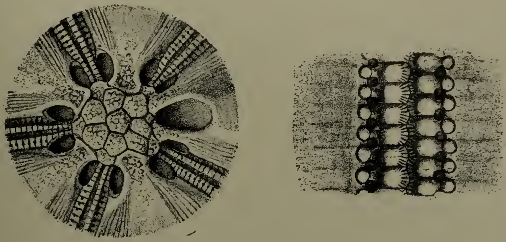

FIG. 1786. *Eleacrinus verneuili,* summit view, showing position of anus, double spiracles and central vault-plates, covering peristome, × 2⅔, and portion of an ambulacrum with outer plates, × 8. (After Etheridge and Carpenter.)

interradials. Resting upon the basals are five V-shaped, usually equal radials (*"forked plates"*) whose upper margins are more or less deeply incised by the radial *sinuses* (Fig. 1788, *a,* 1791). The term *sinus* is applied to the open space between the two *prongs* or *limbs* of the plate. Succeeding and alternating with the radials and resting upon their prongs, are five interradial or deltoid plates which, among different species, vary exceedingly in size (Fig. 1792, *a, b, d*). Only a part of the deltoids is exposed to view, their sides being provided with flanges which are covered by the ends of the ambulacra. The *ambulacra* fill the radial sinuses between the prongs of the radials and vary in form from petaloid (wide in the middle and tapering to each end), to narrow lanceolate (Fig. 1788, *b*).

The open space or *mouth* opening in which the ambulacra meet is five-angled and central in position. This space is usually open, but in well preserved specimens it is covered by a varying number of minute summit plates (tegmen) either regularly or irregularly arranged, but always leaving at the end of each ambulacrum a small passage-way by means of which the food entered the mouth opening beneath (Fig. 1786, *a*). Around the mouth are usually five pairs of circular or slit-like openings or five single openings, the *spiracles.* An additional opening (*anus*) is at times present between the two posterior spiracles (Fig. 1786, *a*). In other types (*Pentremites, Granatocrinus*) the anal opening is shared by the then enlarged posterior spiracle (Fig. 1799, *a*).

Each *ambulacrum* consists of a medially placed narrow plate, (*lancet plate*) running its entire length; upon the outer edges of this plate rests a row of small elongated side plates and upon these in some genera a series of still smaller plates, the outer side plates. The lancet plate is often concealed by the side plates (Fig. 1786, *b*) so that nothing or only a small part of it along the longitudinal groove (food-groove) is visible. The sutures between the side plates are indicated by shallow grooves extending from each side of the ambulacrum to the median groove. Small pits or tubercles present on the side plates, indicate the places where the small jointed appendages (pinnules) were formerly attached; when, as rarely happens, they are fully preserved, they entirely conceal the ambulacral surface.

Piercing the outer edge of the side plates, or the outer side plates when these are present, are marginal pores (Fig. 1786, *b*) which enter a suspended longitudinal tube or bundle of parallel tubes beneath. These tubes (*hydrospires*) begin at the lower end of the ambulacrum, run parallel with its sides, and terminate in the two spiracles bordering its upper end; the function of these was probably respiratory.

The stem is very rarely preserved; it is round, provided with a small central canal, and composed of short joints (Fig. 1793, *a*).

Literature.

1886. **Etheridge, R., and Carpenter, P. H.** Catalogue of the Blastoidea, London, pub. by British Museum.

1903. **Hambach, G.** Revision of the Blastoideæ, with a Proposed New Classification, etc. Trans. Acad. Sci. of St. Louis, Vol. XIII., pp. 1–68, pls. I.–VI.

See also papers by Barris (Davenport Acad. Sci. Proc.) and the various State Reports.

Artificial Key to Genera.

A. Base tapering; calyx spindle-shaped or club-shaped .... 1.
- 1. Greatest diameter of calyx nearer summit than base .... a.
  - a. Summit broad .... *.
    - *. Five round spiracles present .... V. *Pentremitidea*.
    - *. No round spiracles present .... †.
      - †. Base forming a low cup .... XII. *Orophocrinus*.

†. Base usually forming a deep cup... .... XI. *Codaster*
a. Summit contracted...**.
**. Posterior spiracles confluent with anus.................. II. *Troostocrinus.*
**. Posterior spiracles separate from anus.........................III. *Metablastus.*
1. Greatest diameter of calyx central or below..........................VI. *Pentremites.*
B. Base not tapering ; calyx globular or ovoidal...2.
2. Deltoids very broad, resembling sharks' teeth.....................I. *Blastoidocrinus.*
2. Deltoids small, or if long, narrow...b
b. Ambulacra linear, extending nearly or quite the whole length of the calyx. ***.
***. Spiracles in pairs ....††.
††. Posterior deltoid divided into two parts by an anal plate. VII. *Eleacrinus.*
††. No anal plate present...1′
1′. Hydrospire pores present along the edges of the deltoids. VIII. *Schizoblastus.*
1′. No hydrospire pores present along the deltoids..IX. *Cryptoblastus.*
***. Spiracles five, at the ends of the deltoids..............X. *Granatocrinus.*
b. Ambulacra narrow, not extending the whole length of the calyx.........****.
****. Spiracles five...V. *Pentremitidea.*
****. Spiracles double..IV. *Tricœlocrinus.*
b. Ambulacra broad and petaloid, extending half way or more down the calyx. VI. *Pentremites.*

I. Blastoidocrinus Billings.

Rarely found entire. Like *Pentremites* in general form. Base deeply invaginated, appearing in side view as a low inverted truncate cone. Greatest diameter about one fifth vertical distance from bottom, whence the calyx slopes regularly upward in a low dome. Basals unknown but probably very small. Radials five, many-angled and bent, forming below a deep conical pit with outer rim about twice the diameter of the stem and surrounding the stem for a distance of seven or more rings. Each radial ornamented with a mound on the rim of the pit whence radiate upward 10 or 20 depressed grooves. Each radial joined above to two irregular bibrachial plates, with many smaller interradial plates between. The dome-shaped upper portion of the calyx consists chiefly of the five great triangular concave deltoid plates, superficially resembling sharks' teeth. Ambulacral areas between the deltoids occupied by slender, pavement-like plates (brachioles), with a series of three wing plates down the center of each area. Central apical plate star-shaped.

One specimen may consist of 50,000 plates and ossicles. Ordovicic.

1. **B. carchariædens** Billings. (Fig. 1787.) Ordovicic.

Large, attaining a height of 36 mm., and a width of over 40 mm.; section pentagonal; greatest width at boundary of oral and aboral surfaces. (Type of genus.)

Chazy of New York and Quebec.

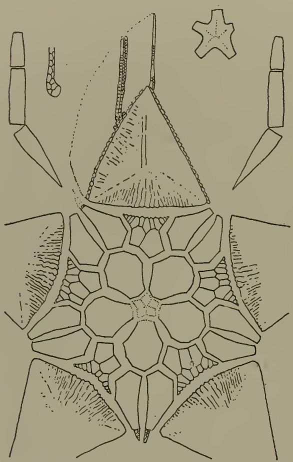

FIG. 1787. *Blastoidocrinus carchariædens*, analysis after Hudson. Basal view, showing also star-shaped central summit plate, and the wing plates.

II. TROOSTOCRINUS Shumard.

Calyx narrow, elongate, somewhat spindle-shaped, with contracted subtruncate or slightly convex upper face and with the triangular base flattened on each side. Greatest diameter one third the distance from the summit. Basal plates one third the height of the calyx. Radial plates long and narrow with limbs much shorter than the bodies. Ambulacra short, narrow, deeply impressed. The four anterior deltoids overlapped by the limbs of the radials, the posterior one much larger than the rest and appearing above the radials. Lancet plates entirely concealed by side plates. Spirals five, small, the four anterior more or less divided by the deltoid ridge and the posterior confluent with the anus. Siluric.

2. **T. reinwardti** (Troost). (Fig. 1788.) Siluric.

Spiracles almost completely divided by the deltoid crests. (Type of genus.)

Niagaran of Tennessee.

III. METABLASTUS Etheridge and Carpenter.

Calyx slender, spindle-shaped with greatest circumference nearly half way from the summit. Summit usually acuminate, always contracted; base elongate, triangular, flattened below on all three sides. Radial plates long and narrow, with limbs much shorter than the bodies and deep and narrow sinuses. Deltoids five, small and similar. Ambulacra short and narrow. Lancet plates concealed by side plates. Spiracles ten slits, the posterior pair sepa-

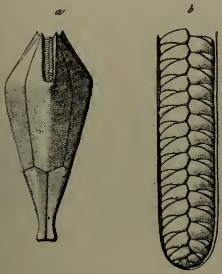

FIG. 1788. *Troostocrinus reinwardti*, × 2, with ambulacrum much enlarged. (After Roemer.)

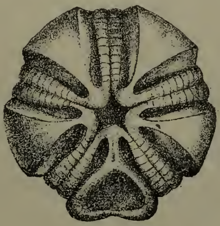

FIG. 1789. *Metablastus lineatus.* Summit view, × 4. (After Etheridge and Carpenter.)

rate from the anus and nearer to the mouth. Agrees with *Tricœlocrinus* in the position of the two posterior spiracles. Mississippic.

3. **M. lineatus** (Shumard). (Fig. 1789.) Mississippic.

Calyx long and spindle-shaped. Basals and radials long and slender. (Type of genus.)

Burlington of Missouri, Illinois and Iowa.

4. **M. wortheni** (Hall). Mississippic.

Differs from *M. lineatus* in its longer ambulacra and heavier basal cup.

Keokuk of Indiana, Illinois, Iowa and Missouri.

IV. TRICŒLOCRINUS Meek and Worthen.

Differs from *Troostocrinus* in its calyx which is broadest below and has a short and wide base, with the three spaces corresponding to the flattened sides of *Troostocrinus* deeply and broadly excavated. Ambulacra longer than in *Troostocrinus* or *Metablastus*. Mississippic.

5. **T. woodmani** Meek and Worthen. (Fig. 1790.) Mississippic.
Radials long and narrow. (Type of genus.)
Warsaw of Indiana.

6. **T. obliquatus** (Roemer). Mississippic.
Radials elongate-oblong.
St. Louis of Tennessee, Indiana; Warsaw of Illinois.

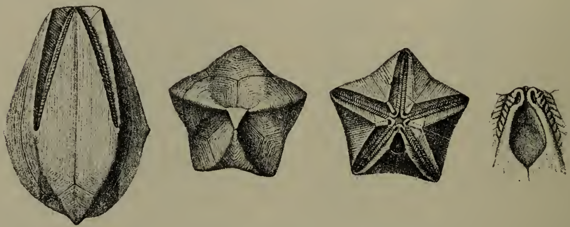

FIG. 1790. *Tricœlocrinus woodmani.* A complete calyx, with basal and summit views, nat. size, and anal portion enlarged, × 2. (After Etheridge and Carpenter.)

V. PENTREMITIDEA d'Orbigny.

Shape of calyx varying from slender and elongate to club-shaped, and to *Pentremites*-like. Base more or less long and conical. Number and general arrangement of plates as in *Pentremites* but ambulacra narrow. Lancet plates more or less concealed by the side plates, and deltoids usually invisible. Devonic.

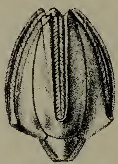

FIG. 1791. *Pentremitidea filosa*, × 2. (After Whiteaves.)

7. **P. filosa** Whiteaves. (Fig. 1791.) Devonic.

Greatest diameter of calyx ranging from slightly below the middle of the calyx to the base of the ambulacra.

Hamilton of Ontario and Michigan.

8. **P. americana** Barris. Devonic.
Small, pyriform; height twice the greatest diameter, which is a little below the middle; form conical at base, but pentalobate above; radials two thirds the length of the calyx, the forks occupy two thirds the length of the plates, are narrow and end in sharp points. Readily distinguished from the preceding by its greater length of base, and more conical aspect of lower half.
Hamilton (Traverse) of Michigan.

VI. Pentremites Say.

Calyx usually ovate or pear-shaped, with elongate, subtruncate, never trilobate base; summit sometimes flat, seldom convex. Basals small, forming a small cup. Radials long, forming the greater portion of the calyx. Deltoids small, sometimes concave. Ambulacra broad, subpetaloid. Lancet plates wholly exposed and resting below on "under lancet plates." Side plates and outer side plates numerous, the former abutting against the edges of the lancet plate. Hydrospires three to nine. Spiracles single or occasionally double, the two of the posterior side confluent with the anus and forming with it a single large opening. Summit covered with numerous spines (usually broken off in the fossil) placed closely against one another so as to form a pyramid which completely covers the summit of the greater portion of the spiracles. Mississippic.

A. Large (breadth usually 1 inch or more)......1.
  1. Height of calyx exceeding breadth......14. *P. obesus.*
  1. Height and breadth about equal......a.
    a. Base very short......16. *P. sulcatus.*
    a. Base long......17. *P. cervinus.*
B. Small (breadth usually less than 1 inch)......2.
  2. Height of calyx exceeding breadth......b.
    b. Calyx elliptical......9. *P. elongatus.*
    b. Calyx ovoid, *i. e.*, greatest diameter usually below middle..10. *P. conoideus.*
    b. Calyx pear-shaped, greatest diameter about the middle......*.
      *. Outline long, oval......15. *P. pyriformis.*
      *. Outline broad, oval......11. *P. elegans.*
  2. Height and breadth about equal......c.
    c. Calyx globular, *i. e.*, greatest diameter near middle......12. *P. globosus.*
    c. Calyx ovoid, *i. e.*, greatest diameter below middle......13. *P. godoni.*

9. **P. elongatus** Shumard. (Fig. 1792, *a, b.*) Mississippic.
Length of calyx nearly or quite twice the breadth.
Burlington of Iowa and Missouri.

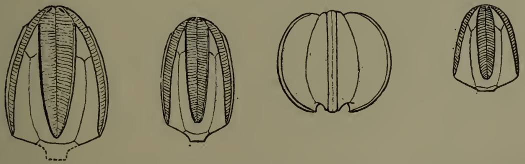

Fig. 1792. *a, b, Pentremites elongatus*, a robust and a slender individual; *c, Granotocrinus norwoodi*, outline of a rotund form; *d, Pentremites conoideus.* (After Etheridge and Carpenter.)

10. **P. conoideus** Hall. (Fig. 1792, *d.*) Mississippic.

Differs from *P. elongatus* in its smaller and more conical calyx, with very short, almost flat base.

Keokuk of Missouri; Warsaw of Indiana; St. Louis of Indiana, Illinois and Missouri.

11. **P. elegans** Lyon. Mississippic.

Like *P. pyriformis* in general size and outline but proportionally broader.

Maxville of Ohio and Kentucky?

12. **P. globosus** Troost. Mississippic.

Calyx very small, globose, with greatest diameter about the center.

Kaskaskia of Illinois, Alabama (?) and Tennessee.

13. **P. godoni** Defrance. (Fig. 1793, *b.*) Mississippic.

Differs from *P. elongatus* in its globose calyx. (Type of genus.)

FIG. 1793. *a* (left), *Pentremites pyriformis; b, P. godoni.* (After Hall, Iowa Geol., I., 2.)

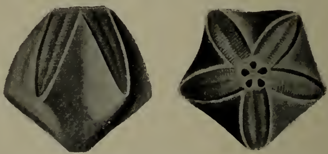

FIG. 1794. *Pentremites cervinus.* (After Hall, IowaGeol., I., 2.)

Kaskaskia of Georgia, Kentucky, Tennessee, Alabama, Indiana, Illinois and Missouri.

14. **P. obesus** Lyon. Mississippic.

Calyx somewhat globose, and very large and massive; height two or more inches. Differs from *P. sulcatus* in the greater length of the calyx, especially of the basal portion, the less truncate summit and the somewhat less curved ambulacra.

Kaskaskia of Kentucky, Illinois and Missouri.

15. **P. pyriformis** Say. (Fig. 1793, *a.*) Mississippic.

Calyx pear-shaped, with greatest diameter in the middle and with the summit obtuse and rounded and base narrow, often remaining attached to the upper joint of the column. Height three fourths inch or more.

Kaskaskia of Kentucky, Tennessee, Alabama, Indiana, Illinois and Missouri.

16. **P. sulcatus** (Roemer). . Mississippic.
Calyx large, subglobose, with very short and obtuse base and truncate summit. Ambulacra and interradial areas very concave. In size and shape much like *P. cervinus* but differs in its shorter and more obtuse base and less angularly expanding ambulacra.
Kaskaskia of Illinois and Missouri.

17. **P. cervinus** Hall. (Fig. 1794.) Mississippic.
Basal plates forming a pentagonal cup with elevated angles and concave sides.
Kaskaskia of Alabama and Illinois.

VII. Elæacrinus Roemer. (*Nucleocrinus* Conrad.)

Calyx olive-shaped, usually smaller toward the base. Base usually excavated. Basals small, inconspicuous, sometimes hidden within the stem cavity. Radials small, with very short limbs. Deltoids greatly enlarged and elongated, forming over two thirds of the entire calyx, the posterior one wider than the others and divided by a large anal plate. Ambulacra almost entirely enclosed by the deltoids. Lancet plates exceedingly long and narrow, partly

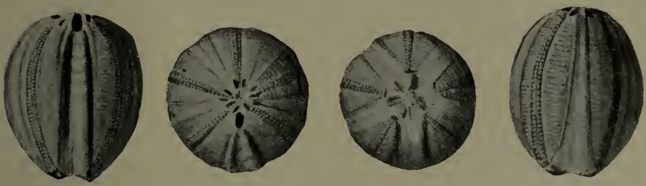

Fig. 1795. *Elæacrinus verneuili,* 4 views of a typical specimen. (After Troost and E. Wood.)

exposed. Side plates numerous. Hydrospires two on each side of an ambulacrum. Spiracles ten, in five pairs, notching the upper ends of the deltoids. Anal opening distinct. Summit covered by comparatively large orals arranged nonsymmetrically and forming a flattened disc which completely closes the mouth opening. Column round or somewhat five-sided. Devonic.

18. **E. verneuili** (Troost). (Figs. 1786, 1795.) Devonic.

Radial plates very short, with scarcely any subdivision into bodies and limbs. Ambulacra very short and narrow. (Type of genus.)

Onondaga of Kentucky, Indiana and Ohio.

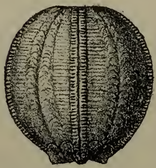

FIG. 1796. *Elæacrinus verneuili* var. *pomum*. (After Eth. and Carp.)

18*a*. **E. verneuili** var. **pomum** Etheridge and Carpenter. (Fig. 1796.) Devonic.

Distinguished by its almost globular calyx.

Onondaga of Ohio and Indiana.

19. **E. elegans** (Conrad). (Fig. 1797.) Devonic.

Pentalobate; summit plates five instead of seven or more as in *E. verneuili*.

Hamilton of New York.

20. **E. obovatus** Barris. Devonic.

Calyx more elongated than in other species of the genus.

Hamilton of New York, Michigan and Iowa.

FIG. 1797. *Elæacrinus elegans*, natural size and enlargement of one inter-ambulacral space. (After Hall.)

VIII. SCHIZOBLASTUS Etheridge and Carpenter.

Calyx globose, pentagonal-globose, or melon-shaped. Section 5- or 10-sided. Basal plates sometimes very slightly visible in side view. Radials either long or short. Deltoids of variable size but always visible in side view. Ambulacra very narrow, extending the whole height of the calyx. Lancet plates sometimes largely concealed by the side plates. Hydrospire folds one to four on each side of an ambulacrum. Spiracles small, appearing as linear slits between the lancet plate and the deltoid ridges; posterior pair either confluent with the anus or opening separately on each side of it under a "hood." Surface usually ornamented with granular striæ.

Differs from *Granatocrinus* in the position of the spiracles. Mississippic.

21. **S. melonoides** (Meek and Worthen). (Fig. 1798.) Mississippic.

Cross section somewhat 10-sided owing to broad vertical interradial ridges.

Burlington of Missouri and Iowa.

22. **S. sayi** (Shumard). Mississippic.

Distinguished from *S. melonoides* by the large size of its deltoids which form almost the whole of the calyx. (Type of genus.)

Burlington of Missouri and Iowa.

FIG. 1798. *Schizoblastus melonoides*, two views of a specimen, × 2. (After Etheridge and Carpenter.)

IX. CRYPTOBLASTUS Etheridge and Carpenter.

Calyx subglobose, lobate, with a flattened or slightly concave base. Basals small. Radials long and deeply incised, making up more than three quarters of the calyx. Deltoids small, triangular. Spiracles two in each of the four anterior plates but merged with the anus in the posterior. Lancet plate separated from the radials by a hydrospire plate but coming into direct contact with the deltoids. Mississippic.

23. **C. melo** (Owen and Shumard). (Fig. 1799, *b*.) Mississippic.

Summit wider than base. Ambulacra nearly linear. Surface granular. (Type of genus.)

Burlington of Illinois, Missouri and Iowa.

X. GRANATOCRINUS Troost.

Like *Schizoblastus* in general appearance. Calyx ovate to globose, with slightly concave to deeply funnel-shaped base. Section pentagonal, round, or roughly decagonal. Interradial areas more or less depressed. Basals small, usually concealed in the central cavity of the stem. Radials very variable in size, often long and invariably turned in below to assist in forming the base. Deltoids also variable in size and form. Ambulacra long, nearly parallel-sided, reaching to the base of the cavity, always impressed at their upper ends. Lancet plates narrow, not filling the furrows, and more or less exposed throughout two thirds of the ambulacra. Side plates transversely elongate. Outer side plates usually well developed. Hydrospires pendent, usually but two or three folds on each side of an ambulacrum, the inner one forming a well-

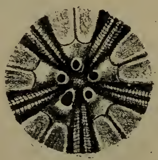

FIG. 1799. *a*, *Granatocrinus norwoodi*, summit (central part), × 2; *b*, *Cryptoblastus melo*, summit view, × 3. (After Etheridge and Carpenter.)

defined hydrospire plate. Spiracles five, oval or round, piercing the apices of the deltoids. Posterior spiracle larger, including the anus. Summit closed by minute pieces which rarely exhibit any definite arrangement. Column round. Surface ornamented with rows of granules. Mississippic.

24. **G. neglectus** Meek and Worthen. Mississippic.

Small (height usually less than one third inch), and base five-lobed. Spiracles not rising into tubes.

Burlington of Missouri and Iowa.

25. **G. norwoodi** Owen and Shumard. (Figs. 1792, *c*; 1799, *a*.) Mississippic.

Calyx globose or elliptical-globose. Basal cavity deep and funnel-shaped. All spiracles except the anal extended into erect tubular openings. (Type of genus.)

Burlington of Missouri, Illinois and Iowa.

XI. Codaster McCoy.

Calyx inverted, conical or ovoid. Base obtusely trilobate or tapering more or less acutely. Summit usually broad and either truncate or slightly convex and presenting a stellate appearance due to the alternation of the radiating oral ridges with the ambulacra. Greatest circumference always nearer the summit end of the calyx. Basal plates forming a deep conical or triangular cup. Radial plates large, never deeply excavated by the sinuses. Deltoids wholly confined to the summit, four of them irregularly triangular and bearing prominent ridges and the fifth more triangular than the others, without a ridge and pierced by the anus. Ambulacra confined to the upper face and petaloid or narrow and linear; lancet plate usually deeply excavated for the side plates. Hydrospires suspended vertically in the calyx, two in each interradius except the azygous one, and opening externally by a variable number of slits, partly in the truncated upper surfaces of the radials and partly in the deltoids and nearly parallel to the ambulacra. Siluric–Mississippic.

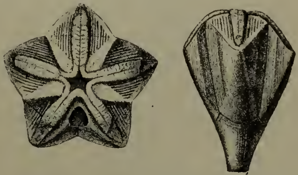

FIG. 1800. *Codaster pyramidatus*, summit view, × 2⅔, and lateral view, × 2. (After Etheridge and Carpenter.)

26. **C. pyramidatus** Shumard. (Fig. 1800.) Devonic.

Radial plates bearing flattened marginal bands.

Onondaga of New York, Kentucky and Ohio.

27. **C. alternatus** Lyon. Devonic.

Differs from *C. pyramidatus* in its concave summit and in the absence of the flattened marginal bands of the radials.

Onondaga-Hamilton of Kentucky.

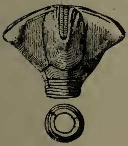

FIG. 1801. *Orophocrinus stelliformis*, side and stem view. (After Meek and Worthen, Ill. Geol., V.)

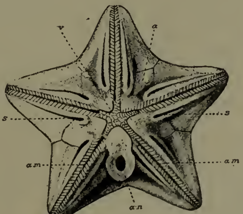

FIG. 1802. *Orophocrinus stelliformis*, enlarged ventral view. *a*, end of vault; *am*, ambulacral furrows; *an*, anal aperture; *s*, spiracles; *v*, oral vault. (After Meek and Worthen, Ill. Geol., V.)

XII. Orophocrinus von Seebach.

Like *Codaster* in general shape and arrangement of plates, but basal plates forming a lower cup and spiracles only ten and linear, one on each side of an ambulacrum. Upper parts of lancet plates exposed but often closed distally by the numerous side plates. Stem round, composed of short and rounded or slightly pentagonal joints. Mississippic.

28. **O. stelliformis** (Owen and Shumard). (Figs. 1801, 1802.) Mississippic.

Calyx balloon-shaped. Base narrow, expanding gradually to the basiradial sutures and thence rapidly to the radial lips. (Type of genus.)

Burlington of Missouri and Iowa.

29. **O. campanulatus** (Hambach). Mississippic.

Differs from *O. stelliformis* in the bell-shaped calyx, shorter ambulacra and less prominent radial lips.

Burlington of Missouri and Iowa.

Class **CRINOIDEA** Miller.

The crinoids or sea lilies are marine invertebrates, represented in the modern seas by a number of genera and species which range from shallow water to a depth of about 3,000 fathoms. They live in colonies and are usually of very local distribution. They are usually attached by a long stem, rarely by the cup directly, or free-swimming.

The skeleton or test of a crinoid consists of the *stem* or *column* and the *crown*. When lateral appendages are present on the stem they are called *cirri;* those of the lower or distal end are *radicular cirri* and form the *root*. The stem is composed of joints which may be of uniform or varying size. In modern species *nodes* and *internodes* may generally be recognized, the former bearing the cirri, and the latter appearing between the nodal joints. In form the plates often change with growth, the primitive form being shown by the joints beneath the calyx. The *axial canal* passes through the center of the stem, and is variously shaped.

The *crown* consists of *calyx* and *arms;* the former encloses the visceral cavity, the latter constitute the free appendages radiating from the calyx.

The *calyx* is composed of the *dorsal cup* and the ventral disk or *tegmen*, the arm regions forming the line of demarkation between them (Fig. 1805, *a*). The dorsal cup conforms in general to the apical or abactinal system of other echinoderms, the ventral disk to the oral or actinal.

The *dorsal cup* is composed of a number of plates which have a definite arrangement in horizontally disposed series (Fig. 1804). The *radials* (R) are the five plates from which the *rays* (the arms or arm trunks) may be traced; their upper faces unite with the *brachials* by straight, crescent-shaped, or angular *facets*. In some of the earlier crinoids one or more of the R are compound, *i. e.*, bisected transversely, in which case the two parts are distinguished as *superradials* and *inferradials*. Below the R and alternating with them in position are the *basals* (B) varying in number from two to five. If only this single row of the B intervenes between the R and the column, the base is *monocyclic;* when there is a second series of plates in the base below the B and alternating with them they are the *infrabasals* (*ib.*) and the base is called dicyclic. All plates above the R, in radial succession and constituting the arms

FIG. 1803. *Eucalyptocrinus crassus*, with stem. (After Hall.)

are called *brachials.* The first brachials following the R are called *costals* or brachials of the first order (*primibrachs*); there are usually one or two in vertical series, rarely more (Fig. 1804, c^1, c^2, c^3). When in following up the series of costals (primibrachs) from the R, one is found that bears on its upper face two plates instead of one, or one plate and a pinnule, thus giving rise to two succeeding series, the plates of these two succeeding series are called *distichals* or brachials of the second order (*secundibrachs*). In like manner distichals give rise to *palmars* or brachials of the third order (*tertibrachs*). Succeeding divisions, the *postpalmars,* are not named but when referred to are called brachials of the fourth, fifth, etc., orders (*quartibrachs,* etc.). The bifurcating plates which give rise to these successive orders are called *axillaries.* These plates may form part of calyx.

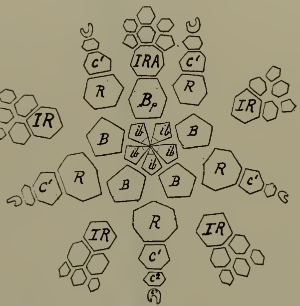

FIG. 1804. Analysis of the calyx of a camerate crinoid. *ib,* infrabasals; *B,* basals or parabasals; *Bp,* posterior basal; *R,* radials; *IR,* interrradials; *IRA,* anal interradius; c^1, c^2, c^3, first, second and third costals or primibrachs.

The free *arms* may be simple or branching. When small lateral appendages are given off alternately from opposite sides of the arms, these are called *pinnules.* The arms are *uniserial* when their joints extend through to both sides of the arms (Fig. 1806, *b*); *biserial* when they interlock from opposite sides. Biserial arms are uniserial in their lower parts, these passing through wedge-shaped stages to the biserial condition. The apical portion of biserial arms is also uniserial (see Fig. 1806). When two or more arm plates are united transversely by a rigid suture, and only the upper plate bears pinules, they are said to form a *syzygy;* the lower non-pinulate plate is called the *hypozygal,* and the upper the *epizygal,* the two constituting one element. The rays and their subdivisions may be laterally in contact; they are, however, usually separated by supplementary plates. Such supplementary plates receive various names according to the plates or series of plates which they separate; those between the R and the succeeding rays are called by the general term *interradials* (IR, Fig. 1804) whether belonging to the dorsal cup or to the ventral disk; those of the dorsal cup between the brachials may be distinguished as *interbrachials,* those of the ventral disk lying between the ambulacra as *interambulacrals,* while those between the different orders of brachials as *intercostals, interdistichals,* etc. (interprimibrachs, intersecundibrachs, etc.). In most Palæozoic crinoids *anal plates* form part of the dorsal cup on the posterior side in line with the anus. The *first anal plate* (IRA) when present rests on the upper face of the posterior brachial B_p, thus adding a sixth plate to the row of five R. Even though the IRA may be lacking, auxiliary anal plates may be present, interposed between the interbrachials and following the median line of the posterior area. The *radianal* (RA) or second anal plate when present rests in the reëntrant angle of two adjoining B to the right of the first anal plate.

The *ventral disk* or *tegmen* consists of the orals, ambulacral and interambulacral plates. The *orals* are five large interradial plates surrounding the mouth or covering it (Fig. 1810). They may be of uniform size and form, or the posterior plate may be larger and nearly central. The orals may be large, small or indistinguishable.

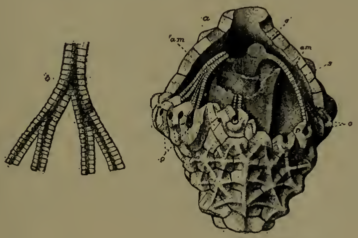

FIG. 1805. *Cactocrinus proboscidialis.* *a*, calyx with broken vault, × 1½; *am*, ambulacral canals; *c*, digestive sac; *o*, arm openings; *s*, "convoluted organ," × 1½; *b*, ambulacral canal, magnified. (After Meek and Worthen, Ill. Geol., V.)

The plates of the tegmen are, in general, much less regular than those of the dorsal cup and often are not differentiated into special series. The *ambulacral plates* consist of the ambulacral or side pieces and the covering plates; the latter form a roof over the food grooves and generally comprise two alternating rows of small, somewhat regularly arranged plates which are always movable on the arms and pinnules but on the tegmen only in those crinoids in which the mouth is exposed. In some of the CAMERATA these plates are so large as to be distinguished as *radial dome plates.* In the FISTULATA the posterior side of the ventral disk is prolonged upward into a large tube, the *ventral sac* or ventral tube; this may or may not contain the anus, but if it does, the opening is usually on the anterior side of the tube. The *anus* may be central in the ventral disk or any where between its center and the margin. Its position determines the posterior side of the calyx. It may open directly through the tegmen, from the anterior side of the ventral tube as in the FISTULATA, or at the end of a special tube, the *anal tube.*

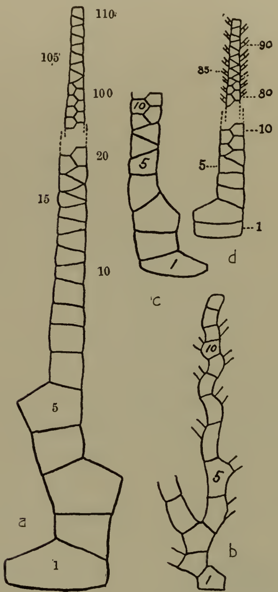

FIG. 1806. Diagrams of crinoid arms. *a*, *Platycrinus hemisphericus*, showing the change in the form of the plates from uniserial to biserial and back to uniserial in the apical portion of the arm; *b*, *c*, *P. huntsvillæ*; *b*, a young individual in which all plates are uniserial; *c*, part of adult showing change to wedge-shaped in 6th plate and biserial condition after the 7th plate; *d*, *Dichocrinus inornatus*, adult arm showing change to biserial after the 5th and back to uniserial after the 84th plate. (After Grabau, Am. Journ. Sci., XVI., pp. 289–300, 1903.)

The mouth may be *tegminal,* opening through the ventral disk, and surrounded by the ends of the ambulacra and by the orals when present, or by the interambulacral plates; or *subtegminal,* when completely roofed over by the orals or interambulacral plates (Fig. 1805, *a*). From the mouth radiate the ambulacra to the tips of the rays following the ventral furrows of the arms and pinnules. When subtegminal they enter the calyx through the arm openings at the upper edge of the dorsal cup (Fig. 1805, *o*); when tegminal they are on the surface of the disk. The ambulacra contain the *food-grooves*. In most CAMERATA the ventral disk is pierced by a succession of small respiratory pores near the arm bases.

The plates of the crinoid are united by suture or by muscular articulation; when *anchylosed* the sutures are close, with the lines of union obliterated by subsequent lime deposit.

The subdivisions into orders is based largely on the part that the lower brachials take in the dorsal cup and their manner of union with it. In the CAMERATA the lower brachials take part in the dorsal cup and all plates of the calyx are united by close suture. In the FLEXIBILIA and ARTICULATA, the lower brachials are incorporated into the dorsal cup but all plates from the radials up are movable and the mouth and ambulacra are tegminal. In the two other orders the arms are free above the radials, the FISTULATA being distinguished by the presence of the ventral sac and by tegminal ambulacra, and the LARVIFORMIA by the ventral disk composed of orals only, with subtegminal ambulacra.

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Artificial Key to the Genera.[1]

A. Arms free above the radials...I.

I. Disk composed of only five orals in the form of a pyramid. Ambulacra subtegminal (*Larviformia*)...1.

1. Radials simple..a.

a. Upper edge of radials bevelled off to form straight articular facets. IV. *Symbathocrinus.*

a. Upper edge of radials deeply forked, the prongs extending upward between the arms..II. *Stephanocrinus.*

1. One or three of the radials compound. Calyx small...............................b.

b. Three of the radials compound..................................III. *Haplocrinus.*

b. The right posterior radial compound..................................I. *Pisocrinus.*

I. Posterior side of disk extended into a sac. Ambulacra suprategminal (*Fistulata* and *Articulata*)..2.

2. Monocyclic..c.

c. Ventral sac small, extending but little above the rest of the tegmen.....11.

11. Arms simple...V. *Hybocrinus.*

11. Arms branching...aa.

aa. Two radials compound..................................VI. *Anomalocrinus.*

aa. Three radials compound................................VII. *Heterocrinus.*

aa. No radials compound; arms extremely broad. XXIV. *Edriocrinus.*

c. Ventral sac large. Arms three...22.

22. Ventral sac touching the two simple radials......VIII. *Calceocrinus.*

22. Ventral sac not touching the two simple radials...IX. *Halysiocrinus.*

2. Dicyclic..d.

d. Infrabasals rudimentary or completely resorbed. Joints of column in the form of 5-angled stars..................................LXXVIII. *Pentacrinus.*

d. Infrabasals and basals present though often hidden..........................33

33. All radials simple...bb.

bb. Ventral sac coiled.......................................XII. *Botryocrinus.*

bb. Ventral sac not coiled..†.

†. Arms without pinnules..*.

*. Arms rather delicate..1″

1″. Anal plate 1..............................XIII. *Cyathocrinus.*

1″. Anal plates 3..............................X. *Carabocrinus.*

*. Arms massive...XIV. *Barycrinus.*

†. Arms with pinnules...**.

**. Articular facets of radials crescentic and rarely occupying the full width of the plates..2″.

2″. Arms branching..........................XV. *Poteriocrinus.*

2″. Arms simple..........................XXIII. *Agassizocrinus.*

**. Articular facets of radials straight and completely occupied by the lower edge of the first brachials........................3″.

3″. Dorsal cup deep......................XVII. *Scytalocrinus.*

3″. Dorsal cup low...a″.

a″. Arms strongly zigzag.........XVIII. *Decadocrinus.*

a″. Arms not strongly zigzag.......................................1‴.

1‴. Arms branching..........XVI. *Scaphiocrinus.*

[1] Adapted in the main from Wachsmuth and Springer.

1'''. Arms simple..................................a'''.
a'''. Arms twenty or more..XIX. *Woodocrinus.*
a'''. Arms usually ten............................1).
1). Basals equal......... ....a).
a). IRA and RA present.
XX. *Eupachycrinus.*
a). IRA and RA absent.
XXII. *Erisocrinus.*
1). Posterior basal elongate.
XXI. *Ceriocrinus.*
33. Right posterior radial compound..................XI. *Dendrocrinus.*
B. Lower brachials taking part in the calyx...II.
II. All plates of calyx united by close suture. Mouth and food groove closed (*Camerata*)..3.
3. Lower brachials and interbrachials forming an important part of the dorsal cup...... ....e.
e. Interradials poorly defined, with many of them mere irregular supplementary pieces...LIII. *Reteocrinus.*
e. Interradials well defined ....44.
44. Dicyclic ....cc.
cc. Radials in contact except at the posterior side......................††.
††. Anal side but slightly elevated. Anus without a tube.
LIV. *Thysanocrinus.*
††. Anal side bulging. Anus at end of a tube.................***.
***. Rays produced into tubular extensions, IB large.
LV. *Lampterocrinus.*
***. Rays branching in regular way. IB small.
LXIII. *Siphonocrinus.*
cc. Radials separated all around........ ....†††.
†††. Arms branching ....4*.
4*. Ventral disk narrower than dorsal cup.....................4''.
4''. Three interbrachials in second row.
LVII. *Rhodocrinus.*
4''. Two interbrachials in second row.
LVIII. *Archæocrinus.*
4*. Ventral disk equal to or exceeding dorsal cup. Tubular appendages suspended from margin of disk.
LX. *Gilbertsocrinus.*
†††. Arms not branching..5*.
5*. Lower distichals with pinnules incorporated in calyx.
LVI. *Hercocrinus.*
5*. Lower distichals without pinnules.......LIX. *Lyriocrinus.*
44. Monocyclic ....dd.
dd. Radials in contact all around....................... ....4†.
4†. Arms borne in compartments formed by partitions attached to the tegmen...6*.
6*. Partitions extending to tips of arms.
LXVII. *Eucalyptocrinus.*
6*. Partitions enclosing only the lower portions of the arms.
LXVIII. *Callicrinus.*

4†. Arm compartments not present..7*.

7*. Dorsal cup perfectly symmetrical ; no anal plates present. LXVI. *Dolatocrinus.*

7*. Dorsal cup with one or more anal plates...................5''.

5''. Basals five.......................... ....b''.

b''. Arms uniserial....................LXI. *Glyptocrinus.*

b''. Arms biserial.....................LXII. *Periglyptocrinus.*

5''. Basals four.............................LXV. *Melocrinus.*

5''. Basals three....................LXIV. *Macrostylocrinus.*

dd. Radials in contact except at the posterior side where they are separated by an anal plate.......................................6†.

5†. First anal plate heptagonal, followed by a second between two interbrachials ....8*.

8*. Ventral disk highly differentiated, with large and heavy plates, forming a rigid integument. Arms not branching beyond the calyx.....................................6''.

6''. Anus at end of a tube.................................c''.

c''. Interbrachials separated from interambulacrals by an arch of brachials................................2'''.

2'''. Calyx biturbinate..............................b'''.

b'''. Arms short, equidistant. Anal tube very long and central............XLVI. *Batocrinus.*

b'''. Arms long, paddle-shaped. Anal tube excentric.....................XL. *Eretmocrinus.*

2'''. Calyx conical. Dorsal cup almost flat. Ventral disk very high ; anal tube central. XLVII. *Alloprosalocrinus.*

c''. Interbrachials connected with interambulacrals. Arms in groups with openings directed upward. Anal tube large, central.. ....3'''.

3'''. Arms 20...........................L. *Lobocrinus.*

3'''. Arms 12–16....................LI. *Macrocrinus.*

c''. Interbrachials in contact with interambulacrals at anal side only.......................................4'''.

4'''. Calyx wheel-shaped. Anal tube very large, central. Arms short..XLVIII. *Eutrochocrinus.*

4'''. Calyx rotund. Anal tube moderately small, about central. Arms long..XLIX. *Dizygocrinus.*

6''. Anus without a tube.......................... ....d''.

d''. Calyx lobed...5'''.

5'''. Arms one from each opening..LII. *Aorocrinus.*

5'''. Arms paired; spines present on arms and tegmen ....XLI. *Dorycrinus.*

d''. Calyx hemispherical or pyramidal. XLII. *Agaricocrinus.*

8*. Ventral disk composed of small, irregularly arranged plates. Arms generally branching beyond the calyx...7''.

7''. Calyx elongate, urn-shaped...XLIII. *Periechocrinus.*

7''. Calyx depressed globose........XLIV. *Megistocrinus.*

7''. Calyx low, strongly lobed at arm regions. XLV. *Gennæocrinus.*

5†. First anal plate hexagonal, followed by two interbrachials without a second anal. Arms branching from two main trunks by alternate bifurcation. Basals three and equal..9*.
9*. Anus at end of a tube.....................................8″.
8″. Calyx lobed; interradial spaces depressed.........e″.
e″. Arms given off from alternate sides of tubular extensions of the calyx.. ..XXXVII. *Steganocrinus.*
e″. Arms rarely bifurcating. Anal tube long and central..............................XXXIII. *Actinocrinus.*
e″. Arms generally bifurcating. Anal tube short and excentric....... ....XXXV. *Amphoracrinus.*
8″. Calyx not lobed; arms about equidistant, given off in a ring around the calyx. Anal tube long and central. f″.
f″. Arms directed upward.......XXXIV. *Cactocrinus.*
f″. Arms directed outward below, incorporated into the calyx and forming a broad rim.
XXXVI. *Teleiocrinus.*
9*. Anus without a tube.......................................9″.
9″. Arms in groups with channeled spaces between. Ventral disk hemispherical. Anus excentric.
XXXVIII. *Physetocrinus.*
9″. Arms extended below in a broad rim. Ventral disk low. Anus subcentral.............XXXIX. *Strotocrinus.*
3. Brachials and interbrachials but slightly represented in dorsal cup............f.
f. Monocyclic.................... ....55.
55. Radials in contact all around. Base pentagonal......................ee.
ee. Costals two........................... ....XXV. *Coccocrinus.*
ee. Costal one..6†.
6†. Column circular, with large canal.......XXVI. *Marsipocrinus.*
6†. Column elliptic, with small canal........XXVII. *Platycrinus.*
55. Radials separated at posterior side by anal plate. Base hexagonal. ff.
ff. Basals directly followed by the radials.. ....7†.
7†. Basals three.. ....XXVIII. *Arthracantha.*
7†. Basals two...10*.
10*. Costals two..............................XXIX. *Dichocrinus.*
10*. Costal one, very small, sometimes hidden..............10″.
10″. Anal plate resembling anterior radial in form and size.
XXX. *Talarocrinus.*
10″. Anal plate much smaller than the radials. Radial dome plates produced into wing-like appendages.
XXXI. *Pterotocrinus.*
ff. Basals separated from the radials by accessory pieces.
XXXII. *Acrocrinus.*
f. Dicyclic. Radials in contact except at the posterior side.
LXIX. *Crotalocrinus.*
II. All plates from radials up movable. Mouth and food grooves exposed (*Flexibilia*)........ ....4.
4. Arms non-pinnulate...g.

g. Rays (radials and lower brachials) laterally in contact on all sides.
LXXII. *Ichthyocrinus.*

g. Four of the rays in contact, the two posterior being separated by an RA and an IRA.......................................LXXIII. *Lecanocrinus.*

g. Rays all separated by interbrachials.......................................66.

66. Arms spreading and talon-like.................LXXV. *Onychocrinus.*

66. Arms rather closely apposed.......................................gg.

gg. Both IRA and RA present................LXXVI. *Forbesiocrinus.*

gg. Only IRA present..............................LXXIV. *Taxocrinus.*

g. Radials separated by interradials but the succeeding rays laterally in contact except at anal side where there is a longitudinal row of anal plates.
LXXI. *Cleiocrinus.*

4. Arms pinnulate...LXXVII. *Uintacrinus.*

Of doubtful classification.

Anchor-shaped, with lateral processes..............................LXXX. *Ancyrocrinus.*

Broadly shield-shaped, concave....................................LXXIX. *Aspidocrinus.*

Pear-shaped or spheroidal channeled bodies of numerous plates.
LXX. *Camarocrinus.*

Order I. LARVIFORMIA Wachsmuth and Springer.

I. Pisocrinus Angelin.

Calyx small, globose or cup-shaped and composed of heavy plates. B 5, unequal, forming a triangle which is largely sunken in the basal cavity. Following this triangle are three large plates, one on each side and forming most of the calyx; two of these plates are R and the third, the inferradial, is followed by two R. The fifth R is a small intercalated plate. All of the R are deeply excavated centrally for the insertion of the arms. Tegmen rarely preserved, but consisting of five large, symmetrical orals, above which rises a long, narrow anal tube. Arms long and composed of extremely elongate, heavy, cylindrical joints. Siluric.

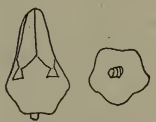


FIG. 1807. *Pisocrinus milligani.* (After Miller and Gurley).

1. **P. milligani** Miller and Gurley. (Fig. 1807.) Siluric.

Of medium size, resembling *P. gorbyi*, but larger and shorter in proportion to its diameter. Calyx obpyramidal, truncated below, and with a deep columnar pit, expanding in the radial regions and pentalobate in summit view.

Niagaran of Tennessee.

2. **P. gorbyi** Miller. Siluric.

Small; height and width about equal. Summit five-lobed.

Niagaran of Indiana.

II. Stephanocrinus Conrad.

Calyx composed of three elongate B of dissimilar outline, five R and five IR. R deeply forked, the prongs (limbs) formed by the margins of two contiguous R extending upward between the arms and building together with the IR a row of pyramids. The radial cuts are occupied by the ambulacral grooves which are

Fig. 1808. *Stephanocrinus angulatus*, two individuals and enlargement of stem. (After Hall.)

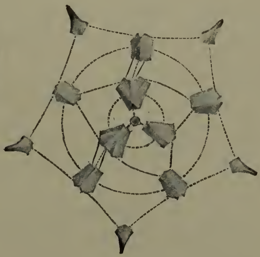


Fig. 1809. *Stephanocrinus angulatus*, analysis of calyx. (After Hall.)

roofed over by two rows of covering pieces. Tegmen composed of five large, triangular orals. Arms very short, composed of about ten pieces, all of which are axillary and give off side arms; these side arms are biserial, nonpinnulate, and are made up of long, strongly wedge-shaped joints. Stem consisting of circular joints, pierced by a circular canal. Ordovicic–Siluric.

3. **S. angulatus** Conrad. (Figs. 1808, 1809.) Siluric.

Calyx reverse-pyramidal. Sutures scarcely visible. R 6-sided, with short, forked upper side. IR broad below, contracting to a point above. Strong and angular keels present on the plates. Stem joints thick and equal.

Niagara shale of New York.

III. Haplocrinus Steininger.

Calyx small, pear-shaped to globose. B 5; R 5, unequal. Three of the R composed of two pieces of which the uppermost or superradial is the larger and bears an articular facet for the attachment of the arms. Arms small, simple, uniserial, resting within deep grooves formed along the sides of the orals. Orals large, five-sided and in contact laterally, the posterior one pierced by a small anal opening. Mouth beneath the tegmen. Stem composed of thin joints. Devonic.

FIG. 1810. *Haplocrinus clio.* Opposite views of two specimens, × 6. (After Hall.)

4. **H. clio** Hall. (Fig. 1810.) Devonic.

Very small, pentagonal in upper view, with protruding arm bases.

Marcellus of New York.

IV. SYMBATHOCRINUS Phillips.

Calyx small, bowl-shaped. B 3, unequal. R 5, nearly equal. Tegmen formed of five small orals, the posterior the largest. Anal tube long and slender. Arms 5, long, simple, composed of thick plates with sharp edges. Mississippic.

5. **S. dentatus** Owen and Shumard. Mississippic.

Slightly smaller than *S. robustus* and upper part of calyx more contracted, tending to become spindle-shaped.

Burlington of Missouri and Iowa.

6. **S. robustus** Shumard. (Fig. 1811.) Mississippic.

Surface of calyx finely granulose. Margin of basal excavation finely crenulate.

Keokuk of Kentucky and Illinois.

FIG. 1811. *Symbathocrinus robustus,* × ⅔. (After Meek and Worthen.)

Order II. FISTULATA Wachsmuth and Springer.

V. HYBOCRINUS Billings.

Calyx cup-shaped or obconical. B 5, high. The right posterior R compound, the inferradial supporting the ventral sac, the superradial extremely small. Tegmen somewhat extended posteriorly, forming an elongate sac, the first plate of which closely resembles the superradial in form and size. Arms simple, without pinnules. Ordovicic.

7. **H. pristinus** Billings. Ordovicic.
Closely similar to *H. tumidus,* but plates not so convex and more coarsely granular.
Chazy of Quebec.

8. **H. tumidus** Billings. (Fig. 1812.) Ordovicic.
Plates tumid in the center, obscurely granular.
Trenton of Ottawa.

VI. Anomalocrinus Meek and Worthen.

Calyx very large, subglobose. B 5. R irregular, that of the posterior ray often longitudinally bisected in the median line. Ventral sac small and tubular. Arms uniserial and bifurcating. Pinnules given off in series alternately. Ordovicic.

Fig. 1812. *Hybocrinus tumidus.* (After Billings, Can. Org. Rem. Dec., IV.)

Fig. 1813. *Anomalocrinus incurvus,* posterior view; an additional basal piece occurs. (After Meek, Pal. Ohio.)

9. **A. incurvus** Meek and Worthen. (Fig. 1813.) Ordovicic.
Surface granular.
Cincinnatian of Ohio.

VII. Heterocrinus Hall.

Calyx small, with long and cylindrical arms. Three of the R compound, the others simple and shorter; the inferradial of the posterior ray has the form of an axillary, supporting to the left the ventral sac, and to the right the superradial. Arms comparatively stout, giving off long branchlets at intervals which often branch again. Stem very large, five-sided, divided by five partitions, the lines of division being interradial in position. Ordovicic.

FIG. 1814. *Heterocrinus simplex;* the larger is var. *grandis*, with enlargement of arms. (After Meek.)

10. **H. simplex** Hall. (*H. canadensis* Billings.) (Fig. 1814.) Ordovicic.

Pinnules directed upward nearly parallel with the rays. Column broadening towards base of calyx.

Cincinnatian of Ohio; Trenton of Ontario and Quebec.

11. **H. tenuis** Billings. Ordovicic.

Much smaller and more slender than *H. simplex* (length, including arms, about one inch). Column moniliform to base of calyx.

Trenton of Ontario and Quebec.

VIII. CALCEOCRINUS (Hall) Ringueberg.

Calyx and arms bent down on the column so as to " resemble a wilted flower," the right posterior interray lying along the stem. Calyx laterally compressed, being almost linear at the junction of B and R. Anterior side flat, broadly truncate below, constricted in the middle and composed of the R plates (the anterior and the usually compound left and right anterior lateral R). B on the posterior side, separated from the R of the opposite side by a widely gaping articular line. Posterior side consists, in addition to the B, of three plates, the left posterior and the compound right posterior R. The right posterior and right anterior lateral superradials are fused into a T-shaped piece abutting with either wing against the right posterior and right anterior lateral inferradials.

This T-piece is low, wide and sometimes very small. The anal tube is supported by the T-piece and the right anterior and right posterior inferradials, not touching the two large, simple R. Arms three, rising only from the three anterior R, and composed of single joints which are usually as long as wide and grooved ventrally.

Remarkable especially in the connection of B and R by muscles and ligaments instead of by suture, allowing the calyx to bend along this articular line. Siluric–Devonic.

12. **C. radicula** Ringueberg. Siluric.

Calyx compressed cylindrical. Arms three—one dorsal and two lateral, the lateral arms bifurcating. Basal plate narrow, triangular. All arms branching. Calyx one third of an inch high.

Niagaran (Rochester shale) of New York.

IX. Halysiocrinus (Ulrich) Bather.

Similar to *Calceocrinus,* but the T-piece is either obsolete or concealed, leaving the tube supported by the right posterior and right anterior lateral inferradials and abutting against the anterior and left posterior R. Likewise the simple anterior R of *Calceocrinus* is here compound, the two parts separated by the right and left antero-lateral R. Mississippic.

13. **H. ventricosus** Hall. Mississippic.

Resembles *H. bradleyi,* but is slightly smaller, the greatest breadth

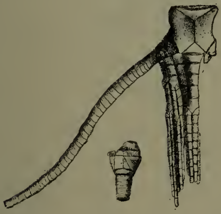


Fig. 1815. *Halysiocrinus bradleyi;* dorsal and anterior view, side view of base, × ⅔. (After Meek and Worthen.)

Fig. 1816. *Carabocrinus geometricus,* × 4. (After Hudson.)

of the calyx is toward the summit instead of the base and the arms bifurcate less frequently. (Type of genus.)

Burlington of Missouri and Iowa.

14. **H. bradleyi** Meek and Worthen. (Fig. 1815.) Mississippic.
Column thick, composed of round plates which become somewhat pentagonal near the calyx; arms bifurcate frequently.
Keokuk of Indiana.

X. Carabocrinus Billings.

Closely similar to *Cyathocrinus* in form of calyx, mode of branching, delicacy of arms, etc., but differs in the anal area which here is composed of three plates, the lowest one resting on the IB.
Trenton of Tennessee and Canada.

15. **C. geometricus** Hudson. (Fig. 1816.) Ordovicic.
Small. Differs from *C. radiatus* in its less globular form.
Chazy of New York.

16. **C. radiatus** Billings. (Fig. 1817.) Ordovicic.
Calyx globose, covered with rounded ridges.
Trenton of Ottawa.

XI. Dendrocrinus Hall.

Calyx obconical, with height exceeding width. Structure of calyx as in *Cyathocrinus*, except that in *Dendrocrinus* the right

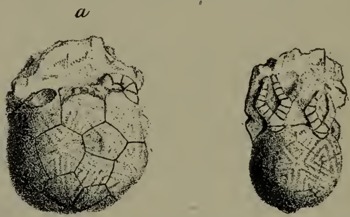


Fig. 1817. *Carabocrinus radiatus*, opposite sides of different specimens. (After Billings, Can. Org. Rem. Dec., IV.)

posterior R is compound by a vertical division and the ventral sac is very large, its base formed by the two or three plates which succeed the IRA and which are partly enclosed in the calyx. Ordovicic–Siluric?

17. **D. conjugans** Billings. Ordovicic.
Height and greatest width of calyx about one third of an inch. Arms half the width of the R and rounded, twice bifurcating.
Trenton of Ottawa.

18. **D. cylindricus** Billings. Ordovicic.
Calyx one fifth of an inch in diameter. Ventral sac as long as the arms. Plates all smooth.
Trenton of Quebec.

19. **D. latibrachiatus** Billings. Ordovicic.
Calyx small (less than one third of an inch high), conical. Arms very broad, equalling at base the width of the R.
Cincinnatian of Anticosti.

20. **D. cincinnatiensis** Meek. (Fig. 1818.) Ordovicic.
Height and width of calyx about equal.
Cincinnatian of Ohio.

21. **D. caduceus** Hall. (Fig. 1819.) Ordovicic.
Height of calyx exceeding width. Surface marked by broad

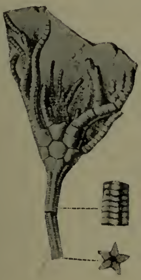


FIG. 1818. *Dendrocrinus cincinnatiensis*, side view and stem joint enlarged. (After Meek.)

FIG. 1819. *Dendrocrinus caduceus*, lateral view, natural size, and part of stem, × 2. (After Meek, Pal. Ohio.)

and obscure ridges which connect, leaving rhombic excavations between.
Cincinnatian of Ohio.

22. **D. casei** Meek. Ordovicic.
Height and breadth of calyx about equal (one third of an inch).

Surface divided by strong ridges into deep triangular spaces. Ventral sac more than five times the length of the calyx.

Cincinnatian of Ohio.

XII. Botryocrinus Angelin.

Dorsal cup obconical, with truncated base. IB 5, somewhat protuberant. B 5. R large, with concave facets for the arms. Ventral sac one half to two thirds the length of the arms, supported by the small radianal plate recurved toward the summit. Arms uniserial, 10. Anus anterior, at base of the ventral sac. Siluric.

23. **B. polyxo** Hall. Siluric.

Plates of the dorsal cup usually slightly prominent in the center, with low, angular ridges extending to the sutures.

Niagaran of Indiana and Illinois.

XIII. Cyathocrinus Miller (emend. Wachsmuth and Springer).

Dorsal cup bilaterally symmetrical, globose, cup-shaped, with convex sides incurving above. IB 5, equal. B large, the posterior B truncated for the support of an anal plate. R 5, all simple, their upper faces provided with a facet occupying less than the full width of the plates. Anal plate one between the R; its succeeding plates not enclosed in the calyx, but forming part of the ventral sac. Ventral sac rarely extending more than half the height of the arms. Number of costals extremely variable among the rays. Arms rather delicate, composed of elongate cylindrical joints and giving off numerous branches most of which divide again. Stem round. Ordovicic–Mississippic.

24. **C. cora** Hall. Siluric.

Dorsal cup very large (one to one and one half inches in diameter), subglobular, usually found as internal molds. Surface covered with groups of parallel ridges which cross the sutures at right angles. R constricted at the arm bases, forming five rounded interradial protuberances. Arms very slender, dividing at once into two main divisions which extend out horizontally and give off vertical branches on the upper side.

Niagaran of Illinois and Wisconsin.

25. **C. enormis** Meek and Worthen. Mississippic.

Like *C. iowensis,* but thinner and more conical.

Lower Burlington of Missouri and Iowa.

26. **C. iowensis** Owen and Shumard. Mississippic.

Calyx oblong in outline, owing to the broadly truncated base and straight sides.

Burlington of Missouri and Iowa.

27. **C. multibrachiatus** Lyon and Casseday. Mississippic.

Much larger than *C. maximus,* with numerous, long, slender arms and strong, round stem.

Keokuk of Indiana.

28. **C. parvibrachiatus** Hall. Mississippic.

IB small, partly concealed by the column. B very large and strongly tumid. Arms short and rapidly tapering.

Keokuk of Illinois and Iowa.

29. **C. maxvillensis** Whitfield. (Fig. 1820.) Mississippic.

Calyx pointed below; sides curving.

Maxville of Ohio.

30. **C. stillativus** White. Carbonic.

Dorsal cup very shallow. Plates very convex to angular.

Carbonic of Missouri and Kansas.

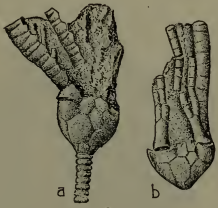


FIG. 1820. *Cyathocrinus maxvillensis,* two specimens showing different parts. (After Whitfield.)

XIV. BARYCRINUS Wachsmuth.

Differs from *Cyathocrinus* in its massive arms. Ventral sac composed of but few rows of heavy plates longitudinally arranged. Column obtusely five-angled, with very large axial canal. Mississippic.

31. **B. meekianus** Shumard. Mississippic.

Plates massive, convex. IB nearly hidden by the heavy column. R slightly larger than the B. Anals two, the lower very small.

Chouteau and Burlington of Missouri.

32. **B. sculptilis** (Hall). Mississippic.

Calyx basin-shaped, small, with a breadth of slightly over one inch, which is twice the height, truncated at base and expanding rapidly upward. Plates somewhat rugose, very convex medially and deeply excavated at the corners.

Burlington of Iowa.

FIG. 1821. *Barycrinus hoveyi*, × ⅔. (After Meek and Worthen.)

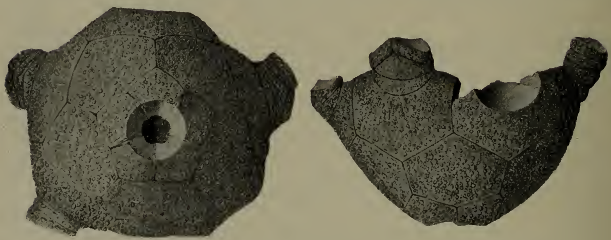


FIG. 1822. *Barycrinus magnificus*, side and basal views, × ½. (After Meek and Worthen.)

33. **B. hoveyi** (Hall). (Fig. 1821.) Mississippic.
Arms slender, usually only two to a ray.
Keokuk of Indiana, Missouri and Iowa.

34. **B. magnificus** Meek and Worthen. (Fig. 1822.) Mississippic.
Calyx large, bowl-shaped. Surface covered with small tubercles.
Keokuk of Illinois and Iowa.

XV. POTERIOCRINUS Miller.

Calyx obconical. B 5, high, with five IB which are sometimes hidden by the column. R five, three 6-sided and two 7-sided and rising above the others; articular facets crescent-shaped. Anal and radianal plates present. Ventral sac long and tubular, extending the full length of the arms. Arms long, branching and composed of cuneate joints. Column round or somewhat five-sided. Devonic–Mississippic.

35. **P. agnatus** Miller. Mississippic.

Calyx cup-shaped, wider than high; each ray with a single brachial. Surface smooth. Arms 16, several bifurcating.

Keokuk of Missouri.

36. **P. amænus** Miller. Mississippic.

Calyx as in *P. agnatus*, but smaller and surface granular. Some rays with a simple brachial and some with double. Arms 16, flattened externally and fitting closely together.

Keokuk of Indiana.

XVI. Scaphiocrinus Hall.

Dorsal cup low, saucer-shaped. Plates as in *Poteriocrinus*, but articular facets of the R horizontal and completely occupied by the lower faces of the first brachials. Arms long, uniserial and branching, composed of wedge-shaped plates. Mississippic–Carbonic.

37. **S. swallovi** (Meek and Worthen). Mississippic.

Calyx below the arms tapering regularly down to the column, composed of smooth plates. Arms long and rounded, bifurcating, uniserial.

Burlington-Keokuk of Iowa.

Fig. 1823. *Scaphiocrinus unicus*, × ⅔. (After Meek and Worthen.)

38. **S. unicus** Hall. (Fig. 1823.) Mississippic.

Distinguished by the single undivided arm of the anterior ray.

Keokuk of Indiana.

39. **S. crineus** Hall. (Fig. 1824, *a, b*.) Mississippic.

Plates of arms strongly wedge-shaped. Surface smooth or finely granulose.

Waverly of Ohio.

40. **S. subcarinatus** Hall. (Fig. 1824, *c, d*.) Mississippic.

Small, with slender arms. Calyx plates angular in the middle. Surface granulose.

Waverly of Ohio.

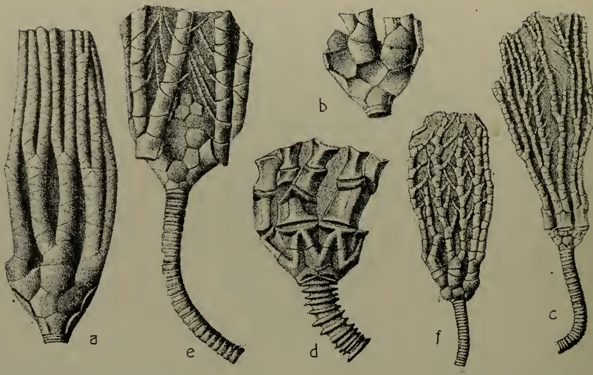


FIG. 1824. *a*, *b*, *Scaphiocrinus crineus*; *c*, *d*, *S. subcarinatus*; nat. size and enlarged; *e*, *Decadocrinus pleias*; *f*, *D. ægina*. (After Hall and Whitfield.)

XVII. SCYTALOCRINUS Wachsmuth and Springer.

Dorsal cup usually deep. Arrangement of plates as in *Scaphiocrinus*, but the arms are stronger and remain undivided after the first bifurcation, above the first or second brachial. Pinnules long and close. Mississippic.

FIG. 1825. *Scytalocrinus robustus*, × ⅔. (After Worthen.)

41. **S. robustus** (Hall). (Fig. 1825.) Mississippic.

Calyx spreading more abruptly from the top of the B than below.

Keokuk of Indiana and Illinois.

XVIII. DECADOCRINUS Wachsmuth and Springer.

Dorsal cup very short, concave at bottom. Arrangement of plates as in *Poteriocrinus*, but arms simple, thinner and composed of long, cuneate joints, which give them a strongly zigzag outline. Arms 10, rarely 9; pinnules robust, resembling small arms and widely separated. Ventral sac club-shaped. Mississippic.

42. **D. pleias** (Hall). (Fig. 1824, *e*.) Mississippic.

Calyx rapidly expanding. Arms composed of a single row of subcuneate plates. Surface of plates smooth or finely granulose. Column subpentagonal, composed of alternately thicker and thinner plates.

Waverly of Ohio.

43. **D. ægina** (Hall). (Fig. 1824, *f*.) Mississippic.

Arms composed of elongate joints, which give rise to jointed branches from near the margin of their longer side. Surface of plates granulose.

Waverly of Ohio.

XIX. Woodocrinus de Koninck.

Calyx saucer-shaped. IB 5, small. B large, curving inward below with the IB to form the concavity around the column. R truncated above. Brachials truncated below. Arms bifurcating,

Fig. 1826. *Woodocrinus æqualis*, × ⅔. (After Meek and Worthen.)

Fig. 1827. *Woodocrinus elegans*, anterior side. (After Hall.)

uniserial and closely in contact laterally. Anal area composed of several rows of plates. Column round. Mississippic.

44. **W. troostanus** (Meek and Worthen). Mississippic.

Entire length to extremity of arms about one and one half inches.

Differs from *W. merope* in the absence of angulation of the brachials and in the flatness of the arms.

Burlington of Illinois and Iowa.

45. **W. æqualis** (Hall). (Fig. 1826.) Mississippic.

B extremely tumid. Arms bifurcating several times.

Keokuk of Indiana.

46. **W. merope** (Hall). (Fig. 1828, *a*.) Mississippic.

Small, somewhat 5-angled from the prominent angulation of the brachials. Surface of calyx marked by somewhat nodose radiating ridges. Arms subangular.

Waverly of Ohio.

47. **W. elegans** (Hall). (Fig. 1827.) Mississippic.

Crown elongate, pear-shaped. Arms broad, flattened and closely appressed.

Burlington of Missouri and Iowa.

XX. Eupachycrinus Meek and Worthen.

Dorsal cup low saucer-shaped. IB small and concealed by the column. B large. IRA and RA both present, the latter very large

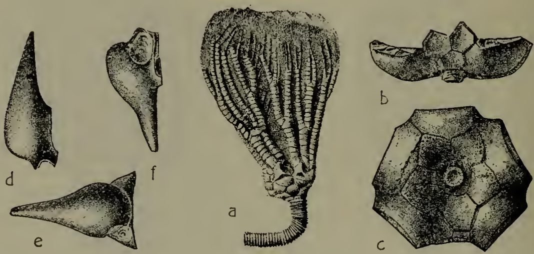


Fig. 1828. *a, Woodocrinus merope; b, c, Eupachycrinus mooresi; d–f,* costals of same with spines. (After Whitfield.)

and supporting a small plate of the ventral tube. Arms usually 10, rarely more. Mississippic–Carbonic.

48. **E. orbicularis** (Hall). Mississippic.

Calyx globular, greatly depressed. Plates smooth.

Keokuk of Illinois and Iowa.

49. **E. mooresi** (Whitfield). (Fig. 1828, *b–f*.) Carbonic.

Smaller than *E. tuberculatus,* without the tubercles. Costals large and spine-bearing; spines bulbous below.

West Virginia (Lower Cambridge limestone) and Ohio.

50. **E. tuberculatus** Meek and Worthen. (Fig. 1829.) Carbonic.

Large. Whole external surface covered with regularly arranged tubercles.

Carbonic of Illinois.

FIG. 1829. *Eupachycrinus tuberculatus,* lateral and basal view of calyx. (After Meek and Worthen, Ill. Geol., V.)

XXI. CERIOCRINUS White.

Dorsal cup as in *Eupachycrinus,* but the posterior B more elongate than the others and supporting a small IRA. Radianal wanting. Costals one or two, the lower frequently extended into a spine. Arms 10, short and heavy. Carbonic.

51. **C. hemisphericus** (Shumard). (Fig. 1830.) Carbonic.

Calyx small, smooth, basin-shaped.

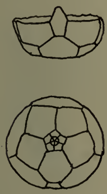


FIG. 1830. *Ceriocrinus hemisphericus.* (Ill. Surv.)

Carbonic of Missouri, Illinois, Kansas, Iowa and Nebraska.

52. **C. inflexus** (Geinitz). Carbonic.

Basin-shaped, deeply impressed below. Height of calyx about two fifths of an inch; diameter at top nearly one inch. Surface smooth.

Carbonic of Nebraska, Oklahoma and Utah.

XXII. ERISOCRINUS Meek and Worthen.

Differs from *Eupachycrinus* in the absence of both IRA and radianal. IB 5, minute, covered by the stem. Mississippic–Carbonic.

53. **E. typus** Meek and Worthen. Carbonic.

Calyx basin-shaped, rounded below, with outline somewhat five-angled as seen from above or below. Plates smooth and slightly convex.

Carbonic of Illinois, Nebraska and Utah.

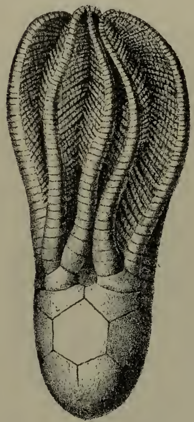


FIG. 1831. *Agassizocrinus dactyliformis.* (After Roemer.)

XXIII. AGASSIZOCRINUS Troost.

Attached in larval state, free-swimming in adult. Dorsal cup elongate, with massive plates. IB and B very large, the former consisting of five elongate pieces which form an almost solid semi-globose body, with suture lines nearly or quite obliterated. R very short, wider than high. Anal and radianal both present. Arms 10, long and stout. Column absent in adult. Kaskaskia of North America.

54. **A. dactyliformis** Shumard. (Fig. 1831.) Mississippic.

Calyx obconical, with curved sides.

Kaskaskia of Arkansas and Illinois.

55. **A. conicus** Owen and Shumard. (Fig. 1832.) Mississippic.

Elongate-conical, narrower and with more pointed base than *A. dactyliformis.*

Kaskaskia of Illinois.

XXIV. EDRIOCRINUS Hall.

FIG. 1832. *Agassizocrinus conicus*, basal portion. (After Meek and Worthen, Geol. Ill., V.)

Attached in larval state, free in adult. IB absent. B very large and elongate, closely anchylosed, with suture lines obliterated. Base in young irregular and linear, in adult deeply bowl-shaped, with scar of attachment obliterated by calcareous deposits. B followed by 5 R and an anal plate. R comparatively small, quadrangular; articular facets but slightly excavated, occupying the full width of the plates, and with a sharp articular ridge. Anal plate supporting a second small plate. Arms broad at base, composed of extremely short transverse pieces. Devonic.

56. **E. sacculus** Hall. (Figs. 1833, 1834.) Devonic.

Arms bifurcating several times, making eight or more divisions at the extremities.

Oriskany of Maryland.

FIG. 1833. *Edriocrinus sacculus*, a nearly entire individual with arms. (Pal. N. Y., III.)

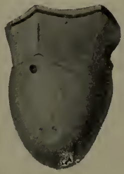


FIG. 1834. *Edriocrinus sacculus*, base with radials and first brachials attached. (Pal. N. Y., III.)

Order III. CAMERATA Wachsmuth and Springer.

XXV. Coccocrinus Müller.

Like *Platycrinus*, but with wider costals which with the IR form a part of the dorsal cup; the two costals succeeded by two distichals. Only one IR to each side. Orals 5, large and triangular, forming nearly all the ventral surface, meeting in the center, but parted toward the arm bases, leaving narrow slits. Siluric–Devonic.

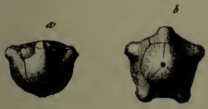


FIG. 1835. *Coccocrinus bacca: a*, lateral, *b*, basal view. (After Roemer.) (Specimens not so symmetrical as figures.)

FIG. 1836. *Marsipocrinus*, analysis of calyx. (After Weller.)

57. **C. bacca** Roemer. (Fig. 1835.) Siluric.

Small. Orals unknown.

Niagaran of Tennessee.

XXVI. Marsipocrinus Bather. (*Marsupiocrinus* Phillips.)

Resembling *Platycrinus*, but the lower brachials and first IR entering somewhat more into the dorsal cup; the radial facets nearly straight instead of excavated; the column circular instead of elliptic and the axial canal much larger and pentagonal (Fig. 1836). Siluric.

58. **M. tennesseensis** (Roemer). (Fig. 1837.) Siluric.
Width of calyx about twice the height, the latter about equally divided between cup and tegmen. Plates thin and flat, usually

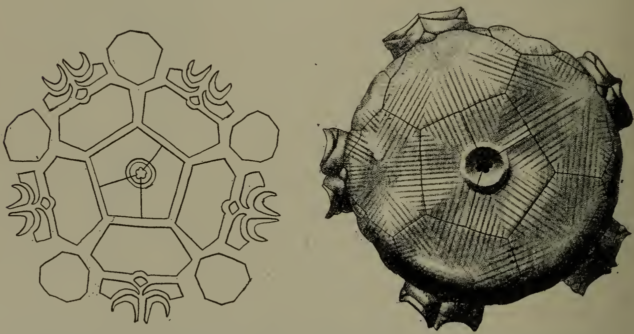


Fig. 1837. *Marsipocrinus tennesseensis*, base of calyx and analysis. (After Roemer.)

covered with longitudinal and transverse striæ meeting at an angle.
Niagaran of Tennessee.

59. **M. præmaturus** (Hall and Whitfield). (Fig. 1838.) Siluric.
Plates heavy and strongly convex. Surface smooth.
Niagaran of Ohio.

XXVII. Platycrinus Miller.

B 3, large, two of them equal and twice as large as the third, and all closely anchylosed. R long, large, laterally united by close sutures and furnished above with a crescent-shaped articular facet for the brachials, and the limbs with notches for the support of the IR. Succeeding each R is a row of small brachials which divides above the costals into two branches which bifurcate independently. Plates of the anal interray more numerous than those of the four regular sides. Orals large, unsymmetrical and resting against the interradials. Covering pieces of the ambulacra usually exposed, very rigid, and incorporated into the tegmen. Anus excentric, either opening directly through the disk or placed at the

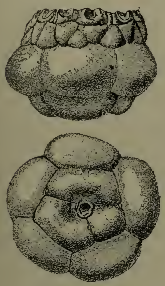


FIG. 1838. *Marsipocrinus præmaturus*, side and bottom view. (Ohio Pal.)

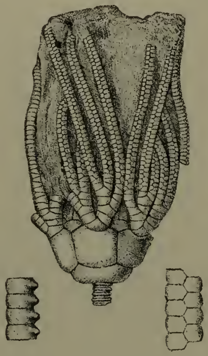


FIG. 1839. *Platycrinus burlingtonensis*, calyx and two enlarged views of arms, × 3. (After Meek and Worthen.)

end of a short, thick tube. Arms uniserial at their lower ends, but gradually becoming biserial. Stem elliptical and twisted, the axes of the upper and lower surfaces of the individual joints being slightly shifted upon one another. Axial canal minute. Devonic–Mississippic.

A. Dorsal cup deep, bowl-shaped, with much of the B visible in side view............I.
  I. Interbasal sutures not prominent..1.
    1. Plates smooth...a.
      a. Arms six to a ray..............................61. *P. burlingtonensis.*
      a. Arms seven or eight to a ray..............................62. *P. halli.*
    1. Plates covered with nodes..............................66. *P. hemisphericus.*
  I. Interbasal sutures raised into ridges..2.
    2. Lower brachials with wavy sutures..............................67. *P. huntsvillæ.*
    2. Lower brachials with the usual sutures...b.
      b. Calyx small, with short compact arms..............................65. *P. bonoensis.*
      b. Calyx larger, with tapering arms..............................68. *P. saræ.*
B. Dorsal cup shallow, bowl-shaped, with rarely more than the edges of the B visible in side view..............................60. *P. americanus.*
C. Dorsal cup discoid..II.
  II. Plates deeply corrugated..............................63. *P. discoideus.*
  II. Plates nearly or quite smooth..............................64. *P. subspinosus.*

60. **P. americanus** Owen and Shumard. Mississippic.

Dorsal cup more than once and a half as wide as high. Plates ornamented by coarse granules arranged concentrically around their margins. Suture lines channeled through the beveling of the plate edges.

Burlington of Missouri, Illinois and Iowa.

61. **P. burlingtonensis** Owen and Shumard. (Fig. 1839.) Mississippic.

Ventral disk depressed hemispherical, bearing an incurving anal tube 5 or 6 mm. long.

Burlington of Missouri, Illinois, Iowa and New Mexico.

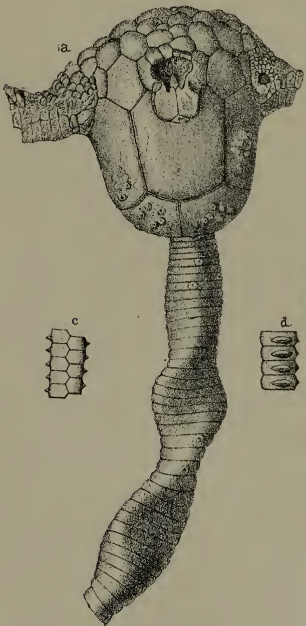


FIG. 1840. *Platycrinus halli: a*, calyx with stem; *c*, *d*, outer and side views of part of arm. (After Meek and Worthen.)

FIG. 1841. *Platycrinus subspinosus.* (After Meek and Worthen, Pal. Ill., II.)

62. **P. halli** Shumard. (Fig. 1840.) Mississippic.
Interradial sutures slightly depressed, giving to the cup a somewhat five-sided outline. Arms 7 or 8 in each ray, short and heavy.
Burlington of Missouri and Iowa.

63. **P. discoideus** Owen and Shumard. Mississippic.
Like *P. subspinosus* in general form. Calyx in proportion to arms, much larger and surface of plates deeply corrugated.
Burlington of Missouri, Iowa and New Mexico.

64. **P. subspinosus** Hall. (Fig. 1841.) Mississippic.
Dorsal cup discoid, almost flat to the middle of the R and thence curving upward. Arms spreading almost horizontally outward and recurving over the disk. Plates smooth or only obscurely corrugated.
Burlington of Missouri, Iowa and New Mexico.

65. **P. bonoensis** White. Mississippic.
Dorsal cup wider than high, bowl-shaped and spreading. Plates

FIG. 1842. *Platycrinus hemisphericus*, calyx with arms, with *Igoceras pabulocrinum* attached. (After Keys.)

FIG. 1843. *Platycrinus huntsvillæ*. (After Troost and E. Wood.)

slightly convex centrally, smooth. Arms five or six in each ray, short and stout, and closely packed. Smaller and stouter than *P. huntsvillæ*.
Keokuk and Warsaw of Indiana and Missouri.

66. **P. hemisphericus** Meek and Worthen. (Figs. 1842, 1806, *a*.) Mississippic.

Sutures of calyx depressed but not grooved. Plates covered with rounded nodes.

Keokuk of Indiana and Iowa.

67. **P. huntsvillæ** Troost MS. (Figs. 1843, 1806, *b, c*.) Mississippic.

Sutures of the lower brachials with one another waving or zigzag. Arms frequently inflated in the middle portion. Stem joints bearing conspicuous nodes. Interbasal sutures raised into ridges.

St. Louis of Alabama and Illinois.

68. **P. saræ** Hall. Mississippic.

General shape of calyx much as in *P. huntsvillæ,* but more broadly truncate and slightly concave basally, with a rim projecting over the stem. Arms, six in each ray, tapering. Pinnules very long and close. Plates smooth or obscurely ridged.

St. Louis of Tennessee, Illinois and Missouri; Warsaw of Illinois.

XXVIII. Arthracantha Williams. (*Histricrinus* Hinde.)

B 3, equal, forming a cup hexagonal in outline and supporting 6 plates (5 R and a large anal plate between the two posterior R). R large, excavated above for the two costals and with slightly truncated limbs for the reception of the IR. Plates covered with numerous tubercles each with a small pit for the reception of a movable spine. Arms branching, biserial. Column round. Devonic.

Fig. 1844. *Arthracantha punctobrachiata*, side view. (After Whiteaves.)

69. **A. punctobrachiata** Williams. (Fig. 1844.) Devonic.

Interbrachials 3 to each regular interradius and followed by many rows of small interambulacral pieces which meet on the summit, as there are apparently no orals.

Hamilton of Ontario.

XXIX. Dichocrinus Münster.

Calyx oblong to almost cylindrical. Dorsal cup consisting almost wholly of B, R, and a large anal. Plates delicate. B 2, large, the suture running from the anal plate to the anterior R. R large, subequal, except the anterior which is pentangular. Costals two to a ray, short and narrow. Arms thin, sometimes pendent. Pinnules very long. Anus excentric, at end of a protuberance or tube. Column round. Mississippic.

70. **D. ficus** Lyon and Casseday. Mississippic.

Plates smooth except for a slight median angularity of the R. B forming a deep conical cup. Arms 20, recurving.

Keokuk of Kentucky, Indiana, Missouri and Iowa.

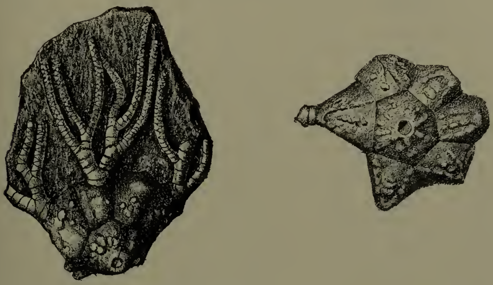


FIG. 1845. *a, Dichocrinus polydactylus,* side view; *b,* basal view of var. (After Meek and Worthen.)

71. **D. polydactylus** Lyon and Casseday. (Fig. 1845, *a, b.*) Mississippic.

R and anal very convex. Plates ornamented with scattered nodes. Arms eight in each ray.

Keokuk of Indiana.

72. **D. striatus** Owen and Shumard. Mississippic.

Calyx subglobose. Plates thickly covered with conspicuous longitudinal ridges forming six rhombs around the calyx.

Burlington of Missouri, Illinois and Iowa.

73. **D. inornatus** Wachsmuth and Springer. (Figs. 1846, 1806, *d.*) Mississippic.

Plates unmarked except with a faint angularity along the center of the R.

Kinderhook of Iowa.

XXX. Talarocrinus Wachsmuth and Springer.

Calyx small, usually higher than wide. Plates thick and unornamented. Differs from *Dichocrinus* in its more massive plates and in having but one costal to a ray; and from *Pterotocrinus* in

Fig. 1846. *Dichocrinus inornatus*, × ⅔. (After Wachsmuth and Springer.)

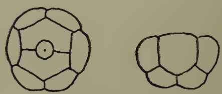


Fig. 1847. *Talarocrinus cornigerus*. (Ill. Survey.)

its small distichals, free from the calyx and in the absence of winglike appendages. Mississippic (probably restricted to Warsaw and St. Louis).

74. **T. cornigerus** (Shumard). (Fig. 1847.) Mississippic.

Ventral disk highly elevated. Plates of radial dome strongly tuberculose. Posterior oral, simple and very large, forming a large ovate tubercle.

St. Louis of Alabama and Kentucky.

75. **T. simplex** (Shumard). Mississippic.

Small (width of calyx not exceeding one third of an inch). Basal cup half the height of the calyx. Structure of arms and ventral disk unknown.

Warsaw of Kentucky, Tennessee, Indiana and Missouri.

XXXI. Pterotocrinus Lyon and Casseday.

Plates heavy and smooth. Dorsal cup wider than high. Ventral disk pyramidal, higher than the cup, and with 5 very large and conspicuous plates arranged radially and passing out between the arms, like wings or horns. B 2, five-sided, followed by 5 R and an anal. Costals one to the ray. Arms 20 and short, in groups of four. Column round. Mississippic (restricted as far as known to Kaskaskia of North America).

76. **P. depressus** Lyon and Casseday. (Fig. 1848.) Mississippic.

Appendages enormous, flat and knife-like. Anus at top of a central slender cone.

Kaskaskia of Kentucky and Illinois.

77. **P. pyramidalis** Lyon and Casseday. Mississippic.

B larger proportionally than in *P. depressus* and slightly oblong at right angles to the suture. R more rapidly spreading. Ventral disk pyramidal, with slightly concave sides, covered with longitudinal grooves for the reception of the arms. Arms unknown.

Kaskaskia of Kentucky and Indiana.

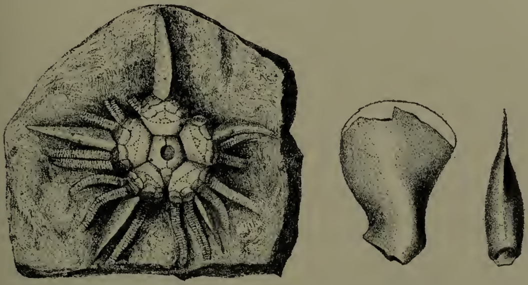


FIG. 1848. *Pterotocrinus depressus*, basal view, showing arms and the interbrachial pieces and side and end view of these appendages. (After Meek and Worthen.)

XXXII. ACROCRINUS Yandell.

Calyx urn-shaped, higher than wide. B 2, equal, forming a nearly flat basin. R separated from B by an indefinite number of supplementary pieces placed in rows and composing the main part of the dorsal cup. R broadly excavated above for the reception of the two small costals and the two distichals. Ventral disk flat, with anal opening near its margin. Arms erect or pendent, with long and closely packed pinnules.

Differs from *Dichocrinus* in the introduction of a belt of supplementary pieces between the B and R. Mississippic.

78. **A. shumardi** Yandell. Mississippic.

Height of calyx more than twice the width. Supplementary plates in 14 to 20 rings. (Type of genus.)

Kaskaskia of Kentucky and Illinois.

XXXIII. Actinocrinus J. S. Miller.

Calyx pear-shaped or ovate. Plates of dorsal cup ornamented with radiating ridges passing from plate to plate and often meeting a node. B three, equal, forming an hexagonal cup. Three of the R six-sided, the posterior pair seven-sided. First costals nearly as high as wide; second costals axillary, supporting both distichals and palmars, and frequently higher orders of brachials. IR very numerous, passing insensibly into the tegmen. Tegmen formed of thick, tubercled, hexagonal plates produced into a tube with anus at the end. Arms biserial and given off in clusters from five protuberant lobes. Pinnules long, slender, and laterally in contact. Column round, long. Mississippic.

79. **A. verrucosus** Hall. (Fig. 1849.) Mississippic.

Plates of dorsal cup tumid and nearly all elevated into a prominent node whence often radiate obscure ridges.

Upper Burlington of Illinois, Iowa and Missouri.

80. **A. tenuisculptus** McChesney. Mississippic.

Small (dorsal cup less than one half inch high). Resembles *A. verrucosus* in proportions of calyx. Plates of cup delicate,

Fig. 1849. *Actinocrinus verrucosus.* (After Hall, Geol. Iowa, I., 2.)

Fig. 1850. *Actinocrinus lowei,* $\times \frac{2}{3}$. (After Hall, Iowa Geol., I., 2.)

slightly tumid, beautifully ornamented with radiating ridges forming a star on each side and two on the anal side.

Lower Burlington of Missouri, Iowa and New Mexico.

81. **A. scitulus** Meek and Worthen. Mississippic.

Below medium size. Somewhat resembling *A. verrucosus* but with less convex ventral disk, forming only one third of the height of the calyx; the arm extensions are shorter, and the interbrachials less numerous.

Upper Burlington of Missouri, Illinois and Iowa.

82. **A. multiradiatus** Shumard. Mississippic.

Size about that of *A. verrucosus* but ventral disk forming only about one fourth of the height of the calyx, and plates of the dorsal cup highly ornamented with strong ridges running in sets of one to four from nodes near the middle of the plates to the margin where they unite with those from adjoining plates.

Upper Burlington of Missouri, Illinois and Iowa.

83. **A. lobatus** Hall. Mississippic.

Very large. Proportions of calyx much as in *A. lowei,* but arm bases more prominent, interradial spaces deeper and pit-like, and onamentation of central nodes and parallel ridges more or less obscure. Arms forty.

Transition between Burlington and Keokuk of Indiana and Illinois; Keokuk of Missouri, Illinois and Iowa.

84. **A. lowei** Hall. (Fig. 1850.) Mississippic.

Large, generally found in crushed condition. Arms eight to a ray.

Keokuk of Missouri, Illinois and Iowa.

85. **A. pernodosus** Hall. Mississippic.

Large, much like *A. lowei,* but with smaller arm extensions, shallower interbrachial depressions, and lower tegmen. Arms six to a ray. Ornamentation somewhat less symmetrical and central nodes more prominent.

Keokuk of Illinois, Missouri and Iowa.

XXXIV. Cactocrinus Wachsmuth and Springer.

Calyx usually longer than wide, with high ventral disk passing into a strong, nearly central tube. Plates ornamented with nodes and radiating ridges. Plates of ventral disk more or less spinose.

Differs from *Actinocrinus* in its more conical, less lobed calyx, with arms in a continuous row around the calyx instead of in clusters. Mississippic (in North America restricted to Kinderhook and Burlington).

86. **C. glans** (Hall). Mississippic.

Somewhat larger than *C. cœlatus* and with length proportionally greater than width. Suture lines very distinct. Plates flat to nodose; surface smooth or nearly so. Arms 20, very long.

Upper Burlington of Missouri and Iowa.

87. **C. limabrachiatus** (Hall). Mississippic.

Size and shape much as in *C. proboscidialis* but arm bases slightly projecting. Arms six to a ray, flattened, their plates corrugated and marked on the upper margin by file-like ridges.

Lower Burlington of Iowa.

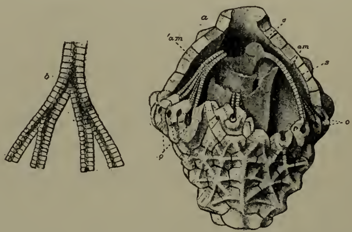


FIG. 1851. *Cactocrinus proboscidialis: a*, calyx with broken vault, × 1½; *am*, ambulacral canals; *c*, digestive sac; *o'*, arm openings; *s*, "convoluted organ"; *b*, ambulacral canal, magnified. (After Meek and Worthen, Ill. Geol., V.)

88. **C. proboscidialis** (Hall). (Fig. 1851.) Mississippic.

Arms crowded, long and heavy, tapering above to a fine point. Anal tube extends beyond the arms.

Characteristic of the Lower Burlington of Missouri, Iowa and New Mexico.

89. **C. reticulatus** (Hall). Mississippic.

In size and outline resembling *C. proboscidialis* but somewhat more slender. Ornamentation of dorsal cup as in that species.

FIG. 1852. *Cactocrinus cœlatus*. (After Hall, Iowa Geol., I., 2.)

FIG. 1853. *Amphoracrinus divergens*, × ⅔. (After Meek and Worthen.)

Ventral disk covered with well-defined spines. Arms four to all rays, except the two posterior and five to these.

Lower Burlington of Missouri and Iowa.

90. **C. cœlatus** (Hall). (Fig. 1852.) Mississippic.

Large. Arms eight to each ray, slender.

Lower Burlington of Missouri and Iowa.

XXXV. Amphoracrinus Austin.

Dorsal cup flat or saucer-shaped. Calyx with five brachial lobes which extend downward proximally, wholly or partly hiding the cup in side view. Ventral disk highly elevated and provided with an excentric, very short anal tube. Whole surface of calyx uniformly granular. Arrangement of plates mainly as in *Actinocrinus*. Mississippic.

91. **A. divergens** (Hall). (Fig. 1853.) Mississippic.

Dorsal cup about one third of the height of the ventral disk and saucer-shaped.

Lower Burlington of Missouri, Iowa and New Mexico.

Fig. 1854. *Amphoracrinus spinobrachiatus*, × ⅔. (After Meek and Worthen.)

Fig. 1855. *Teleiocrinus umbrosus*. (After Hall, Iowa Geol., I., 2.)

92. **A. spinobrachiatus** (Hall). (Fig. 1854.) Mississippic.

Arms simple, spine-bearing.

Lower Burlington of Iowa and New Mexico.

XXXVI. Teleiocrinus Wachsmuth and Springer.

Much like *Cactocrinus*. Calyx obconical to the base of the palmars, then spreading horizontally and forming a broad and continuous rim around the calyx from the outer edge of which the free arms are given off. Ventral disk short, supporting a long and nearly central anal tube. Ornamentation of dorsal cup similar to that of *Actinocrinus* and *Cactocrinus* but coarser, with nodes more conspicuous than the striations and often obscuring them. Arms simple, closely crowded, and rather small. Ventral disk convex, in form of a 10-rayed star, its inner floor strengthened by braces. Column covered by rows of angular processes.

Mississippic (Burlington of Mississippi Valley).

93. **T. liratus** (Hall). Mississippic.

Larger than *T. umbrosus,* with more elongate calyx and higher tegmen. Plates slightly convex, covered with radiating ridges which, in parallel sets of three or four, unite at the middle of the plates in nodes.

Upper Burlington of Missouri, Illinois and Iowa.

94. **T. umbrosus** (Hall). (Fig. 1855.) Mississippic.

Plates varying from nearly smooth to extremely nodose, but usually nodose in the middle and ridged at the margins. Column small, covered with small overhanging processes. (Type of genus.)

Upper Burlington of Missouri, Illinois and Iowa.

XXXVII. Steganocrinus Meek and Worthen.

Like *Actinocrinus* in general structure but rays produced not into mere lobes but into arm-like tubular extensions which rise to the full height of the calyx, giving off armlets alternately from opposite sides. There are either one or two of these brachial extensions to the ray, depending whether they originate from the costals or from the distichals. Arms given off at the sides of these trunks and much smaller. Specimens are usually found with these trunks broken off. Mississippic.

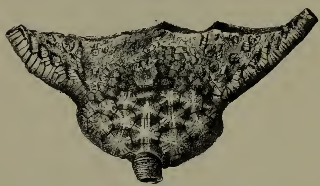


Fig. 1856. *Steganocrinus sculptus*, showing arms, × ⅔. (After Meek and Worthen.)

95. **S. araneolus** Meek and Worthen. Mississippic.

Resembling *S. pentagonus* but only half or one fourth its size, more depressed, with more convex and strongly ridged plates.

Lower Burlington of Missouri, Illinois, Iowa and New Mexico.

96. **S. sculptus** (Hall). (Fig. 1856.) Mississippic.

Brachial trunks only five instead of the usual ten.

Lower Burlington of Missouri, Iowa and New Mexico.

97. **S. concinnus** (Shumard). Mississippic.

Usually larger than *S. sculptus,* 5-angled, with almost flat ventral disk. Surface mostly smooth, with low ridges only at margins of plates. Rays five, each with two trunks.

Upper Burlington of Missouri, Illinois and Iowa.

98. **S. pentagonus** (Hall). Mississippic.

Of medium size (smaller than *S. sculptus*), and distinctly pentangular from upper and lower views. Dorsal cup nearly twice the height of the tegmen. Calyx extensions 5, each bifurcating from the second costals into two free trunks bearing the arms from the sides. Plates but little convex, marked by radiating ridges which form nodes in the center of the plates. Anal tube strongly nodose.

Lower Burlington of Missouri, Iowa and New Mexico.

XXXVIII. Physetocrinus Meek and Worthen.

Arrangement of plates up to the distichals as in *Actinocrinus,* but anus opening through the tegmen and not at the end of a tube. Arm bases projecting in a rim. Rays in two main divisions which give off the arms. Orders of brachials from the costals up consisting of a single plate which supports an arm at one side and a higher brachial at the other. Ventral disk depressed at top and plicated around the margin, its depressions alternating with the brachial lobes. Mississippic.

99. **P. ornatus** (Hall). Mississippic.

Of medium size (calyx usually not much exceeding one inch in width). Ventral disk nearly flat.

Lower Burlington of Missouri and Iowa.

100. **P. ventricosus** (Hall). Mississippic.

Large (calyx often one and one half inches or more wide). Ventral disk hemispherical. (Type of genus.)

Burlington of Missouri and Iowa.

XXXIX. Strotocrinus Meek and Worthen.

Large. Structure of calyx in general as in *Actinocrinus*, but upper part of dorsal cup produced in an immense horizontal rim incorporating the lower parts of the arms and the lower pinnules. Rays of rim 10, each sometimes with 15 arms which are given off alternately from opposite sides, each brachial supporting an arm and a higher brachial. Arms thin and short. Tegmen

Fig. 1857. *Strotocrinus regalis*, ventral (vault) and lateral views of a specimen, × ⅔. (After Meek and Worthen.)

flat, composed of innumerable minute pieces. Anus excentric, opening through the tegmen. Mississippic.

101. **S. regalis** (Hall). (Fig. 1857.) Mississippic.

Plates of dorsal cup convex, covered with strong angular ridges which rarely meet but usually leave a small smooth area in the center of the plates. (Type of genus.)

Upper Burlington of Missouri, Illinois and Iowa.

XL. Eretmocrinus Lyon and Casseday.

Resembles *Batocrinus* but the B project outward in a broad rim, the arms are nearly twice as long, their upper portions much wider, paddle-shaped, and folded inward; the ventral disk is asymmetrical, bulging anteriorly and flattened posteriorly, and the anal tube is shorter, excentric, and often bent abruptly to one side.

Burlington and Keokuk of America.

102. **E. coronatus** (Hall). Mississippic.

Distinguished by the coronate aspect of the tegmen, due to the upward and outward extension of the spines around the periphery.

Lower Burlington of Missouri and Iowa.

103. **E. leucosia** (Hall). Mississippic.

Calyx broadly spindle-shaped. Sides of dorsal cup straight or only slightly concave. Plates moderately convex, unornamented.

Lower Burlington of Missouri and Iowa.

104. **E. magnificus** Lyon and Casseday. Mississippic.

Calyx spindle-shaped, with dorsal cup often shorter than the high, conical tegmen, and with concave sides. R and brachials convex to keel-shaped; interbrachials flat.

Keokuk of Kentucky, Tennessee and Indiana.

XLI. Dorycrinus Roemer.

Calyx broadly turbinate or subglobose, truncate at base, and deeply sinuate in all the interradial areas, but chiefly so in the posterior one. B 3, large, produced below into a conspicuous rim. R usually as large as the two costals together. Distichals two, or one when followed by a row of palmars. Plates of the dorsal cup smooth or corrugated, frequently nodose, but not striated, and all more or less convex. Arms in pairs, two to four pairs to

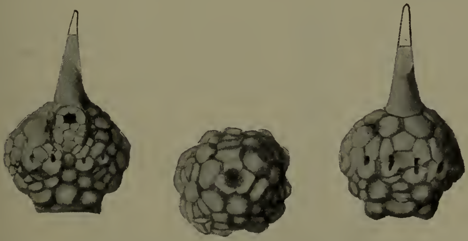


Fig. 1858. *Dorycrinus unicornis*, three views of the same individual. (After Hall, Iowa Geol., I., 2.)

a ray, short and spinose. Tegmen strongly convex, composed of moderately heavy plates. Orals five, large, the posterior one frequently extended into a long spine and occupying a central position. Surrounding the orals and overlying the ambulacra are five other spinose or nodose plates which are separated by interradial pieces. Anus lateral and not extended in a tube. Mississippic.

105. **D. unicornis** Owen and Shumard. (Fig. 1858.) Mississippic.
Calyx spheroidal. Tegmen nearly as high as dorsal cup and with one long central spine. Plates of dorsal cup very convex or nodose.

Lower Burlington of Missouri, Iowa and New Mexico.

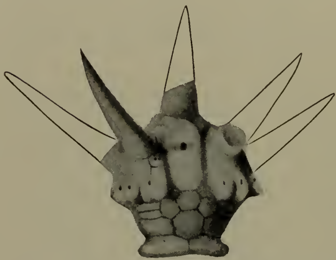


FIG. 1859. *Dorycrinus cornigerus*. (After Hall, Iowa Survey.)

106. **D. cornigerus** (Hall) (Fig. 1859.) Mississippic.
Calyx wider than high. Plates of dorsal cup smooth and almost flat with but slightly grooved suture lines. Tegmen hemispherical, with six long, slender spines.

Burlington of Iowa and Missouri.

107. **D. gouldi** (Hall). (Fig. 1860.) Mississippic.
Height and width of calyx about equal. Plates formed into

FIG. 1860. *Dorycrinus gouldi*, × ⅔. (After Hall, Iowa Geol., I., 2.)

high nodes. Tegmen as high as dorsal cup, pentagonal in outline. Spines six.

Keokuk of Kentucky, Indiana, Illinois, Missouri and Iowa.

108. **D. mississippiensis** Roemer. Mississippic.

Resembling *D. gouldi* in size and outline with pentagonal summit and six spines which are somewhat shorter and more tapering. Calyx deeply impressed and flattened posteriorly. Plates nearly flat to strongly nodose.

Keokuk of Kentucky, Tennessee, Missouri, Illinois and Iowa.

XLII. Agaricocrinus (Troost).

Calyx depressed globose. Dorsal cup greatly depressed, usually with only the arm facets and portions of the interbrachials visible in side view. B 3, small, arranged in a horizontal hexagon. R small, supporting two primary brachials (costals), which are followed by short distichals and, in rays with more than two arms, by still shorter palmars. Interradials of the dorsal cup rarely more than four, those of the tegmen numerous, especially at the anal side. Arms two to four to the ray, long and ponderous, their bases separated by narrow and long interbrachials. Tegmen high, pyramidal the upper end occupied by a massive, button-shaped central piece which is surrounded by four similar, but slightly smaller plates, these constituting the orals. Anus in a posterior, more or less protuberant area. Column long, composed of larger and smaller pieces. Mississippic.

A. Large (greatest width usually over 1 inch)........................I.
 I. Dorsal cup scarcely visible in side view, *i. e.*, calyx resting nearly or quite on the arm bases........................1.
  1. Calyx width nearly twice the height........................116. *A. crassus.*
  1. Width of calyx only slightly exceeding height........................a.
   a. Arms 16........................117. *A. nodulosus.*
   a. Arms 12 (rarely 14)........................11.
    11. Plates of dorsal cup convex........................114. *A. tuberosus.*
    11. Plates of dorsal cup only slightly convex........................113. *A. americanus.*
 I. Dorsal cup high though lower than tegmen........................115. *A. coreyi.*
B. Of medium size or small (greatest width usually one inch or less)........................II.
 II. Dorsal cup high, about the height of the tegmen........................109. *A. brevis.*
 II. Dorsal cup low, scarcely visible in side view........................2.
  2. Plates of ventral disk nearly all flat........................b.
   b. Anal ridge present........................118. *A. splendens.*
   b. Anal ridge absent........................110. *A. planoconvexus.*

2. Plates of ventral disk mostly convex or tumid..c.
   3. Calyx pyramidal..................................... ....111. *A. pyramidatus.*
   3. Calyx depressed pyramidal.................................... .....112. *A. bullatus.*

109. **A. brevis** (Hall). Mississippic.

Small and delicate. Dorsal cup and tegmen of same height. All plates below the arms nodose and with short ridges at the sides where they meet ridges from adjoining plates.

Lower Burlington of Missouri, Illinois and Iowa.

110. **A. planoconvexus** (Hall). Mississippic.

Agreeing with *A. bullatus* in size and in the low convexity of the tegmen, but all plates of the tegmen and dorsal cup except the posterior oral flat.

Lower Burlington of Missouri and Iowa.

111. **A. pyramidatus** (Hall). Mississippic.

Small, pyramidal. Arm facets almost confluent. Arms 10.

Lower Burlington of Missouri and Iowa.

112. **A. bullatus** Hall. (Fig. 1861.) Mississippic.

First interbrachials very large, sometimes twice the size of the

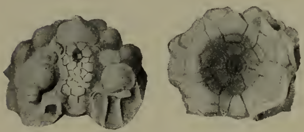


FIG. 1861. *Agaricocrinus bullatus*, basal and anal view. (After Hall.)

FIG. 1862. *Agaricocrinus tuberosus*, anal side. (After Hall, Iowa Geol., I., 2.)

R, followed by two long and very narrow pieces which reach to the level of the arm openings. Anal area wide and flat. Column small.

Upper Burlington of Missouri, Illinois and Iowa.

113. **A. americanus** Roemer. Mississippic.

Like *A. tuberosus* in general outline, but calyx less concave below, first interbrachial longer, rising to the top of the dorsal cup, plates of dorsal cup less convex and anal area more tumid, protruding abruptly. (Type of genus.)

Keokuk of Kentucky, Tennessee and Missouri.

114. **A. tuberosus** Hall. (Figs. 1862, 1863.) Mississippic.

First IB short and scarcely visible in side view.

Keokuk of Tennessee, Illinois and Iowa.

115. **A. coreyi** Lyon and Casseday. Mississippic.

Dorsal cup high for the genus, but somewhat lower than the ventral disk. Plates elevated, smooth. Anus at end of an elongate area.

FIG. 1863. *Agaricocrinus tuberosus*, opposite views. (After Hall, Iowa Geol., I., 2.)

Keokuk of Kentucky and Indiana.

116. **A. crassus** Wetherby. Mississippic.

Larger than *A. tuberosus,* distinctly pentalobate, depressed convex with but slightly concave base and with rays of two arms each except the two posterior which have three or four.

Keokuk of Kentucky, Tennessee, Indiana and Iowa.

117. **A. nodulosus** Worthen. Mississippic.

Distinguished by the greater number of arms, four each to two of the rays, three each to two rays, and two to the anterior ray.

Keokuk of Tennessee, Indiana, Illinois and Iowa.

118. **A. splendens** S. A. Miller. Mississippic.

Smallest of the Keokuk species. Calyx distinctly five-lobed, owing to the prominent arm facets. First IB elongate, rising to the middle of the second costals. Plates of dorsal cup flat. Orals all separated from one another by supplementary pieces. Posterior oral highly convex and about as large as the other four together; from it a ridge extends to the bottom of the calyx and is inflated around the anal opening. Arms 12.

Keokuk of Indiana.

XLIII. Periechocrinus Austin.

Calyx large, elongate, bell or urn-shaped. Plates thin, smooth or delicately sculptured, the R marked generally with a ridge which passes from plate to plate and increases in prominence upward till it becomes identified with the free arms. B 3, equal, forming a deep cup. R and costals long and narrow and constricted above and below. Costals 2, six- or seven-angled, followed by two to four rows of distichals and usually two to six palmars. Arms branching, long and slender. Ventral disk moderately convex or almost flat, composed of small and irregularly arranged plates. Anus nearly central. Column large and cylindrical. (Fig. 1864.) Siluric–Mississippic.

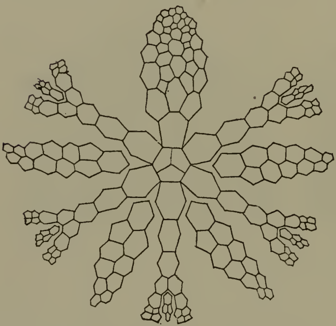


Fig. 1864. *Periechocrinus.* (After Weller.)

119. **P. christyi** (Hall). (*P. whitfieldi* Hall.) Siluric.

Resembles *P. tennesseensis* in outline, but larger, and surface marked with excentric lines of fine granules, parallel to the margins of the plates.

Niagaran of Indiana.

120. **P. chicagoensis** Weller. Siluric.

Calyx small, constricted below and deeply depressed between the arm bases, which stand out conspicuously. Arms 10 (two from each ray).

Niagaran of Illinois.

121. **P. marcouanus** (Winchell and Marcy). Siluric.

Very large and elongate (sometimes three inches long by nearly one and one half inches wide across the arm bases). General outline and surface of plates as in *P. tennesseensis,* but calyx con-

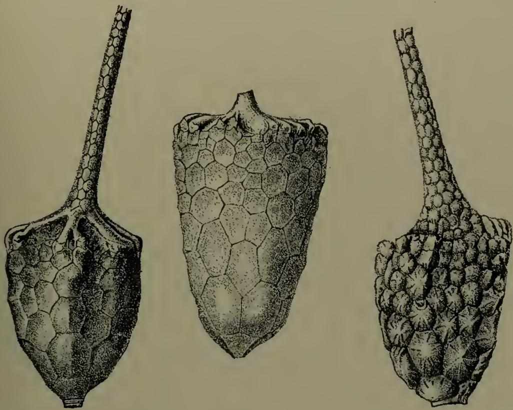


FIG. 1865. *Periechocrinus tennesseensis* (center); *P. ornatus* (sides). Pal. Ohio.

stricted below the arm bases. Arms four to the ray, in pairs. Anus subcentral on a protuberance which terminates an anal ridge. Tegmen almost flat.

Niagaran of Illinois.

122. **P. (Saccocrinus) ornatus** (Hall). (Fig. 1865.) Siluric.

Distinguished by the large anal tube.

Niagaran of Ohio and Indiana.

123. **P. (Saccocrinus) tennesseensis** (Hall). (Fig. 1865.) Siluric.

Primary arms 20. Arm bases conspicuously projecting, with deep depressions between the rays and their main divisions which are deepest on the anal side. Longitudinal elevation of radial series faint.

Niagaran of Tennessee and Ohio.

FIG. 1866. *Periechocrinus whitei,* a small specimen. (After Meek and Worthen.)

124. **P. whitei** (Hall). (Fig. 1866.) Mississippic.

Plates unornamented except for a faint radial ridge.

Kinderhook and Burlington of Iowa.

XLIV. Megistocrinus Owen and Shumard.

Usually large. Calyx wider than high, flattened and sometimes excavated at bottom; plates heavy. B 3, closely anchylosed, forming a thick, hexagonal plate. R usually spread horizontally, wider than long and hexagonal. Costals similar to R in form and size. Number of brachials incorporated with the calyx variable. Arms biserial throughout and branching. Pinnules small and rarely preserved. Tegmen low hemispherical. Anus excentric, sometimes marginal. Column large and long, with five-lobed central canal. Devonic–Mississippic.

125. **M. abnormis** (Lyon). Devonic.

Dorsal cup saucer-shaped, expanding from the bottom to the arm bases which extend out in five large lobes with deep notches between. Plates smooth. Anus a little above the arm bases opening through a flat area.

Onondagan of Kentucky and Indiana.

126. **M. depressus** (Hall). Devonic.

Calyx wider than high; dorsal cup basin-shaped, flattened at bottom and on the sides, but expanding into a short rim for the arm bases. Plates flat, thickened at the margins and covered in well preserved specimens by numerous very fine striæ and at times with small pustules.

Hamilton of New York and Kentucky.

127. **M. spinulosus** Lyon. Devonic.

Distinguished by rays of eight primary arms each, arranged in an uninterrupted line around the calyx.

Hamilton of Kentucky and Ohio.

Fig. 1867. *Megistocrinus evansi*, anal view of calyx. (After Meek and Worthen.)

128. **M. evansi** Owen and Shumard. (Fig. 1867.) Mississippic.

Sometimes very large (varying from one fifth of an inch to two and one half inches long). Basi-radial sutures broad and deeply channelled. Anus at end of a protuberance near or within the arm regions. Arm openings in pairs (five pairs in younger forms and ten in older). (Type of genus.)

Burlington of Missouri, Illinois and Iowa.

129. **M. nobilis** Wachsmuth and Springer. (Fig. 1868.)

Mississippic.

Calyx subglobose, with height and width nearly equal. Basi-radial sutures somewhat grooved. Arms in ten pairs.

Kinderhook of Iowa.

XLV. GENNÆOCRINUS Wachsmuth and Springer.

Calyx deeply indented at the arm region. Plates thin, ornamented with radiating striæ. B 3, small. R and costals similar.

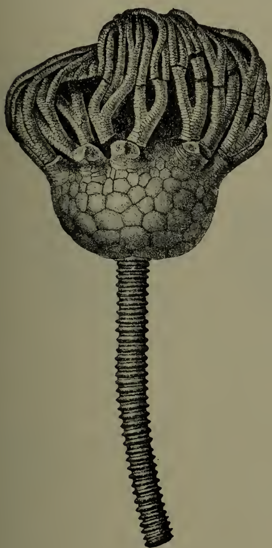


FIG. 1868. *Megistocrinus nobilis*, × ⅔. (After Wachsmuth and Springer.)

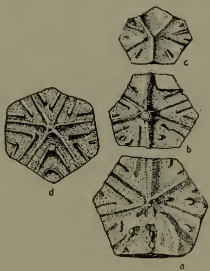


FIG. 1869. *Gennæocrinus kentuckiensis*, dissociated plates; *a*, radial; *b*, costal 1; *c*, costal 2; *d*, interradial. (After Grabau.)

Costals six- and seven-sided. Above the distichals the branching is from alternate sides, arms branching off from one side and brachials of a higher order from the other. Arms eight. Tegmen of small plates, rising but little above the dorsal cup and marked with grooves and ridges. Anus excentric; no anal tube present. Devonic.

130. **G. kentuckiensis** (Shumard). (*G. nyssa* Hall.) (Fig. 1869.) Devonic.

Differs from *G. carinatus* in the greater number of distichals, two to each of the ten costals instead of one to each; differs also in the unequal size of the R and second costals, the latter being half the size of the former.

Hamilton of Kentucky.

131. **G. eucharis** (Hall). Devonic.

Differs from *G. carinatus* in the relative size of R and second costals, the latter less than half the size of the former.

Hamilton of New York.

132. **G. carinatus** E. Wood. (Fig. 1870.) Devonic.

Distinguished by its delicate ornamentation of thin carinæ. R and first and second costals of about equal size.

Hamilton of Indiana.

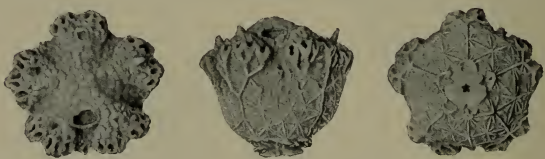


FIG. 1870. *Gennæocrinus carinatus*, three views of the type, × ½. (After E. Wood.)

XLVI. Batocrinus Casseday.

Similar in form to *Actinocrinus*, but rays not lobed and calyx plates without sculpturing. R very large, six- or seven-sided. First costals quadrangular, always shorter than the R and transversely arranged. Arm openings equidistant and directed horizontally. Tegmen elevated, its plates heavy, more or less swollen and of nearly equal size except the posterior oral which is larger and from which rises the anal tube. Anal tube nearly central, very long and gradually tapering. Arms 20–26, simple, biserial and very short. Respiratory pores 20. Column stout, round.

Differs from *Eretmocrinus* in having stout and cylindrical arms instead of paddle-shaped ones and in the greater length of the anal tube; from *Eutrochocrinus* and *Dizygocrinus* in the simple arms. Mississippic.

133. **B. clypeatus** (Hall). Mississippic.

Calyx wider than long. Dorsal cup higher than ventral disk and with concave sides. Plates of calyx flat or moderately convex. Arms 20.

Burlington of Missouri and Iowa.

134. **B. laura** (Hall). Mississippic.

Calyx usually higher than wide. Sides of dorsal cup straight or slightly concave. All plates of calyx flat and smooth.

Upper Burlington of Missouri, Illinois and Iowa.

135. **B. subæqualis** (McChesney). Mississippic.

Height and width of calyx equal (about one inch). Dorsal cup larger than ventral disk, with straight and gradually expanding sides. Plates of calyx nodose or tumid. Arms 22.

Burlington of Missouri, Illinois and Iowa.

136. **B. irregularis** Casseday. Mississippic.

Small (height about three fourths of an inch), with length slightly exceeding width. Dorsal cup deep but not quite the height of the tegmen. Plates of tegmen somewhat nodose. Arms 18.

Warsaw of Kentucky and Indiana.

137. **B. icosadactylus** Casseday. Mississippic.

Width of calyx nearly equal to height (one inch or more). Dorsal cup only about half as high as ventral disk, low saucer-shaped, with a protuberant base. Plates of dorsal cup smooth or nearly so; most of those of ventral disk either thorn-like or spine-bearing. Arms 20. (Type of genus.)

Warsaw of Kentucky and Indiana.

XLVII. Alloprosalocrinus Lyon and Casseday.

Calyx conical, almost flat below the arm bases, which are in contact laterally except on the anal side, where they are separated by the second anal. Ventral disk conical, passing gradually above into the anal tube which is stout and almost central.

Especially remarkable for the shortness of the dorsal cup contrasted with the great height of the ventral disk; in this it resembles *Agaricocrinus,* but differs in the presence of an anal tube. Mississippic.

138. **A. conicus** Lyon and Casseday. Mississippic.
Dorsal cup so flat as to be almost invisible from side view.
Keokuk of Kentucky, Tennessee and Indiana.

XLVIII. EUTROCHOCRINUS Wachsmuth and Springer.

Calyx wheel-shaped. Dorsal cup narrow to the top of the radials, thence spreading abruptly at right angles to the axis of the calyx. Tegmen almost flat to near the base of the anal tube. B 3, equal. R larger than both costals together. Arm openings equidistant. Arms single or in pairs, biserial, very short and incurving. Anal tube stout, central and long. Column round. Mississippic.

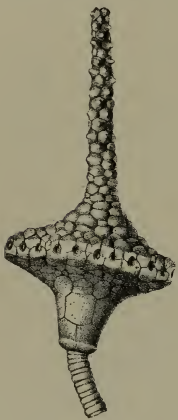


FIG. 1871. *Eutrochocrinus christyi*, × ⅔. (After Meek and Worthen, Ill. Geol., V.)

139. **E. christyi** (Shumard). (Fig. 1871.) Mississippic.
Plates of dorsal cup flat, of tegmen convex. (Type of genus.)
Characteristic of Upper Burlington of Missouri, Illinois and Iowa.

XLIX. DIZYGOCRINUS Wachsmuth and Springer.

Ventral disk usually as high as dorsal cup, sometimes much higher. Plates smooth, granular, or obscurely striated. B very short, forming a slightly projecting circular rim or shallow basin. R shorter than in *Batocrinus*. Upper brachials usually in a continuous ring around the calyx. Arms long and biserial, single or in pairs. Anal tube short, slender, almost central.

Differs from other known genera except *Eutrochocrinus* and *Dorycrinus* in the tendency of the arms to multiplication. Mississippic.

140. **D. rotundus** (Yandell and Shumard). Mississippic.
Calyx ovate to depressed, globose (about one inch wide). Plates flat, with perfectly smooth surface and indistinct sutures. Arms 18 to 22, usually 20.

The most common species of the Upper Burlington of Missouri, Illinois, Iowa, etc.

141. **D. whitei** Wachsmuth and Springer. Mississippic.

Small (width less than three fourths of an inch), depressed-globose, with slightly projecting arm regions. Surface of dorsal cup ornamented with ridges and nodes, those of the tegmen each with a sharp central tubercle. Arms 18, single.

Keokuk of Indiana and Iowa; Warsaw of Kentucky, Indiana and Missouri.

142. **D. biturbinatus** (Hall). Mississippic.

Resembles *D. euconus,* but calyx smaller and more globose, with height and width about equal. Arms 16, rarely 17.

Keokuk of Missouri and Iowa.

143. **D. montgomeryensis** (Worthen). Mississippic.

Of medium size (about three fourths of an inch wide). Dorsal cup somewhat lower than the tegmen, with rounded sides. Arm bases projecting tooth-like around the calyx. Arms 16, in pairs. Plates of dorsal cup flat and smooth; plates of tegmen marked with a small central tubercle.

Keokuk of Indiana, Missouri and Iowa.

144. **D. originarius** Wachsmuth and Springer. Mississippic.

Small (about one half an inch wide). Dorsal cup slightly higher than the tegmen, with straight sides. Arm bases projecting. Plates convex, those of dorsal cup obscurely granular. Arms 16, simple.

Keokuk of Indiana and Missouri; Warsaw of Missouri and Illinois.

145. **D. euconus** (Meek and Worthen). (Fig. 1872.) Mississippic.

Plates smooth. Arms 16.

Keokuk of Indiana and Missouri; Warsaw of Kentucky, Indiana and Illinois.

146. **D. unionensis** (Worthen). Mississippic.

Small (calyx three fourths of an inch wide). Dorsal cup somewhat shorter than ventral disk, which is very convex. Plates of dorsal cup slightly convex, obscurely granular and ridged; those of tegmen nodose. Arms 18, simple.

Keokuk of Missouri; Warsaw of Virginia, Alabama, Kentucky and Missouri.

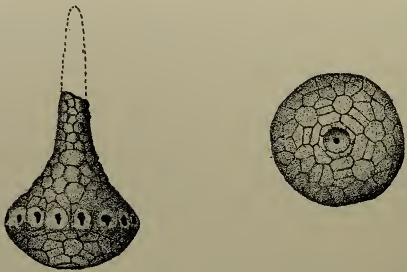


FIG. 1872. *Dizygocrinus euconus;* side and basal view. (After Worthen.)

L. LOBOCRINUS Wachsmuth and Springer.

Calyx pear-shaped to wheel-shaped. Rays more or less distinctly lobed, and arms in groups. B 3, large, forming a cylindrical cup thickened below. R larger than both costals together. Arm openings directed upward. Arms short, cylindrical, biserial. Tegmen large and high. Anal tube central, stout, and very long.

Differs from *Batocrinus* in the apparent absence of respiratory pores (large in that genus) and in that the interbrachials are continuous with the interambulacral plates, not separated from them as in *Batocrinus* by the palmars. Mississippic.

147. **L. pyriformis** (Shumard). (Fig. 1873.) Mississippic.

Plates of dorsal cup smooth, those of tegmen convex or nodose. Arms four to the ray.

Characteristic of the Upper Burlington of Missouri, Illinois and Iowa.

148. **L. æquibrachiatus** (McChesney). Mississippic.

Differs from *L. pyriformis* in its less elongate calyx, depressed tegmen, longer arms, and shorter and more slender anal tube. and in being prominently lobed between the rays.

Upper Burlington of Illinois and Iowa.

149. **L. nashvillæ** (Troost). (Fig. 1874.) Mississippic.

Much larger than *L. pyriformis.* Sides of dorsal cup less concave and plates convex. Plates of tegmen more or less highly convex. Anal tube composed of large tumid plates and one and one half inches from its base surrounded by a ring of five plates bearing long (one inch or less), horizontal spines. (Type of genus.)

Keokuk of Kentucky, Tennessee, Illinois, Missouri and Iowa.

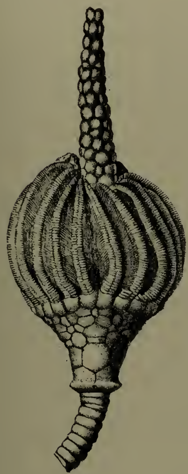


FIG. 1873. *Lobocrinus pyriformis*, × ⅔. (After Meek and Worthen, Ill. Geol., V.)

FIG. 1874. *Lobocrinus nashvillæ*, × ⅔. (After Worthen.)

LI. MACROCRINUS Wachsmuth and Springer.

Calyx biturbinate or subovoid. B large, forming a cylindrical cup. R frequently larger than both costals together. Arm bases in contact laterally, except posteriorly where they are separated by a small interbrachial plate. Arm openings directed outward. Arms 12 to 16, long, with incurving tips. Tegmen shorter than dorsal cup. Anal tube exceedingly long, almost central.

Differs from *Batocrinus* in the more elongate calyx, fewer and longer arms, and in having but five pairs of respiratory pores; from *Eretmocrinus* in its straight and nearly central anal tube and in arm structure. Mississippic.

150. **M. verneuilianus** (Shumard). (Fig. 1875.) Mississippic.

Calyx smooth, sides scarcely concave. Arms usually 14.

Very characteristic of the Upper Burlington of Illinois, Missouri and Iowa.

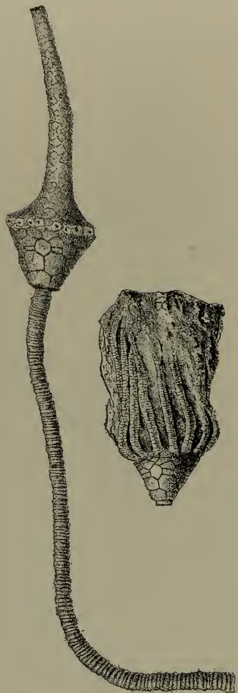


Fig. 1875. *Macrocrinus verneuilianus*, two specimens, one with arms, the other with proboscis and stem. (After Meek and Worthen.)

LII. Aorocrinus Wachsmuth and Springer.

Small. Similar to *Dorycrinus* in form of calyx, arrangement of plates and of arms, *i. e.*, arms in groups, the anterior ray usually having the fewest. Tegmen usually shorter than dorsal cup, with smooth, nearly flat plates except the posterior oral which is convex or tubercle-like. Anal area composed of small plates forming a low ridge with anus near upper end.

Differs from *Dorycrinus* in having single arms and no spines. Devonic–Mississippic.

151. **A. parvus** (Shumard). Mississippic.

Calyx rotund, abruptly projecting out at the arm bases and lobed.

Upper Burlington of Missouri, Illinois and Iowa.

LIII. Reteocrinus Billings.

Calyx obconical. IB 5, sometimes barely protruding beyond the column. B 5, large and protuberant. R and fixed brachials forming broad, highly elevated ridges which pass insensibly into the arms. Between these ridges are profoundly depressed interradial areas, composed of minute irregular pieces. Arms 10 at their origin but usually bifurcating. Tegmen depressed-convex, consisting of very small pieces forming a continuation from the interbrachials. Anal opening excentric, at top of a small protuberance. Column large, pentagonal. Ordovicic.

152. **R. stellaris** Billings. Ordovicic.

Arms extremely short and tapering rapidly. Interbrachial depressions paved by numerous irregular pieces with a slightly stellate surface. (Type of genus.)

Trenton of Ottawa.

LIV. Thysanocrinus Hall.

Calyx subglobose or urn-shaped. IB 5 and small, often hidden by the column. B 5, four of them equal and angular above, the fifth truncated and supporting a large anal plate. The rays marked by a ridge; surface of plates otherwise smooth or ornamented. Costals two. Arms 10 or 20, biserial. Pinnules long. Column round or obtusely 5-angled (Fig. 1876).

Siluric of America, England and Sweden.

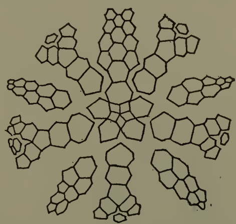


Fig. 1876. *Thysanocrinus*. (After Weller.)

153. **T. inornatus** (Hall). Siluric.

Calyx urn-shaped. Cross section at top of costals pentagonal and across distichals decagonal. B each with a node and hence forming a 5-lobed rim around the column. Ill-defined radiating ridges follow the median line of the rays and also branch laterally. Interbrachial spaces deeply depressed so as to give the calyx at the arm bases a prominently lobed aspect. Anus at end of a conspicuous ridge of anal plates. Tegmen depressed.

Niagaran of Indiana and Wisconsin.

154. **T. occidentalis** Hall. Siluric.

Larger than *T. inornatus* and with no anal ridge. Ornamentation consisting of ridges forming a pentagon around the column from whose angles pass other ridges spreading over the B and R and continued up the brachials of the calyx.

Niagaran of Indiana.

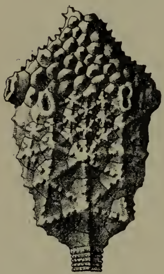
155. **T. pentangularis** (Hall). Siluric.

Calyx inverted bell-shaped, with five-lobed rim around the base, each node of the basals giving rise to two ridges which extend up to the central nodes of the R, from which proceed ridges up the brachials. Differs from *T. inornatus* in the more depressed interbrachial areas and perfectly flat tegmen.

Niagaran of Illinois and Wisconsin.

LV. Lampterocrinus Roemer.

Calyx unsymmetrical, elongate. IB anchylosed into a spreading cup. B 5, large, four equal and angular, the posterior higher and truncated. R very large. Costals two, the second supporting an arm and the distichals. Brachials from distichals up forming



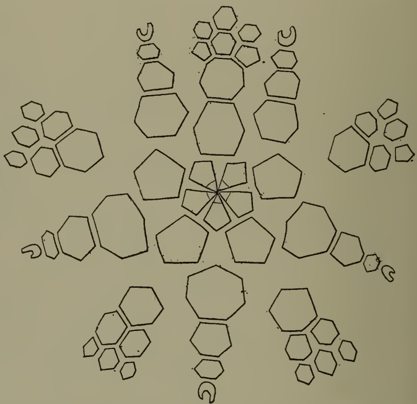


Fig. 1877. *Lampterocrinus tennesseensis.* Calyx slighty reduced and analysis. (After Roemer.)

with the covering pieces a rigid tube from which small arms branch at intervals. Interbrachials large, passing uninterruptedly from the dorsal cup into the tegmen. Tegmen asymmetrical, strongly bulging posteriorly and supporting a large, central anal tube. Column pentangular.

Differs from *Siphonocrinus* in the arm structure. Siluric.

156. **L. tennesseensis** Roemer. (Fig. 1877.) Siluric.

Plates convex, ornamented with radiating ridges dividing the surface into deeply impressed areas.

Niagaran of Tennessee.

LVI. HERCOCRINUS Hudson.

Base of calyx with narrow concavity. IB very small and nearly covered by the stem joints. R nearly equal in size to B (exposed part). Costals two; the next few succeeding brachials each giving off a large pinnule which is incorporated into the dorsal cup, those of adjoining rays being in conjunction, or meeting to form web-like extensions of the arm bases. Arms 10, biserial. IR of variable plates, not forming part of the ventral disk. Tegmen of numerous small plates. Anus nearly central, elevated (Fig. 1878). Ordovicic.

FIG. 1878. *Hercocrinus*, analysis of calyx. (After Hudson.)

157. **H. elegans** Hudson. Ordovicic.

Small (one half inch wide), pyriform. Base flattened, rather pentangular. R prominently triangular at contact with base. IR convex, numerous, polished and jewel-like; three or more IR separate the R. B with a smooth transverse ridge.

Chazy of Lake Champlain.

158. **H. ornatus** Hudson. Ordovicic.

More nearly globular than *H. elegans*. B with rough transverse ridge, forming a circular border to the base. R and brachials similarly roughened by ridges. R separated by two IR.

Chazy of Lake Champlain region.

LVII. RHODOCRINUS Miller.

Calyx small, globose. Dorsal cup flat or concave below, constricted above. IB 5, small. B 5, large, truncated above. R smaller than B. Costals two, often coalesced into a single plate. Distichals free in part. Arms in pairs and bifurcating. Tegmen narrow, but slightly elevated above the dorsal cup. Anus excentric, sometimes marginal. Column round. Devonic–Mississippic.

159. **R. whitei** Hall. Mississippic.

The largest known American species (three fourths of an inch broad). Calyx wider than high, deeply concave below. Plates of dorsal cup strongly convex, smooth. Anus subcentral, at the end of a short tube.

Lower Burlington of Missouri and Iowa.

LVIII. Archæocrinus Wachsmuth and Springer.

Closely similar to *Rhodocrinus,* but with relatively larger calyx, shorter arms, and but two interbrachials in the second row while *Rhodocrinus* has three. Ordovicic.

160. **A. pyriformis** (Billings). Ordovicic

Large (about one and one half inches wide), obconical, contracted above. Surface smooth or finely granulose. Distichals to height of the sixth plate incorporated in the calyx.

Trenton of Montreal.

LIX. Lyriocrinus Hall.

Calyx depressed-globose, flattened to the middle of the R. IB 5, very small, concealed by the column. B 5; R separated all around by the large IR. Costals two, large. Two of the distichals enclosed in the calyx. Tegmen flat, not rising above the dorsal cup and arm openings directed upward. Arms two to the ray, rising in a straight line with the sides of the calyx, simple, biserial. Anus subcentral. Column round (Fig. 1879). Siluric.

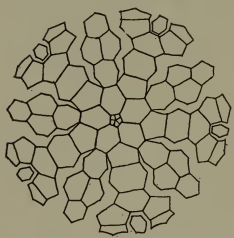


Fig. 1879. *Lyriocrinus,* analysis of calyx. (After Weller.)

161. **L. dactylus** Hall. (Fig. 1880.) Siluric.

Center of base abruptly depressed for the reception of the column. Plates finely ornamented with granules which become elongate near the margins of the plates. (Type of genus.)

Niagaran of New York.

162. **L. melissa** (Hall). Siluric.

Usually larger than *L. dactylus,* with heavier arms. Basal pit surrounded by a 5-angled rim. Anus subcentral, very wide.

Niagaran of Indiana.

LX. Gilbertsocrinus Phillips.

(*Ollacrinus* Cumberland, *Goniasteroidocrinus,* Lyon and Casseday.)

Calyx composed of delicate plates. Dorsal cup greatly exceeding the tegmen, elongate, cylindrical. IB 5, frequently hidden by the column. B and IR large, the latter rapidly decreasing in size upward. From the last axillary spring two tufts of small, branching, pinnule-bearing arms; these are either folded over the tegmen or they bend downward with the ventral side exposed to view, the pinnules being directed upward. Tegmen flat or low hemispherical, with five interradial pits and its margin extended into 10 tubular appendages passing outward and downward. Plates smooth or ornamented. Anus subcentral, opening directly through the tegmen. Column circular.

Fig. 1880. *Lyriocrinus dactylus.* (After Hall.)

Differs from *Rhodocrinus* in the presence of the tubular appendages. Devonic–Mississippic.

163. **G. spinigerus** (Hall). (Fig. 1881.) Devonic.

Tegmen flat. Rays marked by ridges proceeding to the arm openings. R, first costals, and first IR extended into sharp nodes or small spines.

Hamilton of Ontario.

Fig. 1881. *Gilbertsocrinus spinigerus.* (After Whitf.)

164. **G. typus** Hall. Mississippic.

Agrees with *G. spinigerus* in general outline, projecting rim around the upper margin and presence of spines, but is larger, with slightly convex tegmen.

Upper Burlington and Burlington-Keokuk transition bed of Iowa; Upper Burlington of Missouri.

165. **G. tuberosus** (Lyon and Casseday). Mississippic.

Calyx large (one and one half to two inches wide). Tegmen flat, with long and branching appendages. Plates tumid. R prolonged into spines, directed downward. Anus usually covered by *Platyceras equilaterum.*

Keokuk of Kentucky, Indiana and Iowa.

LXI. Glyptocrinus Hall.

Calyx obconical to subglobose, often ornamented with radiating striæ passing from plate to plate, the elevations following the rays more pronounced, and forming well-defined rounded ridges which meet imperceptably with the free arm plates. B 5. Interbrachials very numerous and enclosing supplementary anals which sometimes form a continuous series. There are also numerous interdistichals and frequently interpalmars which form conspicuous depressions between the arm plates. Tegmen low, very slightly extended above the level of the arm bases and composed of minute irregular pieces. Anus excentric, at summit of a small protuberance. Arms 10 to 20, rarely branching beyond the second bifurcation, rising vertically from the calyx, long, slender and uniserial. Column round, or seldom five-sided. Ordovicic.

166. **G. ramulosus** Billings. Ordovicic.

Calyx large (one to two inches wide). Plates unmarked except by a conspicuous ridge passing up each ray. Fixed pinnules pass from the second, fourth and fifth plates. Arms long, slender, once-branching.

Trenton of Ottawa.

167. **G. decadactylus** Hall. (Figs. 1882, 1883.) Ordovicic.

Arms 20, simple. (Type of genus.)

Hudson River group of Kentucky and Ohio.

LXII. Periglyptocrinus Wachsmuth and Springer.

Closely allied to *Glyptocrinus* but with larger B and well-developed biserial arms. Ordovicic.

168. **P. priscus** (Billings). Ordovicic.

Small (calyx less than one inch wide), obconical. Conspicuous ridges pass from the arms down to the center of the R and there divide and continue to the B. Surface pustulose.

Black River of Canada.

FIG. 1882. *Glyptocrinus decadactylus*, side view. (After Meek, Pal. Ohio.)

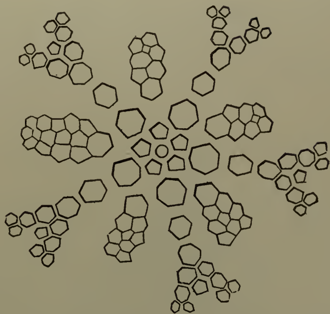


FIG. 1883. *Glyptocrinus decadactylus*, analysis of calyx. (After Meek, Pal. Ohio.)

LXIII. SIPHONOCRINUS S. A. Miller.

Calyx large, oblong, extremely asymmetrical. Dorsal cup deeply depressed interradially, giving to the calyx a strongly lobed outline. Tegmen usually as high as the dorsal cup, inflated posteriorly from below the brachial zone to the summit, forming a conspicuous helmet-shaped protuberance. IB 5. Costals two.

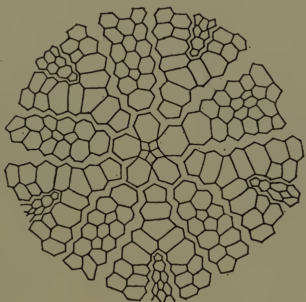


FIG. 1884. *Siphonocrinus*, analysis of calyx. (After Weller.)

Anus at end of a tube which is either erect and at the summit of the tegmen or anterior and near the arm regions (Fig. 1884). Siluric.

169. **S. nobilis** (Hall). (Fig. 1885.) Siluric

Four arm openings to the ray, arranged in pairs.

Niagaran of Illinois and Wisconsin.

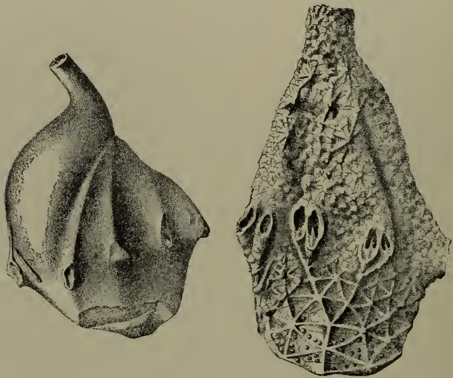


FIG. 1885. *Siphonocrinus nobilis.* Internal mold, with broken base; and impression from external mold, × ⅔. (After Hall, 20th Mus. Rep.)

LXIV. MACROSTYLOCRINUS Hall.

Calyx small, obconical to subglobose, generally with prominent ridges along the radial and anal plates. Surface densely covered with very fine striæ or small granules. B 3, large and unequal, forming a cup. R very large. Costals two and small, one third the size of the R. Arms 10, long, simple, biserial. Anal inter-

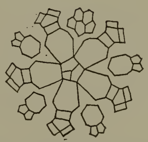


FIG. 1886. *Macrostylocrinus.* (After Weller.)

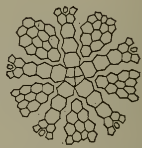


FIG. 1887. *Melocrinus.* (After Weller.)

radial area distinct, with three plates in first row. Tegmen low. Column round (Fig. 1886).

Distinguished from related genera by the number of B and by the anal interradius, possessing three plates in first row instead of one. Siluric.

170. **M. striatus** Hall. Siluric.

Calyx about one half inch high, inverted pyramidal.

Niagaran of Indiana.

LXV. Melocrinus Goldfuss.

Calyx pear- or melon-shaped, the rays extended into free tubular appendages passing upward and bearing biserial arms on both sides. B 4. Costals two. Tegmen highly elevated or scarcely convex, formed by relatively larger unsymmetrical orals. Anal aperture excentric, usually extended in a small tube. Column

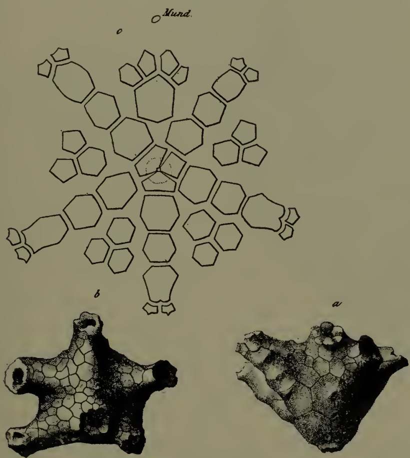


Fig. 1888. *Melocrinus roemeri*, summit, side view and analysis. (After Roemer.)

round, composed of alternate long and short joints (Fig. 1887). Siluric and Devonic.

171. **M. oblongus** Wachsmuth and Springer. Siluric.

Slender, with greatest width either less than or just equal to length. Dorsal cup obconical; sides straight to the top of the second costals whence the rays turn outward. Plates unornamented. Tegmen low.

Niagaran of Kentucky and Indiana.

172. **M. roemeri** Wachsmuth and Springer. (Fig. 1888.) Siluric.
Plates smooth.

Upper Niagaran (associated with *Astræospongia meniscus*) of Tennessee.

173. **M. nobilissimus** (Hall). Siluric?–Devonic.

Larger than *M. pachydactylus*, with longer dorsal cup and with nearly straight sides. Interradial spaces more deeply impressed above. Radiating ridges less conspicuous and without nodes. Arms and pinnules more crowded in that species.

Niagaran (?) of Tennessee; Helderbergian of New York.

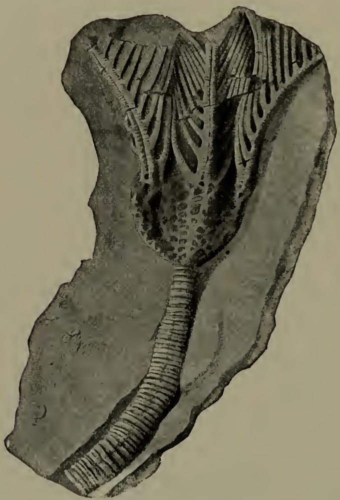


Fig. 1889. *Melocrinus pachydactylus.* (After Hall.)

174. **M. bainbridgensis** Hall and Whitfield. Devonic.

Dorsal cup rapidly spreading, with convex sides. Plates covered with granules. Suture lines grooved.

Hamilton of New York and Ohio.

175. **M. pachydactylus** (Conrad). (Fig. 1889.) Devonic.

Radiating ridges conspicuous and ending in a node at center of plates.

Helderbergian of New York.

LXVI. Dolatocrinus Lyon.

Calyx depressed. Dorsal cup flattened below, sometimes to the full height of the costals. B anchylosed, with lines of union obliterated. R large and 6-sided. Costals two. Interbrachials usually in three ranges, the first consisting of one plate (the largest of the calyx) and followed by a second row of one plate. Narrow slits present between the interambulacral plates, four to six in each interradial area. Tegmen comparatively flat, surmounted by a large and almost central tube and with the interambulacral spaces depressed. Arms biserial, generally bifurcating. Devonic.

176. **D. excavatus** Wachsmuth and Springer. Devonic.

Very large, with width of dorsal cup three times the height, the R formed into a deep, sharply pentangular, funnel-shaped pit which penetrates the calyx nearly to the arm regions. Surface of all external plates covered with parallel ridges and keel-like projections.

Onondaga of Indiana.

177. **D. triadactylus** Barris. Devonic.

Distinguished by the ornamentation, the ridges connecting the R being arranged in a pentagon which surrounds the basal pit and

FIG. 1890. *Dolatocrinus glyptus* (*D. ornatus* Meek), basal and summit views. (After Miller and Gurley.)

whose sides support five triangles, forming thus a 5-rayed star in basal view.

Hamilton of Michigan.

178. **D. glyptus** (Hall). (*D. ornatus* Meek.) (Fig. 1890.) Devonic.

Calyx depressed-globose, flattened to near the top of the R.

Hamilton of New York and Ohio.

179. **D. liratus** (Hall). Devonic.

Differs from *D. glyptus* only in ornamentation; the ridges which in *D. glyptus* are interrupted are continuous in *D. liratus* and all the plates bear more ridges and prominences.

Hamilton of New York and Ohio.

LXVII. EUCALYPTOCRINUS Goldfuss.

Calyx with a deep concavity at the lower end, the 4 B forming the bottom and the R the sides of this inverted cup. Interbrachials 3, the first very large, followed by two narrower ones joined by a vertical suture; each pair of these supports one of the 10 vertical partitions, the other five of which are supported by the single interdistichals. Tegmen elongate; upper part extended to form a tube which projects about the arms; composed of four ranges of plates of which the two middle ones are the least regular in their arrangement and the upper one closes the center. Attached to the outer walls of the tegmen and extending to its top are ten partitions which form deep vertical compartments for the reception of two arms each. Arms 20, biserial, composed of very narrow pieces. Anus at end of a tube. Column round (Fig. 1891). Siluric.

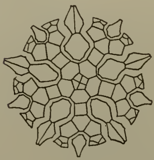


FIG. 1891. *Eucalyptocrinus.* (After Weller.)

180. **E. milligani** Miller and Gurley. (Fig. 1892.) Siluric.

FIG. 1892. *Eucalyptocrinus milligani*, basal and lateral views. (After Miller and Gurley.)

FIG. 1893. *Eucalyptocrinus cœlatus*, var. *levis*. (After Hall.)

Distinguished by the sudden expansion at the base of the arms. Niagaran of Tennessee.

FIG. 1894. *Eucalyptocrinus cœlatus*, var. *levis*. (After Hall.)

181. **E. cœlatus** Hall. Siluric.

Plates of dorsal cup densely crowded with small pustules of uniform size.

Niagaran of New York.

182. **E. cœlatus** var. **levis*** Grabau and Shimer. (*E. decorus* of American authors.) (Figs. 1893, 1894.) Siluric.

Differs from the species in lacking the pustulose surface and in that the five interdistichal plates are truncate at base instead of acute as in the type of *E. cœlatus*.

Rochester of New York, etc.

183. **E. crassus** Hall. (Fig. 1895.) Siluric.

Large (crown sometimes 4 inches long) and usually half as wide.

Niagaran of Ohio, Indiana and Illinois.

184. **E. elrodi** S. A. Miller. (Includes part of *E. cœlatus* Hall.) (Fig. 1896.) Siluric.

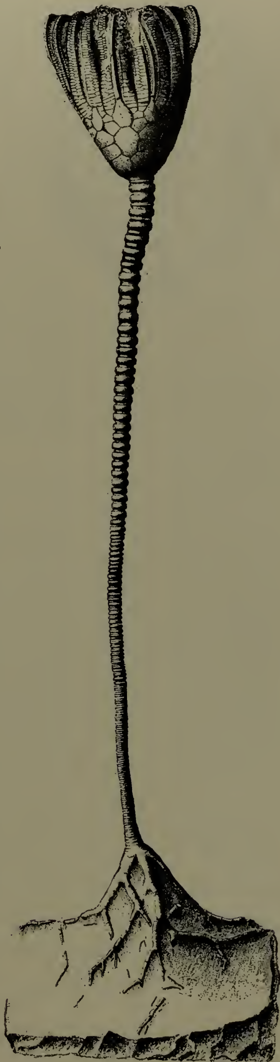


FIG. 1895. *Eucalyptocrinus crassus*, entire specimen, × ⅔. (After Hall.)

FIG. 1896. *Eucalyptocrinus elrodi*, lateral and basal views of a characteristic specimen. (After Hall.)

Basal concavity small and shallow for the genus. Plates of dorsal cup, arms and outer edges of the partition walls marked by numerous nodes often confluent, forming transverse and longitudinal ridges.

Niagaran of Indiana and Illinois.

185. **E. magnus** Worthen. Siluric.

Large. Dorsal cup rapidly spreading from the base and with width greatly exceeding length. Plates flat and smooth or finely granulose.

Niagaran of Tennessee.

186. **E. tuberculatus** Miller and Dyer. Siluric.

Resembles *E. elrodi* in general form, but dorsal cup higher, its height nearly equalling its width and plates somewhat elevated and covered by numerous tubercles of various sizes.

Niagaran of New York, Indiana and Wisconsin.

LXVIII. CALLICRINUS d'Orbigny.

In form of calyx and arrangement of plates similar to *Eucalyptocrinus,* but partition walls, instead of forming closed compartments to the full height of the arms, rise only to a certain height (about one third of the length of arms) and are not closed above. Plates strongly nodose or spinose. Siluric.

187. **C. longispinus** Weller. Siluric.

Each R and first interbrachial plate produced into an enormous spine, whose length exceeds the width of the dorsal cup.

Niagaran of Illinois.

LXIX. Crotalocrinus Austin.

Crown, when arms are closed, similar to an elongate bud; when arms are opened, wheel-shaped, with five lanceolate areas between the bases of the rays. Calyx subglobose, flattened above. IB 5, large, uniform. B 5, extending three fourths of the height of the calyx and supporting the R and a small anal. Costals, distichals, palmars and postpalmars rest against one another and against the broad upper face of the R. Arms long, branching frequently, the branches connected laterally by points of attachment with open spaces between, hence forming a sort of network around the calyx. Tegmen flat, on a level with the spreading arms. Anus excentric, at the end of a tube or a small protuberance (Fig. 1897). Siluric.

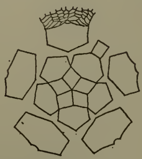


Fig. 1897. *Crotalocrinus*, analysis of calyx. (After Weller.)

188. **C. americanus** Weller. Siluric.

Calyx one and one fourth inches in diameter. R ornamented with very fine irregular papillæ or wavy ridges.

Niagaran of Illinois (Chicago area).

LXX. Camarocrinus Hall.

Pear-shaped, spheroidal or depressed spheroidal, chambered bodies, composed of many small plates, and to one end of which are attached roots and a short stalk of the same nature as those of crinoids. No evidence of ambulacra, mouth or anus. Chambers 6 or 7, rarely 11, one large mediobasal chamber surrounded by the others, the number of chambers usually indicated exteriorly by constrictions over their walls.

Nature of the fossil is problematical. Variously considered as theca of cystoids or crinoids (disproved by absence of ambulacra, mouth and anus), brood sacks or brood receptacles (at total disagreement with breeding organs and habits of living crinoids), degenerate crinoids (unsupported by the detailed structure of these bulbs), or floats attached to the root of some unknown crinoid, held together after the death of the animal by its firmly interlocked walls, while the crown and stalk dropped away (Schuchert). Siluric–Devonic.

189. **C. stellatus** Hall. Siluric.

Form more depressed than that of *C. saffordi*, basal area larger and more open, and plates finely granular, the granules forming a somewhat stellate pattern. (Type of genus.)

Manlius of New York, Maryland and West Virginia.

190. **C. saffordi** Hall. (Fig. 1898.) Devonic.

Calyx spherical, often unsymmetrical owing to its unequally developed lobes (usually five). As in the other forms, the walls

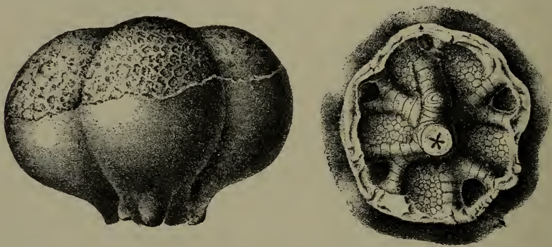


FIG. 1898. *Camarocrinus saffordi.* Basal bulb, lateral view, with external layer removed over part of surface to show plated subsurface layer; also enlargement of the area of stem attachment. (After Hall.)

separate readily into an inner and an outer layer, with spongy interspaces.

Helderbergian of Tennessee.

Order IV. FLEXIBILIA Zittel.

LXXI. CLEIOCRINUS Billings.

Calyx large, conical or pear-shaped. IB probably 3 and B probably 5, all small and hidden by the column. First visible plates are a ring of 10 plates, the R and IR. The posterior IR supports a longitudinal row of anal plates which extend to the top of the calyx. The rays and their divisions following the R are laterally connected, with no more IR between them except at the anal side. Ordovicic.

191. **C. regius** Billings. Ordovicic.

Calyx elongate-conical, one and three fourths inches long, with width near the top of one inch. Final divisions of rays about 40, long and slender. Surface nearly smooth. Column pentangular. Trenton of Ottawa.

LXXII. Ichthyocrinus Conrad.

General form, including arms, ovoid to pear-shaped. Calyx cup-shaped; all the plates above the R united by loose sutures or by muscular articulation, producing flexibility. IB 3, very small, rarely extending beyond the top stem joint with which they are fused. B 5, small. R and lower brachials laterally in contact on all sides. No IR or anals present. Brachials united by more or less wavy sutures and their lower edges furnished with tooth-like projections which fit into depressions on the underlying plates. Tegmen scaly, composed of five orals and numerous very small, movable plates. Arms nonpinnulate, 20–60 or more, infolding at their tips. Crown appearing like a perfectly solid body

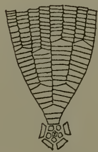


Fig. 1899. *Ichthyocrinus.* (After Weller.)

Fig. 1900. *Ichthyocrinus lævis*, with enlargement of stem. (After Hall.)

Fig. 1901. *Lecanocrinus macropetalus.* (After Hall.)

when the arms are folded. Stem round, the upper joints extremely short and usually wider than the others. Usually to be recognized by its symmetrical, equilateral form. (Fig. 1899.) Siluric.

192. **I. laevis** Conrad. (Fig. 1900.) Siluric.

Plates with lower margins obtusely triangular and upper margin with a corresponding reëntrant angle.

Rochester (Niagaran) of New York.

LXXIII. Lecanocrinus Hall.

Similar to *Ichthyocrinus,* but only four of the rays laterally in contact, the two posterior R being separated by a rhomboidal radianal and a somewhat larger IRA. Siluric.

193. **L. macropetalus** Hall. (Fig. 1901, 1902.) Siluric.

Calyx subglobose. Stem slender, smooth; thick joints alternating with thin ones at irregular intervals.

Rochester shale of New York.

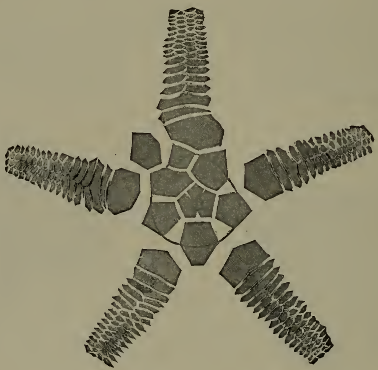


Fig. 1902. *Lecanocrinus macropetalus*, analysis of calyx. (After Hall.)

LXXIV. Taxocrinus Phillips.

Similar to *Ichthyocrinus,* but all 5 R separated by interbrachials. Posterior B larger than the others and truncated, supporting an IRA which is followed by a longitudinal row of small supplementary anals interposed between numerous minute irregular pieces. Ordovicic–Mississippic.

194. **T. elegans** (Billings). Ordovicic.

Calyx small and conical, with arms one and one half inches high.

Trenton of Ottawa.

195. **T. thiemei** Hall. (Fig. 1903.) Mississippic.

Crown short and stout. Basal spines present.

Burlington of Missouri and Iowa.

FIG. 1903. *Taxocrinus thiemei*, × ⅔. (After Meek and Worthen.)

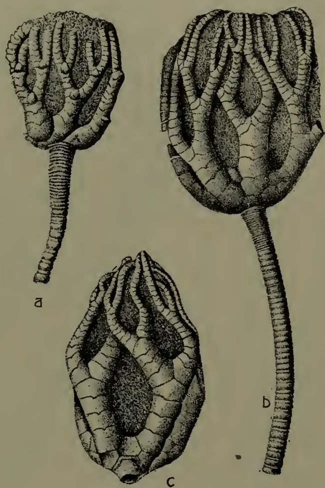


FIG. 1904. *a*, *Taxocrinus kelloggi*; *b*, *c*, *T. communis*. (After Hall and Whitfield.)

196. **T. kelloggi** (Hall). (Fig. 1904, *a*.) Mississippic.

Arms twice bifurcating, each bifurcating plate being strongly nodose. Arm plates angular and granulose.

Waverly of Ohio.

197. **T. communis** (Hall). (Fig. 1904, *b, c*.) Mississippic.

Like *T. kelloggi* in form and structure, but lacks the nodose bifurcating plates.

Waverly of Ohio.

LXXV. Onychocrinus Lyon and Casseday.

Similar to *Ichthyocrinus* in general structure, but calyx depressed, arms spreading and talon-like, interbrachials present between the costals and posterior interray very different from the others, being composed of many minute pieces which enclose a row of small anal

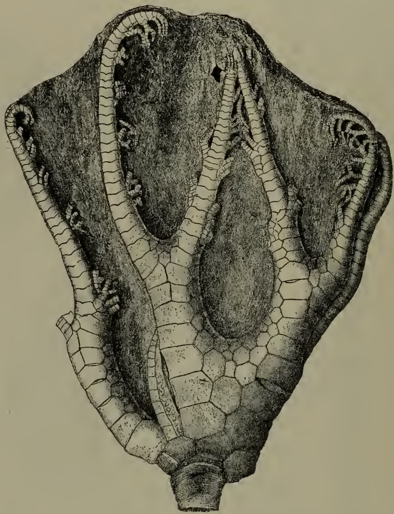


Fig. 1905. *Onychocrinus exculptus*, × ⅔. (After Meek and Worthen.)

plates, supporting a small tube above. Tegmen formed of almost microscopic particles and very flexible. Arms 10, giving off armlets in clusters. Mississippic.

198. **O. exsculptus** Lyon and Casseday. (Fig. 1905.) Mississippic.
Surface ornamented with minute granules.
Keokuk of Kentucky, Indiana and Illinois.

LXXVI. Forbesiocrinus de Koninck and le Hon.

Similar to *Taxocrinus,* but differs in its anal area. Both IRA and RA present. Interbrachials very numerous, sometimes in 12 or more rows. Arms long, bifurcating, with infolding tips. Mississippic.

199. **F. agassizi** Hall. Mississippic.
Larger than *F. wortheni*, with interradial areas less depressed.
Burlington of Iowa.

200. **F. wortheni** Hall. (Fig. 1906.) Mississippic.
Interradial areas depressed.
Keokuk of Indiana, Illinois and Iowa.

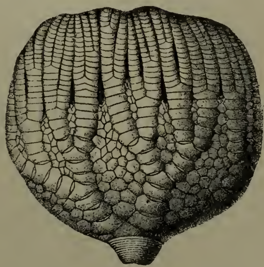


FIG. 1906. *Forbesiocrinus wortyeni*, a complete calyx with arms, × ⅔. (After Meek and Worthen, Ill. Geol., V.)

LXXVII. UINTACRINUS Grinnell.

Symmetry perfectly in fives. Plates thin. Stem wanting. B 5, enclosing a small, five-sided, centrodorsal plate. Costals two, the upper one axillary and supporting two rows of distichals, which are succeeded by palmars. Interbrachials numerous, the lowest ring interposed between the costals. Arms ten, long and pinnulate, composed of very short, almost circular, joints. Pinnules heavy and closely arranged, the lower ones united by sutures and incorporated into the calyx. Habitat free, floating as plankton. Cretacic.

201. **U. socialis** Grinnell. (Fig. 1907.) Cretacic.
Calyx subglobose, composed of numerous, slightly convex plates joined together, with channelled sutures and without distinct surface markings. IR, eight or nine in number, forming a rounded, slightly elevated, shield-like area. IB often present.
Niobrara of Kansas and Utah.

Order V. ARTICULATA Johannes Müller.

LXXVIII. PENTACRINUS Miller.

Calyx small, bowl-shaped, with dicyclic base. B and R united by close suture; R and lower brachials united by muscular articulation or by a rigid suture. IB obsolete. Costals rarely more than two, none of them pinnulate. Tegmen flexible, studded with small, irregular plates. Arms very numerously divided. R laterally in contact, but small, irregular plates frequently present between the costals and distichals. Anal plates present only in the larval

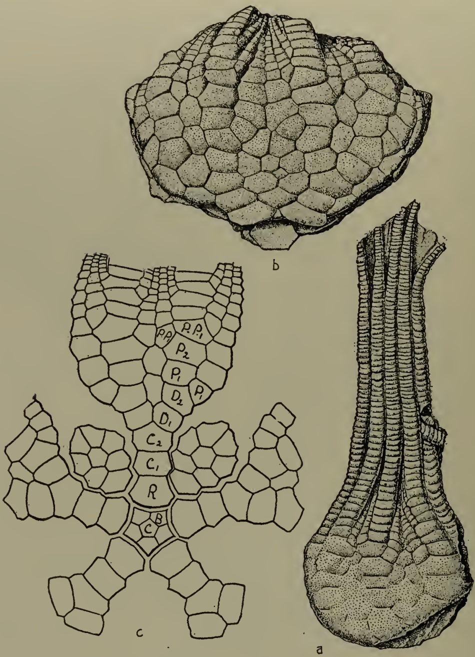


FIG. 1907. *Uintacrinus socialis.* *a*, small individual with arms partly preserved, × ⅔; *b*, lateral view of a larger calyx, × ⅔; *c*, analysis of calyx; *C*, centrodorsal plate; *B*, basals; *R*, radials; C_1C_2, costals; D_1D_2, distichals; P_1P_2, palmars; PP_1, post palmar. (After Clark.)

stages. Stem more or less 5-angled; the angle of the axial canal corresponding with the outer angles of the stem. Cirri very numerous. Triassic–Recent.

202. **P. asteriscus** Meek and Hayden. Jurassic.

Readily identified from the joints of the column, which are thin, very symmetrically pentagonal, star-shaped bodies, with rays usually a little longer than wide and acutely angular at the extremities; the center of each joint is minutely perforated and from it radiate five petaloid areas to the angles of the joint.

Jurassic of the Big Horn Mountains and Black Hills and of Colorado, Nebraska, Utah, Idaho, Wyoming and Nevada.

203. **P. (Isocrinus) knighti** Springer. Jurassic.

Stem smooth pentagonal, with straight sides except near the calyx where they are stellate; calyx forming low cone, without downward projection of basals or radials. IB well defined, filling half the diameter of column facet; arms 10–20, of about 90 brachials, simple or bifurcating once between 16th and 30th distichals; syzygies at intervals of 5–10 brachials.

Shirley beds of Medicine Bow and Red Butte, Wyoming.

INCERTÆ SEDES.

LXXIX. Aspidocrinus Hall.

Broadly circular and concave, depressed hemispherical or shield-shaped, with plain or plicate upper margin. Point of attachment for column distinct.

Possibly the root of a crinoid, or possibly the base of a crinoid, as depressions sometimes present in the upper margin might indicate a second row of 10 or 12 radial and interradial plates. Devonic.

204. **A. scutelliformis** Hall. Devonic.

Diameter about one and one half inches. (Type of genus.)

Helderbergian of New York, etc. (Characteristic of Upper New Scotland and Becraft limestones.)

LXXX. Ancyrocrinus Hall.

Form bulb-shaped, with lateral processes and a central column.

Represents the lower end of a crinoidal stem, the lateral appendages being a kind of radicular cirri used in anchoring the form which is probably free-floating. It may later become detached, leaving the adult free. Devonic.

205. **A. spinosus** Hall. (Fig. 1908.) Devonic.

Lower part of bulb broadly rounded; arms short.

Onondaga of Falls of the Ohio.

206. **A. bulbosus** Hall. Devonic.

Differs from *A. spinosus* in its longer and less ventricose basal portion, its longer and less diverging arms. The column above the bulb often elongated, round in the lower part, obtusely quadrangular above. (Type of genus.)

Hamilton of New York.

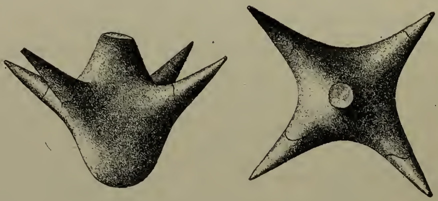


FIG. 1908. *Ancyrocrinus spinosus*, lateral and summit views. (After Hall.)

Branch ASTEROZOA Leuckhart.

Class I. **OPHIUROIDEA** Gray.

The Ophiurians, or brittle stars, are marine echinoderms abundantly represented in the modern fauna. They appear as early as the Siluric and have representatives throughout the Palæozoic. A more or less sharply defined central disk contains the mouth and digestive cavity, which latter does not extend into the slender, rounded arms. The arms consist of an axis of jointed calcareous disks (vertebral ossicles), surrounded by plates or a leathery integument and destitute of open ambulacral grooves. The madreporic body is situated on the oral (actinal) side of the disk. The arms are movable and serve for locomotion. They are often intricately intertwined (Fig. 1909).

FIG. 1909. *Onychaster flexilis*, specimen with folded arms and outer integument of disc and dorsal side of inner end of some of the arms removed, exposing parts surrounding mouth. (After Meek and Worthen, Ill. Geol., V.)

Two orders are recognized:

I. EURYALEÆ, in which the arms generally divide dichotomously soon after their origin (though in some cases simple throughout (Fig. 1909)), and covered with a granulated or scaly integument; while a madreporite may be present in all the interrays. American examples: *Onychaster barrisi* Hall, Burlington of Iowa;

O. asper Miller, *O. confragosus* Miller and *O. demissus* Miller, from the Keokuk of Missouri, and *O. flexilis* Meek and Worthen (Fig. 1909) from the Keokuk of Indiana.

II. OPHIUREÆ, with simple arms, generally encased by four series of plates, the upper and lower of which (scutella *dorsalia, ventralia*) are generally smooth, while the lateral or adambulacral plates are generally furnished with movable spines. American representatives are: *Protaster whiteavesianus* Parks, from the Trenton of Kirkfield, Ontario; *P. granuliferus* M. and W., from the Cincinnatian of Ohio; *Eugaster logani* Hall, from the Hamilton of New York; *Aganaster gregarius* (Meek and Worthen), from the Keokuk of Crawfordsville, Indiana; *Ophioglypha bridgerensis* (Meek), from the Cretacic of Montana; and *Amphitura sanctæ crucis,* Oswold, of the Santa Magarita formation (Miocenic) of California.

Class 2. **ASTEROIDEA.**

The Asteroids, or star fish, have simple arms, which are prolongations of the central disk, containing prolongations of the digestive cavity and the generative organs. The ventral border of the arms is marked by the *ambulacral groove,* formed by two rows of ambulacral ossicles, which meet in the center. Laterally these are bordered by the adambulacral or interambulacral plates, which generally bear movable spines. Between the ambulacral ossicles are grooves for the passage of the tube feet or *ambulacra,* either in a single or a double row on each side of the median line. The dorsal surface is formed by a network of ossicles, often with spines and other appendages. A madreporic body is typically situated dorsally in one of the interrays, but in the Encrinasteriæ is on the oral side.

FIG. 1910. *Stenaster salteri,* × 2. (After Billings, Can. Org. Rem., Dec., III.)

Two subclasses are recognized:

I. ENCRINASTERIÆ, comprising most of the Palæozoic forms and having their ambulacral ossicles but slightly inclined towards each other and arranged in alternating rows; the madreporic body is on the oral side. American examples are: *Stenaster salteri* Billings (Fig. 1910) and *S. pulchellus* Billings, from the Trenton of Canada, and *S. grandis* Meek and Worthen, of the Cincinnatian of Ohio; *Palæasterina stellata* Billings, of the Trenton; *P. rugosa* Billings, *P. speciosa* Miller and Dyer, *P. approximata* M. and D., all of the Cincinnati group; *Palæaster eucharis* Hall, of the Hamilton of New York, *P. chemungensis* Schuchert, of the Chemung of Pennsylvania, and *P. crawfordsvillensis* Miller, of the Keokuk of Indiana.

II. Euasteriæ, with the pairs of ambulacral ossicles opposite each other and inclined at a considerable angle, and the madreporic body in most cases restricted to the dorsal surface. American examples: *Pentagonaster browni* Weller, from the Fox Hills of Wyoming, and *P. ? mammillatus* Gabb, from the Vincentown beds of New Jersey; also *Asterias? dubium* Whitfield, from Jurassic sandstones of the Black Hills.

Branch ECHINOZOA Leuckhart.

Class **ECHINOIDEA** Agassiz.

The echinoids are free-moving marine echinoderms, with a hollow, globular to disk-shaped shell or *test,* composed of numerous, thin, closely-joined calcareous plates. They differ in general appearance from the crinoids in the absence of stem and arms and in the presence of very numerous superficial spines.

The main portion of the test is called the *corona;* it is supplemented by a system of plates at or near the center of the dorsal or *abactinal* surface, and this is known as the *apical system* (Fig. 1911, *A, a*). The test is pierced by two large openings which in life are covered, except at their centers, by leathery membranes studded with small calcareous particles; these are the mouth opening or *peristome,* and the anal opening or *periproct.*

The *mouth* is on the under or *actinal* side of the test, either central or excentric in position and is surrounded by a leathery membrane. It contains in life a very complicated dental apparatus (*"Aristotle's lantern"*) consisting of five hard, interradially situated *teeth* which are in relation with as many *pyramids* resting upon the membrane. Muscles connect the pyramids with each other and with projections from the solid test surrounding it.

The *anus* is surrounded by a soft membrane similar to that around the mouth and is placed either at the center of the apical system or at a variable distance from it in the median line of the posterior interambulacrum, upon either the upper or the under surface of the test. With mouth centrally placed and anus at

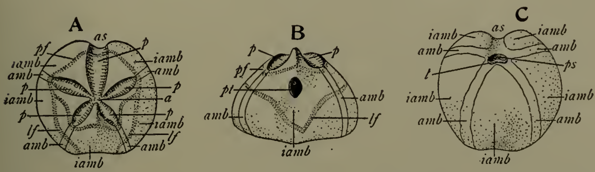


FIG. 1911. Diagram of *Linthia variabilis*. *A*, dorsal view; *B*, posterior view; *C*, ventral view. (After A. W. Slocum.) *a*, apical system; *amb*, ambulacra; *as*, anterior sulcus; *iamb*, interambulacra; *lf*, lateral fasciole; *p*, petaloid part of ambulacrum; *pf*, peripetalous fasciole; *pt*, periproct; *ps*, peristome.

the center of the apical system, the test is said to be *regular* or *endocyclic;* with mouth central or excentric, and anus excentric, the test is known as *irregular* or *exocyclic*.

The plates of the test are arranged in ten meridian-like zones. Five of these, the *ambulacral areas,* are composed of small perforated plates, the remaining five *interambulacral areas* alternate with these and are imperforate and usually larger. In the vast majority of echinoids, each zone is composed of two columns of plates, making twenty columns in all, ten perforate, and ten non-perforate; this number is, however, not attained in some fossil forms and is exceeded in others.

Interambulacral (interradial) plates are always simple; ambulacral plates may be either *simple* or *compound*. When compound they may be formed of two or of more parts, all of which are joined by sutures and form a more or less geometrical plate.

New plates are successively added to the ends of the ambulacra and interambulacra next to the apical system.

Each ambulacrum consists of an *interporiferous area* placed between two *poriferous zones;* only a few Palæozoic genera have the whole ambulacral area pore-bearing. Usually the ambulacral pores are in pairs. The arrangement of the pairs of pores may be in simple series, when one pair is placed over the other in succession from mouth to apex. They are *biserial* when placed so that there are two vertical rows of pairs. Simple series of pores are either absolutely straight or in curves or arcs of three or more pairs. Ambulacra are simple when band-shaped and continuous from center of top to center of bottom. *Petaloid ambulacra* are those in which the pore-bearing zones of an ambulacrum separate between the apex and the circumference (*ambitus*) of test and contract again (petal-like) more or less perfectly before reaching that region. *Subpetaloid* ambulacra are comparatively larger than the petaloid, and the pairs of pores do not tend to close again towards the ambitus. The pores almost cease at the end of the petaloid parts, though a few can usually be traced farther, at times to the mouth. The anterior ambulacrum of the irregular echinoids is generally much less fully developed, and often lies in an *anterior sulcus* (Fig. 1911, *A, C, as*).

In some echinoids (*e. g., Cassidulus*) the group of ambulacral plates bordering the mouth opening are petal-like and swollen (*phyllodes*), with the pores crowded and prominent (Fig. 1928, *g*). This forms the *floscelle.* The five phyllodes are separated by inflated interambulacral plates called the *bourrelets* (Fig. 1930, *a*).

The apical system (Figs. 1917, *b*; 1935, *a*) is usually composed of ten plates arranged in two alternating circles of five plates each, and each plate perforated. The uppermost circle is situated interradially, and consists of large, five- or six-sided pieces, the *basal* or *genital plates* (Fig. 1935 *a, g*); the largest of these, the *madreporite,* is a sieve-like prominence (Fig. 1935 *a, m*). The plate lying to the front and on the left side of the madreporite is the *anterior ocular* which lies upon the upper end of the odd or anterior ambulacrum (Fig. 1935, *b*). The lower circle of smaller plates upon the ends of the ambulacrum are the *radial* or *ocular plates* (Fig. 1935 *a, r*).

The plates are usually covered with *tubercles* and *granules* which carry *spines.* The larger tubercles are called primaries. The base or *boss* of the tubercle supports a rounded knob (*mamelon*), which is said to be *perforated* when pierced by a central foramen for a slight distance, or *imperforate* when it is not so pierced. A plain sunken space surrounding the base of the tubercle is called the *areola* (Fig. 1913); its outer limit is generally marked by a ring of granules (*scrobicular circle*). All tubercles bear movable spines.

Fascioles are narrow bands of close granular ornamentation which support many small spines. The *peripetalous fasciole* follows the margin of the petaloid parts of the ambulacra (Fig. 1911, *A, B, pf*; Fig. 1934, *g*). The *anal fasciole* surrounds the anus, and the *subanal fasciole* encloses a space beneath the anus.

The vertical range of the modern echinoids is from low water, where they are sometimes uncovered, to great depths (nearly 3,000 fathoms). The larvæ lead a meroplanktonic existence. In time echinoids range from the Ordovicic to the present, the division of Palæechinoidea, however, becoming extinct with, or shortly after the end of the Palæozoic.

Echinoidea were divided by Zittel and Bronn into PALÆECHINOIDEA and EUECHINOIDEA. The former contains three orders: (1) CYSTOCIDAROIDA with the genus *Echinocystites;* (2) BOTHRIOCIDAROIDA with the genus *Bothriocidaris,* and (3) PERISCHOECHINOIDA which comprises the remainder of the Palæozoic echinoids. The Euechinoidea are divided by Duncan, into the orders: (1) CIDAROIDA; (2) DIADEMATOIDA; (3) HOLECTYPOIDA; (4) CLYPEASTROIDA, and (5) SPATANGOIDA.

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Group of Mississippi. Field Museum of Natural History publication, no. 134; Geol. Series, Vol. IV., no. 1.

Specific descriptions are also scattered through the writings of **Clark** (Md. Survey); **Conrad**; **Gabb** (Pal. Cal.); **Hall** (Iowa Geol. Surv., vol. 1, pt. 2); **Keyes** (Geol. Mo., IV.); **McCrady** (Plioc. Foss. S. Car.); **Meek** and **Meek** and **Worthen** (Geol. Surv. Ill., vols. 2, 5, 7); **Morton**; **Ravenel** (Journ. Acad. Nat. Sci., VIII., and Cat. of the Echinoidea — Rec. and Foss. — S. Carol.); **Rémond** (Proc. Cal. Acad. Sci., ser. 1, III.); **Say**; **Weller** (Pal. N. J., IV.), and others. The most recent and important work on the classification of Echinoidea is P. M. Duncan, 1889, Revision of the Genera and Great Groups of the Echinoidea. Journ. of the Linnean Society (Zoölogy) Vol. XXIII.

Key to the Genera.

A. *Palæechinoidea.* Test of more than twenty meridional columns of plates, each interambulacrum having more than two columns, or less than twenty (*Bothriocidaris*) when ambulacra are represented by one column only in each zone......I.

I. Interambulacral plates large, each with a large single spine boss in center.......1.

1. Ambulacra of two columns; interambulacra of 4–7; peristome large........*a.*

a. Tubercles of interambulacra surrounded by ring of granules. II. *Archæocidaris.*

a. Tubercles not surrounded by ring.................................I. *Eocidaris.*

1. Ambulacra of 2 + columns; interambulacra of 8 columns. III. *Lepidocidaris.*

I. Interambulacral plates without large spine boss.. ....2.

2. Ambulacra of two columns of plates...*b.*

b. Plates strongly imbricating....................................IV. *Lepidechinus.*

b. Plates not imbricating...V. *Rhoëchinus.*

2. Ambulacra of more than two columns...*c.*

c. Plates not imbricated ....*.

*. Ambulacra 2 + columns; interambulacra 5–7 columns....*Palæechinus.*

*. Ambulacra with 4 columns; interambulacra 4–9 columns. VI. *Oligoporus.*

*. Ambulacra 6–14 columns; interambulacra 4–11 columns. VII. *Melonites.*

c. Plates of corona imbricated.......... ....**.

**. Plates regular...................... ....VIII. *Lepidesthes.*

**. Plates irregular..... ....IX. *Pholidocidaris.*

B. *Euechinoidea.* Test of twenty columns of plates, 2 in each ambulacrum and 2 in each interambulacrum (except *Tetracidaris* which has 4 in each interambulacrum) ....II.

II. Test regular; with peristome and anal opening (periproct) at opposite poles..3.

3. *Cidaroida.* With discontinuous perignathic girdle; both ambulacral and interambulacral plates continued beyond peristome to the true mouth. Ambulacral plates typically simple, each with one pair of pores...........*d.*

d. Ambulacral areas narrow, undulating; pores close together; primary tubercles perforated and crenulated, spines cylindrical to spindle-shaped, generally granulose or spinulose...................................... X. *Cidaris.*

d. Ambulacral areas straight or undulating; primary tubercles not crenulated; spines large, smooth, cylindrical......... ....XI. *Leiocidaris.*

3. *Diadematoida.* With continuous perignathic girdle; ambulacral plates alone continued beyond the peristome, or as separate buccal plates; ambulacral plates typically with more than one pair of pores....................*e.*

e. Pairs of pores superposed so as to form simple vertical series, or arranged in arcs of three..XII. *Diadema.*

e. Pairs of pores alternating to form biserial columns, at least in part.....***.

***. Biserial pores above ambitus only.....................XIII. *Diplopodia.*

***. Pores in two double rows throughout................XIV. *Pedinopsis.*

e. Ambulacral plates highly compound of primaries and demiplates.
XV. *Cyphosoma.*

II. Test irregular, with peristome and periproct not at opposite poles.................4.

4. Peristome central, periproct in posterior interambulacrum........................*f.*

f. *Holectypoida.* A pair of pores or only one pore to an ambulacral plate..4*.

4*. Perignathic processes of ambulacra present; periproct large between margin and peristome.......................................XVI. *Holectypus.*

f. *Clypeastroida.* More than a pair of pores to an ambulacral plate......5*.

5*. Margins rounded and more or less tumid.................................†.

†. Margin entire...‡.

‡. High, with base abruptly hollowed to deep central peristome.
XVII. *Diplothecanthus.*

‡. Low, base flat, peristome not depressed........XXI. *Mortonia*

†. Margin notched; test low and flat....................XXIII. *Encope.*

5*. Margin sharp, depressed, test very flat, with flat base and branched ambulacral furrows...††.

††. Margins and tests entire, without notches or perforations......‡‡.

‡‡. Apical system central..1′′.

1′′. Ambulacral petals extending about half way to margin; periproct nearer the peristome than margin.
XVIII. *Periarchus.*

1′′. Ambulacral petals extending to near margin, periproct marginal or inframarginal.......................XIX. *Scutella.*

‡‡. Apical system excentric, periproct actinal, marginal or supramarginal......................................XX. *Echinarachnius.*

††. Margins notched, test frequently with perforations (lunules).
‡‡‡.

‡‡‡. Test very flat, with five or six usually closed lunules or notches, one in median posterior interambulacrum.
XXII. *Mellita.*

‡‡‡. Test with broad notch or lunule in each ambulacrum, and a lunule in posterior interambulacrum............XXIII. *Encope.*

4. *Spatangoida.* Peristome and periproct both excentric, placed along a longitudinal axis...*g.*

g. Ambulacra similar..6*.

6*. Periproct at upper end of groove on abactinal area of test; floscelle absent or rudimentary...............................XXIV. *Echinobrissus.*

6*. Periproct supramarginal, floscelle well developed..XXV. *Cassidulus.*

g. Ambulacra dissimilar..7*.

7*. Ambulacra nearly similar, flush with surface, not forming petaloid areas..†††.

†††. Periproct inframarginal, broader than long, anterior ambulacrum not in groove..XXVI. *Echinocorys.*

†††. Periproct supramarginal, oval, anterior ambulacrum in groove ‡‡‡‡.

‡‡‡‡. Anterior groove shallow, periproct not sunken. XXVII. *Holaster.*

‡‡‡‡. Anterior groove deep, with angular margin; periproct in depression in truncated posterior face......XXVIII. *Cardiaster.*

7*. Ambulacra petaloid or subpetaloid, divided into trivium and bivium; anterior petal differing from others in form and characters........4†.

4†. Without fascioles..5‡.

5‡. Periproct supramarginal; ambulacra petaloid dorsally, with elongate unequal pores...............................XXIX. *Epiaster.*

5‡. Periproct in posterior truncated area; posterior lateral ambulacra short...XXX. *Enallaster.*

4†. With fascioles, except in subanal area ....6‡.

6‡. Anterior ambulacrum in shallow groove; pores oblique. XXXI. *Hemiaster.*

6‡. Anterior ambulacrum in deep groove; pores round and small. XXXII. *Linthia.*

4†. With subanal fasciole...7‡.

7‡. Ambulacral petal more or less triangular, anterior ambulacrum in groove.........................XXXIV. *Echinocardium.*

7‡. Ambulacral petals not triangular, anterior ambulacrum nearly obsolete, and nearly flush.....................XXXIII. *Maretia.*

Subclass **Palæechinoidea** Zittel.

Order PERISCHOËCHINOIDA McCoy.

I. Eocidaris Desor.

Ambulacra with two columns of plates, with pores near outer extremity; interambulacral plates in four or more columns, pentagonal at margin, otherwise hexagonal, with large tubercle on each plate, smooth at base, perforated at summit; distinguished from *Archæocidaris* by absence of a definite areole and ring; spines slender, ornamented with small, sporadic spinules. Devonic–Permic.

1. **E. halliana** Geinitz. Carbonic.

Minute interambulacral plates with median primary spine-boss surrounded by an open ring of secondary smaller ones; primary spines slender, surface finely striate, the striæ spinulose; length of spines 8.5 mm., diameter of plate 2.5 mm.

Upper Coal Measures of Nebraska, Missouri, Iowa and Colorado.

II. Archæocidaris McCoy.

Test large, regular and globular; ambulacra reaching the mouth, straight, with two columns of pore-bearing plates, each with a pair of pores; plates irregular, imbricating towards the mouth; interambulacra with 4–7 columns of large, thin plates, the median ones six-sided, those bordering the ambulacra five-sided or rounded; median plates beveled slightly over those on either side and these over others, to the ambulacral edge. Each interambulacral plate

FIG. 1912. *Archæocidaris agassizi*, spine, × 2. (After Hall.)

with a large primary tubercle on a conical elevation, and surrounded by a large flat areola and a circlet of granules; primary spines large, usually serrated (the spines and single plates are frequently the only parts known). Mississippic–Carbonic.

2. **A. agassizi** Hall. (Fig. 1912.) Mississippic–Carbonic.

Plates small, hexagonal, except those adjacent to ambulacral area; central tubercle slender, elongate, projecting above surrounding, abruptly elevated annulation; a low annular ridge outside of

FIG. 1913. *Archæocidaris shumardana*, plates and spine, × 2. (After Hall.)

this; spines elongate, compressed, contracted below, with greatest diameter one third from base; spiniform tubercles except on lower part.

Burlington of Iowa and Missouri; Upper Coal Measures of Kansas.

3. **A. shumardana** Hall. (Fig. 1913.) Mississippic.

Smaller; tubercles of plate more closely surrounded by annulus; spines slender, scarcely swelling, spinules more distant, larger; section of spine round.

Keokuk and Warsaw of Illinois, Missouri; Eureka of Nevada.

4. **A. wortheni** Hall. (Fig. 1915, *a–c*.) Mississippic.
Corona with four columns of interambulacral plates; tubercle of plates scarcely separated from annulus which spreads below into a slightly elevated disk; spines slender, smooth or finely granulate, section round.
St. Louis of Missouri; Eureka of Nevada.

5. **A. dininnii** White. (Fig. 1914.) Carbonic.
Spines of several kinds; principal ones fusiform, from 50–60 mm. long, with greatest diameter near middle, covered with many irregular spinules, projecting at right angles and most abundant on lower part; smaller spines more slender, equally spinulose.
Coal Measures of Nebraska, Iowa and Missouri.

FIG. 1914. *Archæocidaris dininnii*, spine natural size, and base enlarged. (After Hall.)

6. **A. megastylus** Shumard. Carbonic.
Boss broad and smooth, areolar surface very broad, slightly concave exteriorly and surrounded by secondary tubercles; primary spines robust, long, slender, longitudinally striate, granulose or finely spinulose; basal ring oblique to axis; border crenulated.
Coal Measures of Kansas and Missouri.

7. **A. aculeata** Shumard. Carbonic–Permic.
Primary tubercles small, but prominent on elevated, smooth boss, with deep, circular canal; areola broad, exteriorly marked with obscure striæ and secondary tubercles; primary spine, elongate, fusiform, with rather coarse, oblique spinules; often curved at base and apex.
Upper Coal Measures of Texas and Missouri; Permic of Kansas.

III. LEPIDOCIDARIS Meek and Worthen.

Differs from *Archæocidaris* in having additional partial column of ambulacral plates, due to the fact that the individual plates do not always pass across the half area, and up to eight columns of interambulacrals. Mississippic.

8. **L. squamosa** Meek and Worthen. (Fig. 1915, *d*.) Mississippic.
Ambulacra small, low, often not passing across the half area;

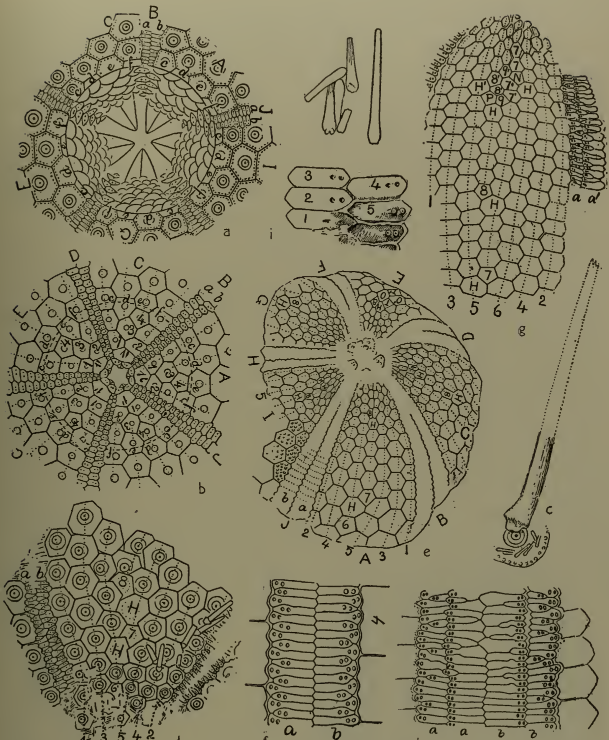

FIG. 1915. *a–c*, *Archæocidaris wortheni* : *a*, restoration of ventral surface (*a*, *b*, ambulacral ; *c–f*, interambulacral plates) ; *b*, ideal reconstruction of plates resorbed in fig. *a*, showing a single initial column of interambulacral plates ; *c*, plate with primary and secondary spines ; *d*, *Lepidocidaris squamosa*, an interambulacrum flanked by ambulacra on each side, showing 5 columns of former at ventral surface and appearance of 6th, 7th and 8th column above a heptagonal plate (*H*) ; *e*, *Rhoechinus gracilis*, a partial internal mold showing order of appearance of columns of interambulacral plates, × 1½ ; *f*, *R. elegans*, ambulacrum enlarged ; *g–j*, *Oligcporus danæ* : *g*, interambulacrum with part of amb. bordering, showing order of appearance of plates as shown by numerals, × ⅔ ; *h*, ambulacral area, × 1½, showing two partial additional columns of plates ; *i*, amb. plates separated by silicification and spines, × 4. (All after Jackson.)

five columns of interambulacrals at ventral border, increasing to eight; spines slender, smooth or finely striated, of circular section. Lower Burlington of Iowa.

IV. Lepidechinus Hall.

Plates of corona of type of *Archæocidaris,* but strongly imbricating; ambulacra with two columns imbricating adorally (downwards); interambulacra with 8–11 columns imbricating aborally (upwards) and from center outwards. Devonic–Mississippic.

9. **L. rarispinum** Hall. Mississippic.
Interambulacral areas with 11 columns of plates in adult (ambitus), where they are elevated into short spines.
Waverly of Ohio and Pennsylvania.

V. Rhoechinus Keeping.

Plates of corona not imbricating, without large tubercles, but covered by numerous pits for insertion of spines; ambulacra of two columns, interambulacra of 4–8. Mississippic–Carbonic.

10. **R. burlingtonensis** Meek and Worthen. Mississippic.
Six columns of interambulacra in adult.
Burlington of Iowa.

11. **R. gracilis** Meek and Worthen. (Fig. 1915, *e*.) Mississippic.
Eight columns of interambulacra in adult.
Burlington of Iowa and Kentucky.

Fig. 1916. *Oligoporus nobilis,* × ½. (After Meek and Worthen.)

VI. Oligoporus Meek and Worthen.

In general form and proportions like *Melonites,* but the ambulacra have only four columns of plates and the interambulacra five to nine at equator or ambitus (adult character). Mississippic.

12. **O. nobilis** Meek and Worthen. (Fig. 1916.) Mississippic.
With four columns of interambulacral plates in the adult.
Burlington of Illinois; Keokuk of Iowa.

13. **O. danæ** Meek and Worthen. (Fig. 1915, *g–j*.) Mississippic.
Four columns of ambulacral plates with occasional short plates,

making fifth and sixth and even seventh and eighth incomplete columns; interambulacra nine in adult.

Keokuk of Illinois, Missouri and Iowa.

VII. Melonites Norwood and Owen.

Test very large, ellipsoidal, grooved longitudinally. Ambulacra broad, concave on both sides of a median ridge, with six to fourteen columns of plates, each perforated near its outer border by a pair of pores. Plates slightly imbricated, the median rows the largest. Interambulacra with four to eleven columns of plates diminishing in number toward the poles. The median plates are six-sided, the two rows adjacent to the ambulacra are five-sided, with the edges indented by the zigzag of the ambulacral plates. Edges of plates sometimes oblique, especially when thick. Tubercles very small, numerous. Spines minute, very thin, needle-like. Periproct circular. Genital plates with three to five genital apertures each. Oculars with a single pore.

The interambulacra enter the peristomial margin as two plates. Passing dorsally new columns are introduced, the first plates of which are five-sided with the most prominent apex pointing ventrally. A ventrally adjacent plate of one of the bounding columns is characteristically seven-sided. Newly added plates dorsally are more or less rhombic in outline. This facilitates the orientation of obscure fragments. Mississippic.

14. **M. multiporus** Norwood and Owen. (Fig. 1917, *a–c*.) Mississippic.

With ten ambulacral and seven to eight or nine interambulacral columns of plates.

The most characteristic fossil of the St. Louis limestone of Missouri, Indiana, Tennessee, Kentucky, etc.

VIII. Lepidesthes Meek and Worthen.

Large; plates of corona regular and imbricated; interambulacra from 3–7 columns, imbricating aborally and laterally; ambulacra broad, from 8–18 (or perhaps 20?) columns, imbricating adorally with pores in center of plates. Mississippic.

15. **L. wortheni** Jackson. (Fig. 1917, *d*.) Mississippic.

With seven to eight columns of ambulacra in adult and interambulacra beginning as four, but subsequently reduced to three columns.

Keokuk of Indiana.

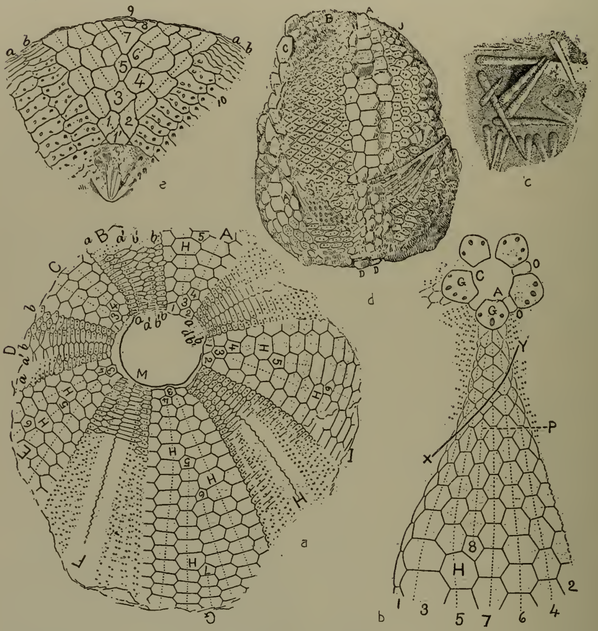

FIG. 1917. *a–c*, *Melonites multiporus*, a part of corona from oral or ventral end, showing two columns at peristome (*A*, *C* and *I*) and three (*E*, *G*). Amb. 4. *b*, dorsal portion of interambulacrum, and the separation of plates in columns. The full number of columns is shown by plates along line, *X–Y*. *a*, genital plates, with 3 or 4 pores; *o*, imperforate ocular plates, × 1½; *c*, spines, × 4; *d*, *Lepidesthes wortheni*, a crushed specimen, × 1½, showing broad amb. area and 4 (later 3) interamb.; *D.D*, dental pyramids; *e*, *Lepidechinus rarispinus*, oral aspect, showing single interamb. increasing to 8, × 1½. (After R. T. Jackson and T. A. Jaggar, Jr.)

16. **L. colletti** White. Mississippic.

With 18 (or 20?) ambulacral, and 4–5 interambulacral columns.

Keokuk of Indiana.

IX. Pholidocidaris Meek and Worthen.

With coarse, highly irregular, imbricating interambulacral plates, of which it has five or more columns; and six or more columns of irregular, much smaller ambulacral plates; large spines at scattered intervals. Distinguished from *Lepidechinus* by the much greater breadth of its ambulacral areas, by its more numerous rows of ambulacral pieces and pores and by larger size. Mississippic.

17. **P. irregularis** Meek and Worthen. Mississippic.

Marginal interambulacral plates large, elliptical, each bearing a cylindrical spine about one inch long; number of columns 5–6; ambulacral plates most irregular in size, increasing in size and decreasing in number towards end of area.

Keokuk of Illinois.

Subclass **Euechinoidea** Bronn.

Order CIDAROIDA Duncan.

X. Cidaris Klein.

Test spheroidal. Mouth opening central below. Anal opening subcentral above. Ambulacra narrow, undulating, extending from top to bottom and composed of very numerous plates. The pairs of pores are arranged in a single series, the two pores of each pair rather close and separated by a small knob or ridge. Primary tubercles perforated and crenulated. Permic–Recent.

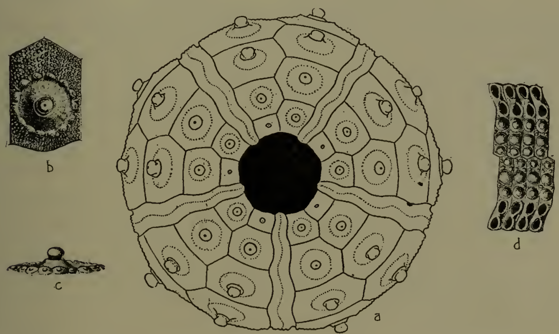

Fig. 1918. *Cidaris texana.* *a*, test restored, × ⅔; *b*, interambulacral plate enlarged; *c*, tubercle much enlarged; *d*, portion of ambulacral area enlarged. (After Clark.)

18. **C. texana** Clark. (Fig. 1918.) Comanchic.

Test large. Ambulacral areas with four rows of granules between the pore-bearing zones on the under side, increased to six at the ambitus and reduced to two at the apex. Pores oval, separated by transverse ridges which partially envelop the openings. Areolas circular, depressed.

Washita of Texas.

XI. Leiocidaris Desor.

Test large, swollen. Differs from *Cidaris* in having the two pores of each pair distant and united by a groove. Tubercles

Fig. 1919. *Leiocidaris hemigranosa*, upper and lateral views, × ⅔. (After Clark.)

large, not crenulated. Spines large, smooth, cylindrical. Cretacic–Recent.

19. **L. hemigranosa** (Shumard). (Fig. 1919.) Comanchic.

Ambulacral areas with six rows of granules in the middle. Pore-bearing zones deeply depressed.

Denison (Washita) of Texas.

Order DIADEMATOIDA Duncan.

XII. Diadema Schynvoet (includes *Pseudodiadema* Desor).

Test highly ornamented. Ambulacra straight, with two vertical rows of small primary perforate and crenulate tubercles extending from mouth to apex. Pairs of pores in simple vertical series or in arcs of threes. Interambulacra with two or more vertical rows of primary tubercles resembling those of the ambulacra but larger. Secondary tubercles and granules surrounding the areolas. Spines long, hollow, longitudinally striated. Mouth large, polygonal. Jurassic–Recent.

20. **D. (Pseudodiadema) texanum** (Roemer). (Fig. 1920.)
Comanchic.

Small, depressed. Sides inflated. Upper and lower surfaces

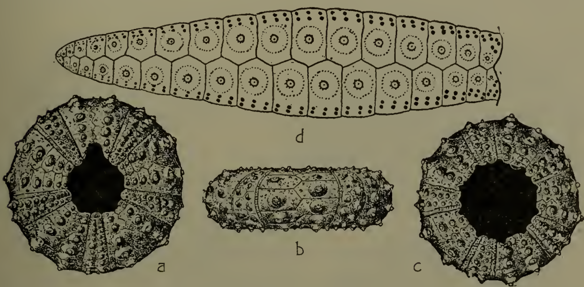

FIG. 1920. *Diadema* (*Pseudodiadema*) *texanum*. *a*, upper surface; *b*, side view; *c*, lower surface; *d*, ambulacral area enlarged. (After Clark.)

equally flattened. Pores in a single series. Peristome wide; periproct subcircular, with deep cut in right anterior ambulacrum.

Fredericksburg of Texas.

XIII. DIPLOPODIA McCoy.

Differs from *Diadema* in having the pairs of pores in double vertical rows near the center of top and bottom of test and single at the ambitus. Jurassic and Cretacic.

21. **D. texana** (Roemer). (*Cyphosoma texanum.*) (Fig. 1921, *a–d.*)
Comanchic.

Large, with inflated sides. Lower surface concave. Pores in single pairs from mouth to ambitus (except immediately bordering the mouth) beyond which to the apex they are in double rows. Periproct large, subpentagonal.

Comanche-Peak (Fredericksburgian) of Texas.

XIV. PEDINOPSIS Cotteau.

Differs from *Diplopodia* in having more than one tubercle on ambulacral plate, and numerous smaller tubercles on interambulacral. Large, round, ventricose, sometimes subconical; ambulacral pore-belts straight, broad, with a simple paired row of double pores on the under side; tubercles small, with median perforation and crenulated. Comanchic–Cretacic.

22. **P. pondi** Clark. (Fig. 1921, *e–g*.) Cretacic.

Under surface flattened, with a slight concavity near the region of the mouth opening; ambulacra with six rows, and interambu-

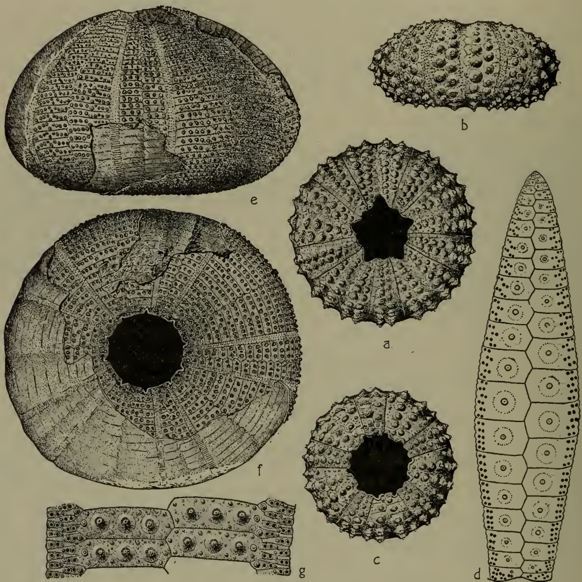

FIG. 1921. *a–d, Diplopodia texana: a*, upper surface; *b*, side view; *c*, lower surface of smaller individual, all × ⅔; *d*, ambulacral area enlarged; *e–g, Pedinopsis pondi: e*, lateral, *f*, lower surface, both × ⅔; *g*, ambulacral plates enlarged. (After Clark.)

lacra with twenty rows of tubercles at the ambitus; tubercles small, equal, crenulated and perforated; peristomial opening small, with distinct incisions.

Austin Chalk (Niobrara) of Texas.

XV. Cyphosoma Agassiz.

Test depressed, highly ornamented. Ambulacra with well-developed pore-bearing zones, undulating, and each plate with three to seven pairs of pores in an arc. Pairs of pores in two rows at the apex and crowded at the mouth opening. Interambulacra with two or more vertical rows of primary tubercles which are imperforate and crenulate, like those of the ambulacra. Apical system encroaching upon the posterior interambulacrum. Jurassic–Recent.

23. **C. volanum** Cragin. Comanchic.

Small, similar in form to *Pseudodiadema texanum;* pore belts sinuous; ambulacral area with two vertical rows of primary tubercles, surrounded by narrow strings of granules in polygons; interambulacral area with two rows of large primary tubercles, with a row of smaller ones on either side of the area.

Upper Washita of Texas.

Order HOLECTYPOIDA Duncan.

XVI. Holectypus Desor.

Ambulacra narrow, straight, widest at the ambitus; some of the plates compound. Interambulacra with rather large plates and

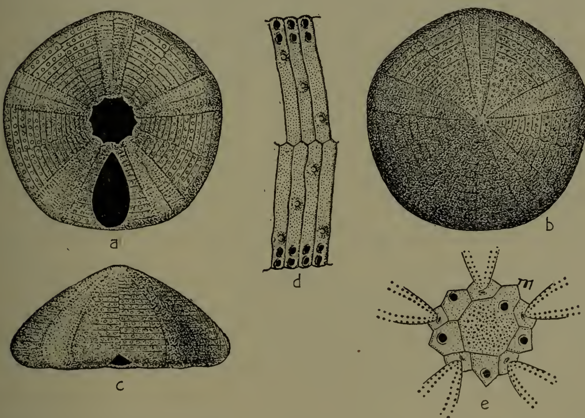

Fig. 1922. *Holectypus planatus.* *a*, lower, *b*, upper, *c*, posterior view; *d*, ambulacral plates much enlarged; *e*, apical system enlarged. (After Clark.)

many rows of tubercles. Mouth opening ten-angled. Anal opening large, pear-shaped, situated between the mouth and the posterior edge of the test. Apical disk small, central. Jurassic–Cretacic.

24. **H. planatus** Roemer. (Fig. 1922.) Comanchic.

Subcircular, subconical, flattened on under surface. Ambulacra with six irregular rows of tubercles. Pores in single pairs. Interambulacra with numerous narrow plates, each plate with a nearly horizontal row of small tubercles.

Widely distributed in the Fredericksburg and Washita of Texas.

25. **H. charltoni** Cragin. Comanchic.

Larger than preceding and less elevated; quinquelaterally rotund; apex tending to rise slightly from a somewhat flattened summit-region; periproct two or three times smaller in proportion than in preceding, inframarginal, and widely separated from peristome; subovate.

Upper Washita of Texas.

Order CLYPEASTROIDA Duncan.

XVII. Diplothecanthus Duncan.

More or less pentagonal echinoidea, generally of large size, with central peristome and small marginal periproct; dorsal or abactinal surface convex, high; ambulacra petaloid; ventral or actinal surface hollowed to the deeply-placed central peristome; actinal furrows straight; internal structures in the form of pillars, investing the ambulacra with a double wall, but not forming concentric partitions near the edges; surface with fine spines. Tertiary–Recent.

26. **D. reticulatus** (Linnæus). (*Clypeaster* (*Echinanthus*) *rosaceous* A. Agassiz.) Tertiary–Recent.

Subelliptical, with rounded posterior end, the form obscurely pentagonal; posterior petals longest; actinal surface often flat for a short distance before descending to deep peristome.

Oligocenic (?) of Cedar Keys, Florida; Tertiary of West Indies and San Domingo; living to depth of five fathoms off coast of South Carolina to the Bahamas, Cuba and Guadaloupe. (There seems to be no important difference between the Tertiary and Recent forms.)

XVIII. Periarchus Conrad.

Scutelloid, with central apex more or less abruptly elevated, short ambulacra open at the ends, and extending only half way to the margin; periproct on under side nearer the mouth than the margin. Eocenic–Oligocenic.

27. **P. lyelli** (Conrad). Eocenic–Oligocenic.

Margin thin, gently concave for less than one fourth the diameter, rising abruptly in center to apical system; ambulacra uniform; length a little more than one fourth the diameter of test, actinal surface flat; grooves bifurcating; diameter 80 mm.

Claibornian of Alabama; Vicksburgian of Georgia.

XIX. Scutella Lamarck.

Test very flat, subcircular in outline, sometimes undulating or notched, broadest behind. Ambulacral furrows branching; petaloid part of ambulacra unequal, well-developed, nearly closed; peri-

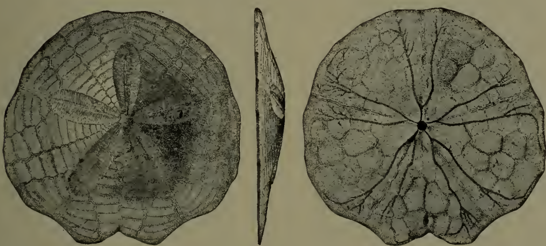

Fig. 1923. *Scutella alberti*, upper, lateral and lower view, × ⅓. (Md. Survey.)

stome small, central, subcircular; periproct very small, mostly inframarginal; apical system central, more or less pentagonal. Tertiary.

28. **S. alberti** Conrad. (Fig. 1923.) Miocenic.

Discoidal, orbicular, very much depressed, but swelling towards the middle, and depressed at apex; diameter 160 mm. × 150 mm.

Chesapeakean (Choptank) of Maryland. (Abundant.)

29. **S. fairbanksi** Merriam. Miocenic.

Smaller than preceding (maximum diameter 36 mm.), broadest posteriorly; margin scarcely notched.

Lower Miocenic (Vaqueros formation) of California.

XX. Echinarachnius Leske.

Differs from *Scutella* in its excentric apical system. Pliocenic–Recent.

30. **E. gibbsi** Rémond. Pliocenic.

In outline much like *Scutella fairbanksi,* but larger, and apical system about one fourth the longitudinal diameter from the posterior end; ambulacra broad, the transverse grooves continued nearly to center; posterior petals flexuous; periproct submarginal.

Fernando of California.

31. **E. interlineatus** Stimpson. (Fig. 1924.) Pliocenic.

Large (ranging to over 120 mm. in diameter), pentagonal to circular; summit nearly central, in front of excentric apical system;

Fig. 1924. *Echinarachnius interlineatus,* × ⅔. (After Merriam.)

Fig. 1925. *Echinarachnius excentricus,* × ⅔. (After Merriam.)

posterior pair of petals shortest; anterior petal open in front, the others closed; periproct supramarginal; ambulacral furrows dichotomise near peristome.

Common in the Merced series of California.

32. **E. excentricus** Eschscholtz. (Fig. 1925.) Pliocenic–Recent.

Apical system excentric, one third diameter from posterior end; posterior pair of petals shortest, wide and nearly closed; summit in front of apical system. Larger than preceding.

San Pedro of California; also Recent on Pacific coast.

XXI. Mortonia Desor.

Depressed, of medium size, more or less circular to subpentahedral, with swollen instead of sharp borders; ambulacral petals long, open at the ends; ambulacral grooves on under side single or bifurcating twice; periproct between peristome and border. Eocenic–Oligocenic.

33. **M. quinquefaria** Say. Oligocenic.

Slightly wider posteriorly, but in general subcircular; periproct approximately at two fifths of the distance from margin to peristome.

Vicksburgian of Georgia and Cedar Keys, Florida.

34. **M. rogersi** Conrad. Oligocenic.

Subpentahedral, with peristome more strongly depressed than in preceding; ambulacral petals wider, open in front; periproct nearer to margin than in preceding. (Type of genus.)

Vicksburgian of Georgia and Mississippi.

XXII. Mellita Klein.

Test flat as in *Scutella,* but with five or six usually closed lunules, or more rarely open cuts, one at the end of each ambulacrum, and

Fig. 1926. *Mellita caroliniana,* ventral, lateral and dorsal views, slightly reduced. (After McCrady.)

one in center of posterior interambulacrum; posterior petals longest; periproct at proximal end of posterior lunule, close to the mouth. Pliocenic–Recent.

35. **M. caroliniana** McCrady. (Fig. 1926.) Pliocenic.

Slightly wider behind; posterior lunule twice as long as others. Differs from the recent *M. sexforis* Lamarck of the Atlantic coast of southern United States and Mexico, in its more orbicular form, more regular convex upper surface, smaller lunules, with slight depression extending to the margin, and less branched ambulacral furrows on under side.

Pliocenic marls of South Carolina, etc.

XXIII. Encope Agassiz.

Larger and thicker than *Mellita,* more or less subpentahedral, with broad notch or lunule in median line of each ambulacrum, and large lunule in posterior interambulacrum. Pliocenic to Recent.

36. **E. macrophora** Ravenel. (Fig. 1927.) Pliocenic.

Large; posterior lunule broad and surrounded by elevated rim; posterior end gently rounded, not notched; marginal notches shal-

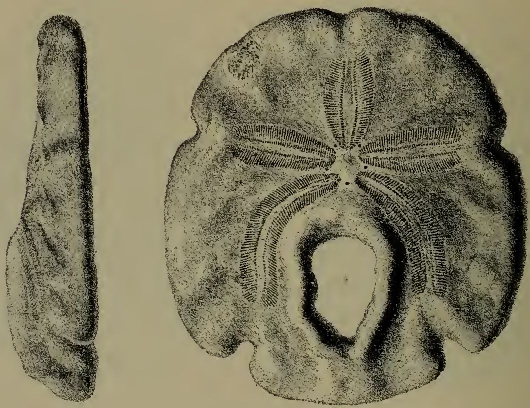

Fig. 1927. *Encope macrophcra,* lateral and dorsal views. Natural size. (After McCrady.)

low, posterior lateral pair deepest; periproct on proximal slope of posterior lunule. Related to recent *E. grandis* Agassiz of Lower California coast.

Pliocenic marls of South Carolina.

Order SPATANGOIDA Duncan.

XXIV. Echinobrissus Breyn.

Test variable, concave beneath. Ambulacra unequal, open at the end of the subpetaloid parts. Pairs of pores in simple series, the outer ones elongate. Below the subpetaloid parts the pores are in small oblique pairs sometimes united by grooves. Peristome anterior to center. Periproct at upper end of a groove situated on the upper surface of the test. Jurassic–Tertiary.

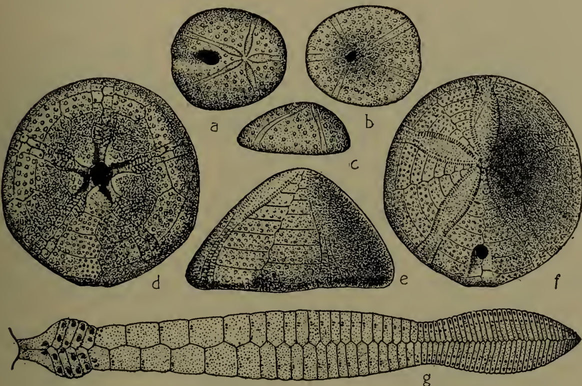

Fig. 1928. *a–c*, *Echinobrissus texanus*, upper, under and side views; *d–g*, *Cassidulus florealis*, lower, lateral and upper views and enlargement of right postero-lateral ambulacrum. (After Clark.)

37. **E. texanus** Clark. (Fig. 1928, *a–c*.) Cretacic.
Test ovate, rounded and low anteriorly, subquadrate posteriorly. Ambulacra narrow. Apical disk forward of center. Mouth opening small.

Austin chalk (Niobrara) of Texas.

XXV. Cassidulus Lamarck.

Test small, oblong, depressed convex dorsally, flat below; ambulacra short, subpetaloid, not closing; pores continued from the middle part to the well-developed floscelle; mouth in front of middle; periproct longitudinally elongated, on the upper posterior margin. Cretacic–Eocenic.

38. **C. florealis** (Morton). (Fig. 1928, *d–g*.) Cretacic.

Marginal outline somewhat five-angled, angular posteriorly. Apex slightly in front of center. Interambulacra wide, covered with small perforated tubercles; peristome pentagonal, with the ambulacral areas near it broadened and conspicuous; periproct in a short, narrow furrow.

Ripleyan of New Jersey (?) and Delaware.

39. **C. æquoreus** Morton. (Figs. 1929, 1930.) Cretacic.

Differs from preceding in its more depressed and elongated form.

Ripleyan of New Jersey and Alabama.

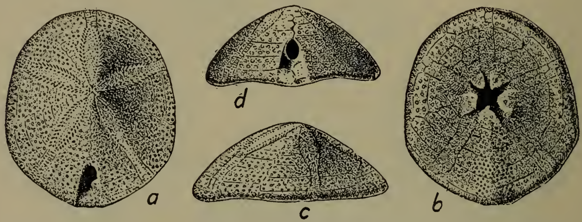

FIG. 1929. *Cassidulus æquoreus.* *a*, dorsal view; *b*, ventral view; *c*, lateral view; *d*, posterior view. (After W. B. Clark.)

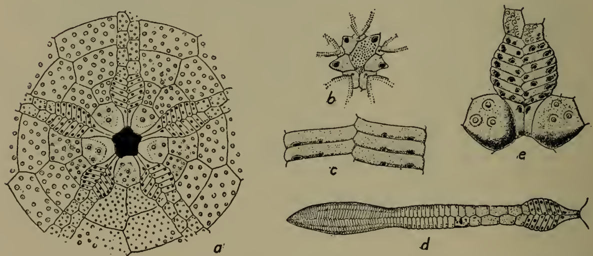

FIG. 1930. *Cassidulus æquoreus.* *a*, diagram showing arrangement of plates into a floscelle around the peristome; *b*, apical disc, much enlarged; *c*, several plates of petaloid region of anterior ambulacrum, much enlarged; *d*, anterior ambulacrum enlarged; *e*, several plates of same, of oral region, much enlarged. (After W. B. Clark.)

XXVI. ECHINOCORYS Breyn. (*Ananchytes* Mercati.)

Test large, oval in marginal outline, high. Upper surface rounded or keeled. Lower surface flat. Ambulacra with but two pairs of pores which are best developed toward the center of the upper surface. Posterior ambulacra long and broad, with oblique pores. Peristome transversely oval; periproct oval, beneath the posterior margin; apical system elongate. Cretacic.

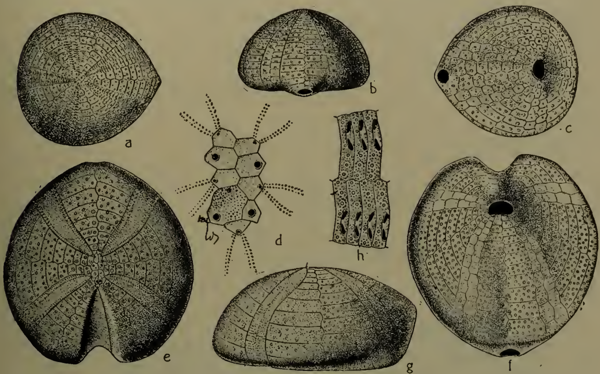

FIG. 1931. *a–d, Echinocorys ovalis,* dorsal, posterior and ventral views, × ⅔, and enlargement of apical system; *e–h, Cardiaster cinctus,* dorsal, ventral and lateral views, × ⅔, and enlargement of ambulacral plate. (After Clark.)

40. **E. ovalis** Clark. (Fig. 1931, *a–d.*) Cretacic.

Test contracted posteriorly; peristome near anterior margin; periproct situated on a slight elevation.

Jerseyan (Vincentown) of New Jersey.

XXVII. Holaster Agassiz.

Test oval in marginal outline, flat beneath, swollen and high above. Plates large. Anterior ambulacrum in a shallow groove. Mouth opening subanterior, elliptical, broadest transversely. Anal opening situated above the lower posterior margin, oval. Apical system elongate. Comanchic to Tertiary.

41. **H. completus** Cragin. Comanchic.

Rather small, subcylindrical on a rotund ovate to broadly oval base; sides subvertical but slightly convex; summit flattish-convex; unpaired ambulacrum about as conspicuous as the others; madreporic function shared by four genital plates.

Washita of Texas.

XXVIII. CARDIASTER Forbes.

Similar to *Holaster,* but anterior groove deeper and with angular margin. Anal opening oval, placed in a depression in the truncate posterior face. A more or less complete marginal fasciole present, passing beneath the anal opening. Cretacic.

42. **C. cinctus** Morton. (Fig. 1931, *e–h.*) Cretacic.

Test cordate. Anal opening oval, situated on the truncated posterior face.

Middle marl bed of New Jersey.

XXIX. EPIASTER d'Orbigny. (*Macraster* Roemer.)

Test heart-shaped, longer than broad. Anterior ambulacrum in a groove. Paired ambulacra petaloid dorsally, with elongate, unequal pores. Interambulacra swollen dorsally. Mouth opening

FIG. 1932. *Epiaster elegans*, lower, lateral and upper views, × ⅓. (Md. Survey.)

transversely oval, swollen anteriorly and usually with projecting lip. Anal opening longitudinal, situated above the lower posterior margin. Comanchic.

43. **E. elegans** (Shumard). (Fig. 1932.) Comanchic.

Large, flattened above and below. Anterior groove shallow. Posterior margin truncate. Apical disk small, compact. Anal opening oval, on truncated posterior margin.

Characteristic of Fort Worth limestone (Washita) of Texas.

44. **E. whitei** Clark. (Fig. 1933, *a–c.*) Comanchic.

Small. Anal opening high on the posterior surface.

Washita of Texas.

XXX. Enallaster d'Orbigny.

Test heart-shaped, longer than broad, with an anterior groove. Petaloid parts of the anterolateral ambulacra divergent, flexuous, tending to close, and with very unequal pore-bearing zones of which the posterior are the larger. Pairs of pores oblique. Posterolateral ambulacra short, divergent. Mouth opening wide, with lip. Anal opening in truncated posterior surface. Comanchic.

45. **E. texanus** (Roemer). (*Toxaster texanus.*) (Fig. 1933, *d–g.*) Comanchic.

Test broad in anterior portion. Anterior groove deep. Upper surface convex, elevated. Base flat, depressed at mouth opening. Ambulacra narrow, unequal, the posterolateral pair much shorter than the others. Anal opening high on the posterior margin.

Characteristic of Comanche Peak (Fredericksburg) of Texas.

XXXI. Hemiaster Desor.

Test heart-shaped, longer than broad, depressed, with numerous plates and an anterior groove. The two posterior ambulacra meet close together and are separated from the three anterior by a

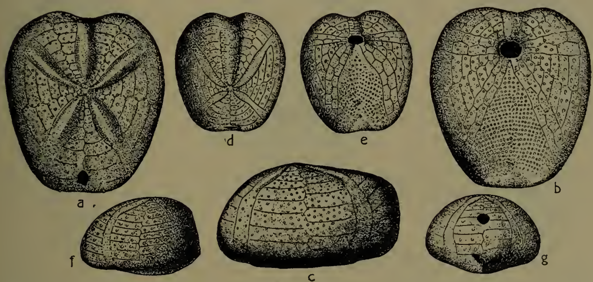

FIG. 1933. *a–c, Epiaster whitei,* upper, lower and lateral views, × ⅔; *d–g, Enallaster texanus,* upper, lower, lateral and posterior views, × ⅔. (After Clark.)

wide space. The anterior ambulacrum lies in a shallow groove; pores oblique and in pairs on either side. The anterolateral ambulacra diverge, are dorsally sunken, petaloid, and much longer than the posterolateral. Pores of the petaloid portion united, the outer ones usually the largest. A fasciole present near the edge of the test, surrounding the petaloid parts. Cretacic–Recent.

46. **H. texanus** Roemer. (Fig. 1934, *f–h*.) Cretacic.

Anterior groove broad and deep. Anterolateral ambulacra bent backward in upper portion. Mouth opening large, transversely oval. Anal opening large, oval, at center of truncated posterior surface.

Characteristic of the Austin (Niobrara) of Texas.

47. **H. lacunosus** Slocum. (Fig. 1935.) Cretacic.

Differs from *H. parastatus* in its smaller size and in the presence of sunken areoles around the tubercles; posterior interambulacral area rounded.

Ripleyan of Mississippi.

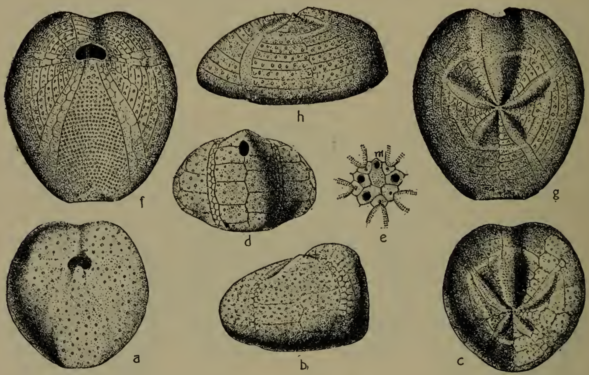

FIG. 1934. *a–e*, *Hemiaster parastatus*, lower, lateral, upper and posterior views, × ⅔, and adoral area enlarged; *f–h*, *H. texanus*, lower, upper and lateral views, × ⅔. (After Clark.)

48. **H. parastatus** (Morton). (Fig. 1934, *a–e*.) Cretacic.

Upper surface elevated, with a deep anterior groove and a sharp posterior ridge, the latter truncated by the flat, nearly vertical posterior margin. Petaloid areas depressed, anterior pair bent backward at their center and about twice the length of the posterior. Mouth opening with distinct overhanging lip. Anal opening small, situated high on the truncated posterior surface.

Ripleyan of Alabama and Mississippi; Jerseyan of New Jersey (Vincentown).

XXXII. Linthia Merian.

Test heart-shaped, longer than broad; anterolateral ambulacra differing from the posterolateral in shape and construction. Anterior ambulacrum in a deep groove, the pores round and small, in

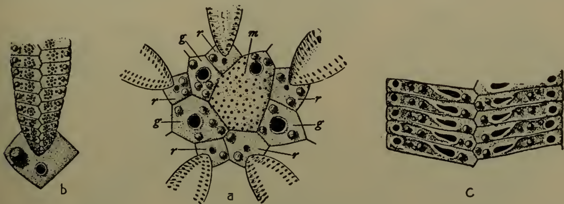

Fig. 1935. *Hemiaster lacunosus.* *a*, apical system, greatly enlarged (*g*, genital plates; *m*, madreporite; *r*, radial plates); *b*, portion of anterior petal where it joins the apical system, greatly enlarged; *c*, several plates of the right anterior petal, greatly enlarged. (After A. W. Slocum.)

pairs on either side. Anterolateral ambulacra longer and more divergent than the others, with petals sunk in grooves. Pores united by grooves. A peripetalous and lateral fasciole present. Cretacic–Recent.

49. **L. variabilis** Slocum. (Figs. 1911, 1936.) Cretacic.

About half the size of *L. tumidula*, the posterior portion often

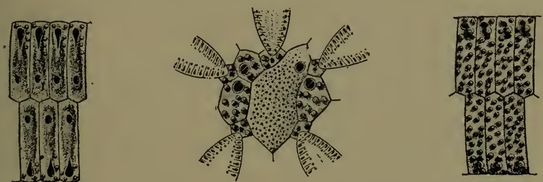

Fig. 1936. *Linthia variabilis*, several plates of the left posterior petal, greatly enlarged; apical system, greatly enlarged; several plates of the anterior petal, greatly enlarged. (After A. W. Slocum.)

strongly elevated and truncate; ambulacral petals proportionately shorter and broader.

Ripleyan of Mississippi.

50. **L. tumidula** Clark. (Fig. 1937, *a–d*.) Cretacic.

Test elevated. Apex central. Posterior border obliquely truncated, bearing the anal opening. Fascioles distinct.

Jerseyan (Vincentown lime sand) of New Jersey.

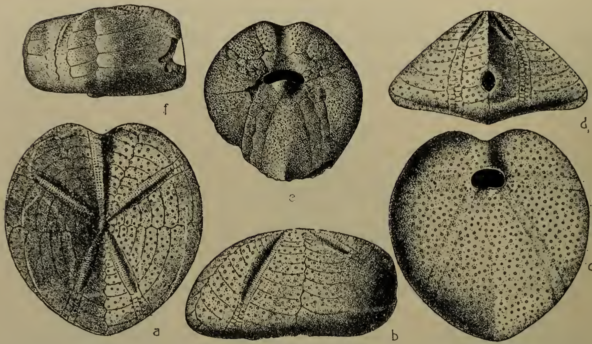

Fig. 1937. *a–d*, *Linthia tumidula*, upper, lateral, lower and posterior views, × 2/3; *e*, *f*, *Echinocardium orthonotum*, lower and lateral views, × 2/3. (After Clark.)

XXXIII. Maretia Gray.

Elongate, subpentahedral echinoids with more or less flattened test; petaloid ambulacra long and rather narrow, in shallow grooves, the anterior one reduced and nearly flush; peristome small, excentric on flat under side; periproct on swollen posterior end, above the margin. Interambulacra with comparatively coarse tubercles, except the posterior one; on the actinal side the posterior ambulacral spaces are smooth. Eocenic–Recent.

51. **M. ruspatangus** Conrad. Oligocenic.

Anterior end with faint impression by frontal groove, dying away upwards; form slightly heart-shaped; posterior ambulacrum slightly keeled, highest point of shell being formed by it. Differs from recent *M. planulata* in its more truncated anterior and less pointed posterior end and much greater height. Length of average test, 65 mm.; greatest width, 54.4 mm.; height, 32 mm.

Oligocenic of Florida and Georgia.

XXXIV. Echinocardium Gray.

Spatangoid, heart-shaped, swollen; ambulacra in a bivium and trivium, the anterior differing from the others; paired ambulacra short, triangular, pointed below, unequal, divided into two unequal parts; anterior ambulacra long, distinct, depressed; anal aperture oval, large, high up on posterior border, with subanal fasciole; mouth excentric in front; tubercles small. Eocenic–Recent.

52. **E. orthonotum** Conrad. (Fig. 1937, *e, f*.) Miocenic.

Ovate, truncate at each end, higher in front; anterior paired ambulacra triangular, posterior narrow.

Chesapeakean of Virginia and Maryland.

APPENDIX A.

SUMMARY OF NORTH AMERICAN STRATIGRAPHY. TABLES OF GEOLOGICAL FORMATIONS.

The following table gives the subdivisions of the geologic scale as adopted in this work:

PSYCHOZOIC OR QUATERNARY.

- Holocenic or Recent System.
- Pleistocenic System.

CENOZOIC OR TERTIARY.

- Pliocenic System.
- Miocenic System.
- Oligocenic System.
- Eocenic System.

MESOZOIC OR SECONDARY.

- Cretacic System.
- Comanchic System.
- Jurassic System.
- Triassic System.

PALÆOZOIC OR TRANSITION.

- Permic System.
- Carbonic System.
- Mississippic System.
- Devonic System.
- Siluric System.
- Ordovicic System.
- Cambric System.

EOZOIC OR PROTEROZOIC, PRIMARY IN PART.

- Algonkic Systems.

AZOIC OR ARCHÆOZOIC; PRIMARY.

- Archæic Systems.

A. THE PALÆOZOIC SYSTEMS.

I. The Cambric System.

General Subdivisions.—The Cambric of North America admits of the following subdivisions:[1]

Cambric or Taconic.

Upper Cambric or Bretonian. (Including all except the highest beds of the Bretonian of Matthew's St. John Group, as well as the upper half of the Johannian. The *Potsdamian* and *Saratogan* represent the upper part only of the Bretonian in this sense.)

Middle Cambric or Acadian. (In the sense generally used by the U. S. Geological Survey. Includes the Acadian and lower half of the Johannian of Matthew's St. John Group.)

Lower Cambric or Etcheminian (for the Atlantic coast development). Georgian (for the Pacific coast and Appalachian development).

Two main provinces are recognized: the Atlantic and the Pacific. The typical sections for the Atlantic province are found in New Brunswick, Cape Breton and eastern Newfoundland, where the following subdivisions are recognized (Matthew):

Superformation.

Basal Ordovicic shales.

Upper Cambric.

12. Asaphellus homfreyi zone.
11. Dictyonema flabelliforme zone.
10. Peltura scarabeoides zone.
9. Parabolina spinulosa zone.
8. Agnostus pisiformis zone.

Middle Cambric.

7. Paradoxides forchhammeri zone.
6. Paradoxides davidis zone.
5. Paradoxides eteminicus zone.

[1] Grabau, A. W., *Science*, N. S., Vol. 39, pp. 351–356, 1909.

4. Paradoxides lamellatus zone.
3. Protolenus zone.

Lower Cambric.

2. Etcheminian-Holmia bröggeri zone (including the *Smith Point limestones* and shales).
1. Coldbrookian.

Subformation.

Precambric formations.

Zones 3 to 12 inclusive, together with some of the succeeding Ordovicic bed, were grouped by Canadian geologists as the *St. John Formation.* On lithologic grounds Matthew divided this into Div. 1, or *Acadian* (zones 3 to 6 inclusive), Div. 2, *Johannian* (zones 7 to 8 inclusive), and Div. 3, *Bretonian* (zones 9 to 12 inclusive), and the overlying basal Ordovicic.

In eastern Massachusetts the lower Cambric is represented by the *Nahant limestones* and argillites, the *Weymouth shales,* and the *North Attleboro limestones.* All of these carry the Holmia fauna and are of Etcheminian age. The middle Cambric is represented by the *Braintree phyllites,* with *Paradoxides harlani,* representing zone 5 of the Atlantic series. Upper Cambric rocks are known in eastern Massachusetts only from boulders.

The Pacific province has as a subprovince the Appalachian belt, which extends from the Gulf to Labrador. Its faunas were distinct, throughout early and middle Cambric time, from those of the Atlantic province, but became confluent with them in late Neo-Cambric time.

Only lower Cambric strata are so far known from the northern part of the Appalachian area. Here the base of the series is formed by the *Vermont quartzite,* succeeded by the *Stockbridge dolomites.* These include the *Georgia shales* in the type section at Georgia, Franklin County, Vermont, and the *Troy limestones* and *Washington County shales* in eastern New York. In southeastern New York the *Wappinger limestone* carries lower middle and upper Cambric fossils and extends into the base of the Ordovicic. On the western border of the Appalachian trough in the Adirondack region, the *Potsdam sandstone* alone represents the Cambric. It is the highest Cambric zone, equivalent according to Matthew to the *Asaphellus homfreyi* zone of the Atlantic coast, and the *Tremadoc* of England. By overlap this formation rests as a basal sandstone upon the crystallines. South of the Adirondacks, the *Saratoga series* of basal sands, limestones and dolomites (*Neelytown limestones*), rests upon the Precambric, and represents the highest upper Cambric. From it the name *Saratogan* is generally applied to the uppermost Cambric of the interior and western region. The lower portion of the *Hudson River shale* series carries the *Dictyonomena flabelliforme fauna* of the upper Cambric of the Atlantic, this portion being known as the *Schaghticoke shale.*

In New Jersey the base of the Cambric is the *Hardiston quartzite,* which carries the Olenellus fauna. It is succeeded by the *Kittatinny limestone* which ranges in age from Lower Cambric at the base, to Lower Ordovicic at the top. In central Pennsylvania, in the Cumberland valley, the *Reading quartzite* and the *Cumberland limestone* are the approximate equivalents of the New Jersey formations. Southeastward of this in Lancaster County and adjoining districts the series apparently begins somewhat higher up. The base is the *Chickies* (*Chiques*) *quartzite* of Lower Cambric age and this is succeeded by the *York shale* and the *Lancaster limestone,* the latter still carrying the Olenellus fauna in its basal portion.

On the Pennsylvania-Maryland border, the following section is given by Stose:[2]

SUPERFORMATION.	
Beekmantownian.	
UPPER CAMBRIC.	
Conococheague limestone	1,635 ft.
MIDDLE CAMBRIC.	
Elbrook formation	3,000 ft.
Waynesboro formation	1,250 ft.
LOWER CAMBRIC.	
Tomstown limestone	1,000 ft.
Antietam sandstone	500 ft.

[2] *Journal of Geology,* XIV., p. 201; XVI., p. 698. See also Keith, Harper's Ferry Folio.

Harpers formation	2,750 ft.
Weverton sandstone	1,250 ft.

SUBFORMATION.

Algonkian.

The series from the base of the *Tomstown limestone* to the top of the "Lower Trenton" is included in the general term *Shenandoah group* of limestones. The basal series is known as the *Chilhowee series.*

In eastern Tennessee the Cambric section comprises:[3]

SUPERFORMATION.

Chickamauga limestone (Ordovicic).

UPPER CAMBRIC.	
Knox dolomite (partly Lower Ordovicic)	3,500 ft.
MIDDLE CAMBRIC.	
Nolichucky shale	450– 550 ft.
Maryville limestone	350– 500 ft.
Rogersville shale	180– 220 ft.
Rutledge limestone	350– 450 ft.
LOWER CAMBRIC.	
Rome formation	750– 950 ft.
Beaver limestone	300 ft.
Apison shale	1,100 ft.
(a break in the series)	
Hesse sandstone	500 ft.
Murray shale	300 ft.
Nebo sandstone	500 ft.
Nichols shale	550– 800 ft.
Cochran formation	1,100–1,700 ft.
Sandsuck shale	1,000 ft.
(Base not exposed.)	

Elsewhere in eastern Tennessee and in North Carolina, the *Cochran formation* is conglomeritic and varies in thickness up to

[3] Keith, Knoxville Folio.

2,500 ft. Below it is the *Hiwassee slate* 700–1,500 ft. thick and below this the *Snowbird formation* 350–5,000 ft. thick, and resting unconformably upon the Precambric crystallines. These basal Cambric beds are probably all of continental origin.

In central Texas, the Cambric section begins generally with the Middle Cambric, though Lower Cambric has been thought to be present. Comstock[4] divides the Cambric of Texas into:

III.,........................ Katemcy series.
II.,.......................... Riley series.
I.,......................... Hickery series.

In the Rio Grande region of New Mexico and Texas, the *Bliss sandstone* (300 ft.) and the *Shandon quartzite* are referred to the Cambric. In Oklahoma the basal Cambric is the *Regan sandstone* of Middle Cambric age, which here rests by overlap on the Precambric *Tishomingo gneiss.* It is from 50–500 ft. thick, and passes upward into the *Arbuckle limestone,* which ranges in age from upper Middle Cambric at the base, to Lower Ordovicic at the top, Further north, in the Ozark region, the basal Cambric begins with the *La Motte sandstone* which rests unconformably upon the Pre-Cambric. It and the succeeding *Bonneterre limestone* represent the Middle Cambric, while the succeeding *Elvins formation* and *Gasconade limestone* represent the Upper Cambric. The latter, together with the overlying *Roubidoux* and *Jefferson City limestone* of Lower Ordovicic age, has been grouped as the *Potosi* or *Yellville limestone* series. In the upper Mississippi valley, the Upper Cambric alone is represented in the *Saint Croix formation,* which is locally subdivided as follows (Berkey):

SUPERFORMATION.

Oneota dolomite (Ordovicic).

SAINT CROIX FORMATION (Upper Cambric).

5. Jordan sandstone.
4. Saint Lawrence dolomite and shales.
3. Franconia sandstone.
2. Dresbach shale.
1. Hinckley sandstone.

(*Unconformity.*)

[4] First Annual Report, Geol. Survey Texas, 1889–90.

SUBFORMATION.

Pre-Cambric crystallines.

The *Madison sandstone* and *Mendota beds* of Wisconsin are correlated by Winchell with the Jordan and the Saint Lawrence beds respectively, the former carrying *Dikellocephalus osceola* and the latter *D. minnesotensis.* The Franconia is correlated by Hall and Sardeson with the Potsdam of New York.

In the Black Hills and the Front Range region, the Palæozoic begins with Upper Cambric *Deadwood sandstone,* where not overlapped by later formations. West of the Front Range, the formation is known as the *Sawatch quartzite.* It carries a Dikellocephalus fauna.

In Montana and the Canadian extension, only Middle Cambric deposits occur, the lower being overlapped and the upper (if deposited) removed by post-Cambric erosion. The basal bed is the *Flat-head quartzite,* succeeded by the *Gallatin limestone,* the two together constituting the *Barker series.*[5]

The entire Cambric series is well developed in Nevada, Utah, Idaho and the Canadian Rockies.[6]

The section in the Canadian Rockies, with thicknesses, mostly at Mt. Bosworth is as follows:

SUPERFORMATION.

Lower Ordovicic limestones.

UPPER CAMBRIC.

10. Sherbrooke formation......	1,375 ft.
9. Paget formation	360 ft.
8. Bosworth formation	1,855 ft.

MIDDLE CAMBRIC.

7. Eldon formation	2,728 ft.
6. Stephen formation	640 ft.
5. Cathedral formation	1,595–1,800 ft.

[5] Little Belt Mt. Folio.

[6] Walcott, "Nomenclature of Some Cambrian Cordilleran Formations," Smithsonian Miscellaneous Collection, Vol. 53, No. 1809; "Cambrian Sections of the Cordilleran Area," *ibid.,* Vol. 53, No. 1812.

LOWER CAMBRIC.

4. Mt. Whyte formation......	390 ft.
3. St. Piran formation	2,705 ft.
2. Lake Louise formation.....	105 ft.
1. Fairview formation	1,000 ft.

Base not known.

Canadian geologists have grouped formations 1 to 3 inclusive as the *Bow River Group* and the remainder, together with some of the basal Ordovicic, as the *Castle Mountain Group*.

The section in northeastern Utah and southern Idaho includes:

SUPERFORMATION.

Lower Ordovicic (Upper St. Charles).

UPPER CAMBRIC.

St. Charles formation	1,227 ft.

MIDDLE CAMBRIC.

Nounan formation	1,041 ft.
Bloomington formation..............	1,320 ft.
Blacksmith formation	570 ft.
Ute formation	729 ft.
Spence shale	30 ft.
Langston formation	498 ft.
Brigham formation	1,232 ft.

Base not exposed.

In the House Range, Utah, the following section occurs:

SUPERFORMATION.

Lower Ordovicic (Upper Notch Peak).

UPPER CAMBRIC.

Notch Peak formation	1,490 ft.
Orr formation	1,825 ft.

MIDDLE CAMBRIC.

Weeks formation	1,390 ft.
Marjum formation	1,102 ft.
Wheeler formation	570 ft.
Swasey formation	340 ft.

Dome formation	355 ft.
Howell formation	435 ft.
Spence formation	20 ft.
Langston (?)	205 ft.

Lower Cambric.

Pioche formation	125 ft.
Prospect Mountain formation	1,200 ft.

Base unknown.

In the foregoing sections, the following definite correlations are made: *Pioche* and *Mt. Whyte; Spence* and *Stephen; Notch Peak, St. Charles* and *Sherbrooke.*

In central Nevada (Eureka district) the following section occurs:

Superformation.

Pogonip limestones (Lower Ordovicic)	3,000–5,000 ft.

Upper Cambric.

Lower part of Pogonip limestone.	
Dunderberg shale..............	350 ft.

Middle Cambric.

Hamburg limestone (partly perhaps Upper Cambric)........	1,200 ft.
Secret Canyon shale............	1,600 ft.
Upper Eldorado limestone.	

Lower Cambric.

Lower Eldorado limestone......	3,050 ft.
Prospect Mountain quartzite....	1,500 ft.

Base unknown.

In west British Columbia and the Yukon Territory, the Cambric appears to be represented by the *Adams Lake series* (25,000 ft.) and the *Nisconlith series* (15,000 ft.) of schists, conglomerates and volcanic material, and phyllites with some limestones and quartzites. In Alaska, several more or less metamorphic series are doubtfully referred to the Cambric. These are the *Birch Creek schists* of the middle and lower Yukon region; the *Totsen series* of schists of northern Alaska; and the *Kigluaik series* of gneisses and mica schists with crystalline limestones, in the Seward Peninsula.

II. The Ordovicic System.

General Subdivision.—The Ordovicic system of North America admits of the following general subdivisions:[7]

Ordovicic or Champlainic System.
- Upper Ordovicic or Trentonian.
- Middle Ordovicic or Chazyan (including the Black River limestone and Norman's Kill shales as well as the Lowville and Chazy limestones).
- Lower Ordovicic or Beekmantownian.

In New York the following divisions are recognized:

Superformation:
- Lower to Upper Siluric.
- (*Frequently a disconformity, more rarely an unconformity.*)

Upper Ordovicic (Trentonian).
- Queenston shales.
- Oswego sandstone.
- Lorraine shales.
- Frankfort shales.
- Utica shales.
- Trenton limestone.

Middle Ordovicic (Chazyan).
- Black River limestone.
- Chazy limestone (including Lowville).

Lower Ordovicic (Beekmantownian).
- Beekmantown limestones, etc.

Subformation.
- Upper Cambric Potsdam sandstone.

The typical development is found in the Champlain valley, though here, as in most localities, the lower and middle Ordovicic

[7] Grabau, *loc. cit.*

beds are separated by a disconformity. The Lower Ordovicic or *Beekmantown,* formerly known as the *Calciferous,* is subdivided into five divisions lettered from the base up from A to E. Divisions D to E are also called the *Cassin limestone.* In the Mohawk valley, the lower beds, which rest directly upon the gneiss, are known as the *Little Falls dolomite;* and in the Black River and northern Adirondack region as the *Theresa formation.* In the Hudson valley, a part of the *Hudson River shales* contains the Graptolite fauna of the Lower Ordovicic. These are known as the *Deepkill shales,* their northeastward extension constituting the *Upper Point Levis* beds in Quebec, and the *St. Anne beds* of Newfoundland.

The Chazy is divided into three divisions (A–C) in the Champlain valley, while northeastward, the *Mingen limestones* represent the upper Chazy and Black River horizons. Divisions K to P of the Quebec group of Newfoundland approximately represent the northeastern continuation of the Chazy series. The lower divisions are Beekmantownian and Cambric. In the Ottawa River region, the upper Chazy (*Camarotœchia plena* beds) is known as the *Grenville limestone.* In the Black River region the *Pamelia* and *Lowville* (*Birdseye*) *limestones* represent local phases of the upper Chazy.

The *Black River* limestone forms the transition to the upper Ordovicic. In the Hudson valley it is represented by the *Norman's Kill* shales carrying graptolites.

The *Utica* and *Trenton* replace each other to a greater or less extent. The *Queenston shale* is unfossiliferous and believed to be of continental origin. In the southern Appalachians the Ordovicic section comprises the following divisions:

Superformation.

Basal Siluric (Tuscarora sandstone).

Upper Ordovicic (Trentonian).

Juniata shale and sandstone (continental).
Bald Mountain conglomerate (Tyrone conglomerate) (continental).
Eden sandstone.
Utica shale, generally with some Trenton limestone at the base.

Middle Ordovicic (Chazyan).

Chambersburg limestone.
Lower Stones River limestones.

Lower Ordovicic (Beekmantownian).

Beekmantown limestone.

Subformation.

Upper Cambric (Conococheague limestone).

The beds to the top of the *Chambersburg limestone* are included with the Upper Cambric in the *Shenandoah group.* Further south, in eastern Tennessee, the section comprises

Superformation.

Siluric (basal) (Clinch sandstone).

Upper Ordovicic (Trentonian).

Bays sandstone and shales..... 300–1,100 ft.
Sevier shales .... 2,200–4,100 ft.

Middle Ordovicic (Chazyan).

Chickamauga limestone .... 1,600–2,000 ft.

Lower Ordovicic (Beekmantownian).

Knox dolomite (in part Upper Cambric) .... 3,500 ft.

Subformation.

Upper Cambric.

The Upper *Chickamauga limestone* is in some localities replaced by the *Athens shale* succeeded by the *Tellico sandstone.*

In the Cincinnati dome region, the Upper Ordovicic beds are typically exposed and are classed together as the *Cincinnati group* (Cincinnatian).

The following subdivision has recently been published by Foerste,[8] the approximate correlation being added.

Cincinnatian.

Richmond (=Queenston shales, Juniata sandstone).

Elkhorn beds.
White water beds.

[8] Bull. Denison University, Nov., 1909.

Saluda beds.
Liberty beds.
Waynesville beds.
Blanchester division.
Clarksville division.
Fort Ancient division.
Arnheim beds.

MAYSVILLE (=Lorraine shales).

Mount Auburn beds.
Corryville beds.
Bellevue beds.
Fairmount beds.
Mount Hope beds.

EDEN (=Frankfort shales).

McMicken or Paint Lick beds.
Southgate beds.
Economy beds.

FULTON (Upper Utica in part).

CYNTHIANA (Utica-Trenton).

Nicholas beds.
Greendale beds.
Perryville beds.

UPPER MOHAWKIAN.

LEXINGTON (Trenton?).

Paris beds.
Wilmore beds.
Logana beds.
Curdsville beds.

(Base not exposed.)

In the Nashville region of Tennessee, a part of these beds (Utica-Trenton) is designated the *Nashville group*, beneath which the following Middle Ordovicic beds occur:

UPPER ORDOVICIC.

Nashville group .... 475 ft.

MIDDLE ORDOVICIC.

Black River or Carter's Creek limestone.	80 ft.
Stones River	360 ft.
comprising:	
Glade limestone.	
Ridley limestone.	
Pierce limestone.	
Central limestone.	

The base is formed of the Upper *St. Peter* horizon.

In western Tennessee (Columbia quadrangle) the Ordovicic has been subdivided as follows:

SUPERFORMATION.

Lower Siluric—Clifton limestone.......	60 ft.	
(*disconformity*)		

UPPER ORDOVICIC.

Fernvale formation	0– 40 ft.	Richmond.
(*disconformity*)		
Leipers formation	0–100 ft.	Lorraine.
(*disconformity*)		
Catheys formation	0–100 ft.	Trenton.
Bigby limestone	30–100 ft.	
Hermitage formation	40– 70 ft.	
(*disconformity*)		

MIDDLE ORDOVICIC.

Carters limestone..	40– 60 ft.	Black River
Lebanon limestone.	70–100 ft.	Upper Stones River.

(Base not shown.)

In the Rio Grande region of New Mexico and Texas, the Ordovicic comprises a lower division, the *El Paso limestone* (1,000 ft.) and an upper, the *Montoya limestone* (250 ft.).

In the Arbuckle Mountain region of Oklahoma, the Upper *Arbuckle limestone* represents the Lower Ordovicic, the Middle being represented by the *Simpson formation* and the Upper by the *Viola limestone* and *Sylvan shale*—though the latter may be basal Siluric.

In northern Arkansas, only the lower and late upper Ordovicic beds are represented. The series is:

SUPERFORMATION.

Siluric: St. Clair limestone.

UPPER ORDOVICIC.

Cason shale.
Polk Bayou limestone.
Izard limestone.

(*Hiatus and disconformity.*)

LOWER ORDOVICIC.

Key sandstone.
Yellville limestone.

SUBFORMATION.

Upper Cambric.

The *Yellville limestone* of this section represents lower Beekmantown, while the *Key sandstone* holds the position occupied by the *Saint Peter* farther north. The *Izard limestone* is correlated by Ulrich with late Frankford, Lorraine, and early Richmond, and the *Polk Bayou* and *Cason* with later Richmond.

In the northern Ozarks[9] the Ordovicic begins with the *Roubidoux formation* which is in part Upper Cambric. It is succeeded by the *Jefferson City limestone* and with it represents the lowest Beekmantownian. The *Crystal City sandstone,* the extension of the St. Peter, separates it from the *Joachim limestone,* which represents the Middle Ordovicic. This in turn is succeeded after a hiatus and disconformity, by the *Plattin limestone* of Upper Ordovicic age. In southern Illinois, the *Galena-Trenton* limestone is succeeded after a disconformity by beds of upper Cincinnati (Richmond) age. The series comprises the *Thebes sandstone* and shales and the *Orchard Creek beds* which are succeeded by the *Cape Girardeau limestone,* which contains a fauna of Siluric affinities.[10] This is followed by Niagaran.

In northern Illinois, the following section occurs:

SUPERFORMATION.

Lower Siluric—Niagaran.

[9] Bull. 237, U. S. G. S.

[10] *Alexandrian Formation,* T. E. Savage, *A. J. S.,* XXV., 1908, p. 431.

UPPER ORDOVICIC.		
Cincinnatian		68–250 ft.
(hiatus)		
Galena limestone	}	300–440 ft.
MIDDLE ORDOVICIC.		
Stones River limestone		
Upper St. Peter sandstone	}	150–275 ft.
LOWER ORDOVICIC.		
Lower St. Peter sandstone		
Lower Magnesian (Lower Beekmantown)		450–811 ft.
SUBFORMATION.		
Upper (?) Cambric sandstones.		

In Iowa the following subdivisions of the Ordovicic have recently been published.[11] The classification here adopted being added:

SUPERFORMATION.

Siluric.

UPPER ORDOVICIC.

10. Brainard shale.
9. Fort Atkinson limestone.
8. Clermont shale.
7. Elgin shaly limestone.
   (probably a hiatus)
6. Galena limestone.

MIDDLE ORDOVICIC.

5. Decorah (green) shale.
4. Platteville limestone.
3. Glenwood shale.
2. Saint Peter sandstone.

LOWER ORDOVICIC.

1. Oneota dolomite.

(Base not exposed.)

According to Sardeson the *Decorah shale* is the equivalent of

[11] Ia. Geol. Survey Annual Report, Vol. 16, p. 60.

the "Black River" of his Minnesota section (Fucoid bed (5) and Stictopora bed (4)), and the *Platteville limestone* of his lower *Beloit* or zones 1–3, which by Ulrich and Winchell are classed as Upper Stones River. Calvin includes them with the Galena limestone in the Galena stage and the upper four divisions in the *Maquoketa* stage.

In the upper Missisippi valley (Minnesota and Wisconsin) the following divisions are recognized:

SUPERFORMATION.

Siluric or higher beds.
(*Generally disconformity and hiatus.*)

UPPER ORDOVICIC.

Wykoff beds.........	Approximate correlation =
Maquoketa shales.....	Upper Richmond.
(*great hiatus*)	
Galena limestone	A. c. = Trenton.

MIDDLE ORDOVICIC.

Black River beds.............	A. c. = Black River.
Stones River bed..........	A. c. = Upper Chazy
Upper St. Peter sandstone..	(Lowville, etc.).
(*marked hiatus*)	

LOWER ORDOVICIC.

Lower St. Peter standstone.	A. c. = Lowest Beekmantown.
Shakopee dolomite.........	
Oneota dolomite...........	

SUBFORMATION.

Upper Cambric, Jordan sandstone.

The *Shakopee* and *Oneota* are classed together as the Lower Magnesian limestone series: The *"Stones River"* and *Black River* beds constitute the *Beloit formation* of Sardeson and the *Platteville limestone* of Bain.

In the Black Hills and Rocky Mountain Front Range, Ordovicic strata generally occur. The *Manitou limestone* is the representative of the basal Ordovicic but is not everywhere present. As a rule the section begins with rocks of Trenton age resting by overlap on the Ordovicic or Upper Cambric. At Canyon City, Colorado, the *Harding sandstone,* with a lower Trenton fauna, rests upon the crystallines and is succeeded by the *Fremont limestone* with an Upper Trenton fauna. In the Bighorn Mountains, the *Bighorn limestone* of Black River—early Trenton age rests by overlap on the Upper Cambric, and is succeeded disconformably, after a great hiatus, by the *Madison limestone* of Mississippic age. In the northern portion of the Bighorn uplift, shaly beds with an Upper Richmond fauna succeed the *Bighorn limestone,* being separated from it by a considerable hiatus and by an even greater one from the overlying Mississippic limestone. In the Black Hills, the *Whitewood limestone* with an Upper Trenton fauna rests upon the Upper Cambric Deadwood and is succeeded by Mississippic.

West of the Front Range in Colorado, the Orodovicic *Yule limestone* succeeds the Upper Cambric. It probably represents the Beekmantownian division.

In the Wasatch Mountains, the *Ute limestone* represents Upper Cambric and Lower Ordovicic. It is succeeded by a quartzite formerly called *Ogden* and believed to be in the main, a continental formation; and this in turn is followed by Siluric and Devonic strata. In Central Nevada, the *Pogonip limestone* ranges in age from Upper Cambric to Lower Ordovicic. Its upper portion is probably Beekmantownian, with a fauna largely distinct from the corresponding eastern faunas, owing to a general geographic separation. It is separated by the *Eureka quartzite,* an extension of the "Ogden," from the *Lone Mountain limestone* of Upper Ordovicic (Trenton-Cincinnati) age.

In the Yellowstone region, the *Jefferson limestone* represents the Lower Ordovicic. It rests upon the *Gallatin limestone* of Upper Cambric age and is succeeded after a hiatus by Devonic sediments.

In Alaska, some graptolite bearing beds and metamorphic limestones, schists and quartzites are referred to the Ordovicic.

III. The Siluric System.

General Subdivision.—The Siluric of North America admits of the following subdivisions:[12]

[12] Grabau, *loc. cit.*

SILURIC OR ONTARIC.

UPPER SILURIC OR

Monroan (including Upper Cayugan) 900–1000 ft.

MIDDLE SILURIC OR

Salinan (lower part of Cayugan) 1000 ft.

LOWER SILURIC OR

Niagaran 1000 ft.

The succession in western and central New York is as follows:

SUPERFORMATION.

Devonic—Onondaga.

(*Great hiatus and disconformity.*)

UPPER SILURIC (Monroan).

Akron dolomite (Cobleskill approximately).

Bertie water lime.

(*Hiatus and disconformity.*)

MIDDLE SILURIC (Salinan).

Salina shales, etc.

Camillus shale.

Syracuse salt.

Vernon shales.

Pittsford shales.

LOWER SILURIC (Niagaran).

Guelph dolomite (Shelby dolomites).

Lockport dolomite.

Rochester shale.

Clinton group.

Clinton limestones and shales.

Medina sandstone.

SUBFORMATION.

Upper Ordovicic (Queenston shales).

In the Rochester region, the Clinton has been subdivided by Hartnagel[13] as follows:

[13] State Museum Bulletin 114, 1907. See also Chadwick, G. H., *Science*, N. S., Vol. 28, 347.

4. Irondequoit limestone.
3. Williamstown shale.
2. Walcott limestone.
2a. Furnaceville iron ore.
1. Sodus shale.

In the Utica region, the *Oneida conglomerate,* representing Upper Medina, rests upon the *Frankfort shales,* and is succeeded by *Clinton shales* and arenites with some limestone beds and iron ores. This eastern Clinton is in part equivalent to the Rochester and Lockport of western New York.

The Upper Siluric comprises the following subdivisions in the Schoharie region:[14]

5. Manlius limestone.
4. Rondout water-lime.
3. Cobleskill limestone.
2. Brayman shale.
1. Binnewater sandstone.

This rests with a hiatus and disconformity upon the Upper Ordovicic (Lorraine). The Cobleskill correlates with the Akron of western New York. In the Helderbergs, the *Rosendale water-lime* appears below the Cobleskill, correlating approximately with the Brayman. Below it often occurs a second limestone—the *Wilbur*—this making the lowest marine Siluric stratum of the Helderbergs. Below them generally occur the *High Falls* or *Longwood shales,* and the *Shawangunk* (*Greenpond*) *conglomerates,* both representing early Middle Siluric or Salinan of continental origin.

In New Jersey and part of Pennsylvania (Delaware valley) the Siluric formations have the following subdivisions:

SUPERFORMATION.

Lower Devonic (Coeymans limestone).

UPPER SILURIC OR MONROAN.

Manlius limestone.
Rondout formation.
Decker Ferry formation.

[14] Grabau, A. W., Bull. N. Y. State Mus. Natural History, No. 92.

Bossardville limestone.
Poxino Island shale.
(*Probably a hiatus and disconformity.*)

Middle Siluric.

Longwood shales and sandstones.
Shawangunk conglomerate.
(*Great hiatus and generally an unconformity.*)

Subformation.

Upper Ordovicic—Hudson shales.

Southwestward, in the Appalachians of south central Pennsylvania, and Maryland, the base of the Siluric is formed by the *Tuscarora sandstone* and conglomerate followed by the "*Clinton*" (*Niagaran*) *shales* and sands, and by red shales of Salina age (*Longwood, Bloomsburg,* etc.). This is succeeded by the *Lewistown limestone* series. This last division varies somewhat in value —but is of Monroan age, representing in most regions, the upper Monroe. In Maryland, the lower Monroe is represented by shales and limestones commonly called "Salina"; the true Salina being absent. A pronounced disconformity separates the lower Monroe from the Middle Niagaran (Rochester) which in turn is underlain by Clinton and Tuscarora. The Upper Monroe beds have recently been named the *Corrigan limestone.*[15]

In Virginia and Tennessee, the Tuscarora is represented by the *Clinch sandstone,* and this is followed by the *Rockwood formation* with its iron ores, the age of which is Niagaran. Higher Siluric beds are generally absent, the succeeding beds being either Lower Devonic (Helderbergian) or the Black shale of later age.

West of New York, the *Medina* gradually dies out, the Clinton being mostly calcareous and resting often with a hiatus of greater or less extent, upon the Ordovicic. The section is most complete in Canada, Michigan and northern Ohio, where the following succession occurs:[16]

Superformation.

Middle Devonic—Onondagan.
(*Great hiatus and disconformity.*)

[15] T. Poole Maynard, *Geol. Soc. Am. Bull.*
[16] Lane, Prosser, Sherzer and Grabau, *Bull. Geological Soc. Am.*, XIX., 553–556.

Upper Siluric or Monroan.

Upper Monroan or Detroit River series.

d. Lucas dolomite.

c. Amherstburg dolomite.

b. Anderdon limestone.

a. Flat Rock dolomite.

(*Small hiatus and disconformity.*)

Middle Monroan—Sylvania sandstone.

(*Small hiatus and disconformity.*)

Lower Monroan or Bass Islands series.

d. Raisin River dolomite.

c. Put-in-Bay dolomite.

b. Tymochtee beds.

a. Greenfield dolomite.

Middle Siluric or Salinan.

Salina shales, gypsum salt and dolomites.

Lower Siluric or Niagaran.

Niagaran dolomite, etc. (including Guelph and Clinton).

Subformation.

Upper Ordovicic—Hudson shales.

In Wisconsin occurs the most complete section of the Lower Siluric or Niagaran, the formations (mostly limestones and dolomites) exceeding 700 feet in thickness. The series is as follows:

Superformation.

Milwaukee dolomites (Hamilton) or more rarely, Monroan dolomites.

(*Great hiatus and disconformity.*)

Lower Siluric or Niagaran.

Guelph dolomite.

Racine beds.

Waukesha beds.

(Comprising northward.)

Upper coral beds.

Lower coral beds.

Byron beds.

Mayville limestone.
Iron Ridge ore ("Clinton").
(*Small hiatus and disconformity.*)

SUBFORMATION.

Upper Ordovicic—Maquoketa shales.

In eastern Iowa, the Niagaran is represented by the *Delaware limestone,* rich in typical Niagaran fossils, and the *Gower limestone* which comprises two phases, the *LeClair limestone* phase, probably a reef facies, and the *Anamosa phase.*

In southern Ohio, the Niagaran has been subdivided as follows:

Hillsboro sandstone.
Cedarville limestone.
Springfield limestone.
West Union limestone.
Osgood beds.
Dayton limestone.
Clinton limestone.

In the southern states the Siluric formations have a somewhat different organic facies. In Illinois and Missouri, the *Girardeau* or *Alexandrian formation* of early Lower Siluric age, rests according to T. E. Savage,[17] upon the late Ordovicic (Orchard Creek), there being nevertheless a small hiatus. It is succeeded disconformably by the Edgewood and this in turn with another disconformity, by the Clinton. The Alexandrian probably represents a southern invasion. Typical northern Niagaran strata overlie the Alexandrian. In western Tennessee, the Niagaran is subdivided as follows:

Brownsport (Foerste).[18]
  Beech River (Pate and Bassler).[19]
  Bob.
  Lobelville.
Dixon.

[17] T. E. Savage, *American Journal of Science,* XXV., pp. 431–44 and later communications (Pal. Soc. Am.).

[18] A. E. Foerste, *Jour. Geol.,* Vol. XI., pp. 554–715.

[19] W. F. Pate and R. S. Bassler, *Proc. U. S. Nat. Mus.,* Vol. XXXIV., pp. 407–32.

Lego.
Waldron shale.
Laurel limestone.
Osgood beds.
Clinton limestone.

The *Laurel, Waldron* and *Lego* together are represented by the *Glenkirk limestone* in the Clifton section.

In Kentucky and Indiana, the *Louisville limestone* succeeds the Waldron shale, representing approximately the Lego and some higher beds. In Arkansas, the *St. Clair limestone* represents early Siluric (Niagaran). Its fauna allies it to the Alexandrian of Missouri. In Oklahoma, the Siluric is represented by the *Sylvan shale* resting disconformably on Richmondian and representing Clinton or earlier horizons. Above the Sylvan shale, the *Hunton limestone* in part represents Niagaran. The greater part of the Hunton represents Helderbergian, a disconformity, representing a great hiatus, dividing this limestone. In the Rio Grande region of New Mexico and Texas, Siluric horizons have been recognized in the *Fusselman limestone* (1,000 ft.).[20]

On the Atlantic coast, the most important of the Siluric deposits is the *Anticosti group* of Anticosti Island, and the local phases of the same in Maine and eastern Canada. The fauna of this series which represents Lower Siluric or Niagaran and possibly some Middle Siluric, is distinct to a large degree from that of the Siluric of the interior of North America, though many elements have been found in common, especially with the "Clinton" of the southern Ohio region.

Other Siluric deposits are found in Alaska, where the *Wales series* of southeastern Alaska and the *Nome series* of the Seward Peninsula (including the *Port Clarence limestone*) are referred to the Siluric. More doubtfully referred to this system are the *Forty mile series* of crystalline limestones and schists of the middle and lower Yukon regions, and the *Skagit series* of crystalline limestones of northern Alaska.

[20] Richardson, G. B., "Palæozoic Formations in Trans-Pecos Texas," *A. J. S.*, 4th sec., Vol. XXV., 1908, p. 479.

IV. The Devonic System.

General Subdivision.—In eastern North America, especially New York, the Devonic admits of the following subdivisions:[21]

Upper Devonic.
- Chautauquan—Chemung and Catskill.
- Senecan.
  - Portage beds.
  - Genesee shale.
  - Tully limestone.

Middle Devonic.
- Erian.
  - Hamilton beds.
  - Marcellus shales.
- Ulsterian.
  - Onondaga (Corniferous) limestone.
  - Schoharie beds.

Lower Devonic.
- Oriskanian.
  - Esopus (Caudagalli) beds.
  - Oriskany beds.
- Helderbergian.
  - Port Ewen beds.[22]
  - Becraft limestone.
  - New Scotland beds.
  - Coeymans limestone.

The typical *Helderbergian*[23] is restricted to the Appalachian area from New York to Maryland. Southward, it is represented by some of the beds referred in Virginia to the *Hancock limestone;* in western Tennessee, by the *Linden beds,* in Illinois by the *Clear Creek limestones* (including the Oriskany) and by "Lower Helderberg" limestones (Hunton limestone in part) in Oklahoma. In Maryland, the Oriskany is known as the *Monterey formation,* and in western Tennessee it is represented by the *Camden chert.* In

[21] Clarke and Schuchert, *Science,* Vol. X., 1899.

[22] Included with the Oriskany by Chadwick (*loc. cit.*).

[23] Schuchert, Charles, *Bull. Geol. Soc. Am.,* XI., pp. 24–332, 1900.

Georgia and Alabama, the *Frog Mountain sandstone* and the *Armuchee chert* (Floyd County) contain an Oriskany fauna.

Northeastward, Helderbergian strata are known from New England, in the Connecticut valley trough (*Bernardston series*) and in Maine, also in the Montreal region (St. Helen's Island) and especially in the *Gaspe limestone* (1,210 ft.) subdivided into the *St. Alban's* beds below, and *Cape Bon-Ami* beds above. These represent the Helderbergian, while the *Grand Greve limestones* (800 ft.) overlying them represents the Oriskanian.

The higher Devonic strata are here represented by the *Gaspe sandstone* (7,000 ft.) which conformably succeeds the limestones. This is mostly of continental origin, carrying plant remains and coal seams; but in the lower portion beds of marine strata are intercalated, carrying a Middle Devonic fauna. The sandstone probably represents the Middle and Upper Devonic horizons. It is unconformably overlain by the *Bonaventure conglomerates* of Mississippic or Carbonic age.

In the southern Appalachians, the Devonic series consists largely of shales and sandstones. The following succession occurs in Maryland:

SUPERFORMATION.

Lower Mississippic beds.

UPPER DEVONIC.

Hampshire formation.
Jennings formation.

MIDDLE DEVONIC.

Romney shales (representing Onondaga, Marcellus and Hamilton).

LOWER DEVONIC.

Monterey (Oriskanian) beds.
Helderbergian limestones.

SUBFORMATION.

Upper Monroan—Corrigan formation.

Southward, in Virginia and West Virginia, the Romney is succeeded by the *Kimberling shale* which may extend up into lower

Mississippic. Below the Romney, lies the *Giles formation,* a local phase of the Helderbergian. The stratigraphic value of the Romney is not uniform in the Appalachians.

In eastern Kentucky, the late Devonic is represented by the *Black shale* and a part of the succeeding *Grainger formation.* The upper part of this formation extends into the Lower Mississippic. The early and perhaps also the Middle Devonic beds are wanting in this section.

The *Portage beds* appear eastward as the *Oneonta sandstone* and westward as the *Naples beds.* In central New York, the *Ithaca beds* and fauna hold sway. In the west central sections, the subdivision of the Portage beds is as follows:

Portage beds.

- Wiscoy shale (Portland shale, westward).
- Portage sandstone (Dunkirk shale, westward).
- Gardeau flags (Angola shale, westward).
- Rhinestreet black shale.
- Cashaqua shale.
- Middlesex black shale.

The Genesee includes the *West River shale* and black *Genesee shale,* and the *Styliolina* or *Genundewah limestone.* The Hamilton-Marcellus is subdivided into:

Moscow shale. Tichenor (Encrinal) limestone. Ludlowville shale. Skaneateles shale.	Hamilton.
Cardiff shale. Stafford limestone. Marcellus black shale (including Agoniatite limestone).	Marcellus.

Westward, in Ontario, the *Esopus* is replaced by the *Decewville beds,* which rest disconformably on the Siluric, the Helderbergian being absent. Here and in Michigan and northern Ohio, the *Onondaga* is represented by the *Dundee limestone* (*Columbus limestone* of northern Ohio) which probably represents Marcellus as well. The Hamilton beds are represented by the *Traverse*

Group of northern Michigan. This comprises Upper Traverse or *Thunder Bay series,* the middle Traverse or *Alpena limestone series* and the lower Traverse or *Presque Isle series.*[24] In central Ohio the *Delaware limestone* and the *Prout limestone* represent a part of the lower Hamilton, being followed after a hiatus by the Upper Devonic *Ohio shale.* The Upper Devonic of Michigan is represented by the black *Antrim shale,* including in its base the Naples fauna. In Ohio the Ohio shale rests disconformably upon lower Hamilton, upon Dundee (Columbus) or upon Siluric formations. In northern Ohio it can be subdivided in descending order into *Cleveland shale, Chagrin formation* and *Huron shale.* The Chagrin formation was called by Newberry the *Erie shale,* and is represented, in part, by the *Girard shale* of northwestern Pennsylvania. The *Olentangy shale* of central Ohio is regarded as a part of the Ohio shale. In southern Indiana and Kentucky, the *New Albany black shale,* representing late Devonic or younger horizon, rests disconformably upon the *Sellersburg beds,* which represent the Hamilton phase of the Middle Devonic, and are preceded by the *Jeffersonville limestone,* commonly correlated with the Onondaga. This rests disconformably upon the limestone of Lower Siluric (Niagaran) age (Louisville). The whole of the Lower Devonic and the Upper and Middle Siluric are wanting.

In Wisconsin, the *Milwaukee dolomite* represents the middle Hamilton and rests disconformably upon Monroan, or upon late Niagaran. Its closest affinities lie with the Traverse group of the Traverse Bay region.

In Iowa, the subdivision of the Devonic is as follows (Calvin):

Superformation.

Carbonic.

(*Disconformity and hiatus.*)

Upper Devonic.

State quarry beds	40 ft.
Lime Creek shales	120 ft.
Owen beds.	
Hackberry beds.	
Sweetland Creek shales	20 ft.

(*Hiatus and disconformity.*)

[24] Grabau, A. W., "The Traverse Group of Michigan," Geol. Sur. Mich.

MIDDLE DEVONIC.

Cedar valley limestones................ 100 ft.
Wapsipinicon limestones and shales...60–75 ft.
Upper Davenport.
Lower Davenport (Fayette breccia).
Independence shales.
Otis beds.
Coggan beds.
(*Hiatus and disconformity.*)

SUBFORMATION.

Lower Siluric (Niagaran).

Upper Devonic beds related to those of Iowa are widely distributed over northwest Canada, and are again known in the Rocky Mountain region and westward. In northwestern Colorado the *Elbert formation* and the lower two thirds of *Ouray limestone* represent the Devonic. The upper part of the Ouray is of Mississippic age. In the Grand Canyon region, the *Temple Butte limestone* represents a part of the Devonic.

In Arizona (Bisbee region) the Devonic is represented by the *Martin limestone* resting disconformably upon Cambric limestone. In the Wasatch Mountains, a part of the *Wasatch limestone* probably represents late Devonic, though most of it is Mississippic. Finally, in Nevada (Eureka district) the *Nevada limestone,* 6,000 ft. thick, is partly at least of Devonic age. The succeeding *White Pine shales,* which have also been placed in the Devonic, are regarded by some as of later age.[25]

In southeastern Alaska, the *Vallenar series* of limestones is in part at least Devonic. In Prince Williams Sound and the lower Copper River Basin, the *Nikolai greenstone* or basalt may be of Devonic age. In the upper Copper and upper Tanana basins, the *Wellesley* and *Chisna groups* of conglomerates and shales and the *Titelna volcanics* are of Devonic age. Finally, the *Rampart series* of the middle and lower Yukon regions and a part of the *Fickett series* of northern Alaska, are referred to the Devonic.

[25] See Girty, Bull. U. S. G. S., 377, p. 10, footnote.

V. The Mississippic System.

This is typically developed in the Mississippi valley, where the following divisions are recognized:[26]

Upper Mississippic or Chester group (Chesteran).
- Kaskaskia limestone.
  - Birdsville formation.
  - Tribune limestone.
- Cypress sandstone.
- St. Genevieve limestone.
  - Ohara limestone.
  - Rosiclare sandstone.
  - Fredonia oölitic limestone.

Middle Mississippic or Meramec group (Meramecan).
- St. Louis limestone.
- Spergen limestone.

Lower Mississippic (Waverlyan).
- Osage group (Osagian).
  - Warsaw shales and limestones.
  - Keokuk limestones.
  - Burlington limestones.
- Kinderhook series (Chouteauan).
  - Chouteau limestone.
  - Hannibal shales.
  - Louisiana limestone.

In the lower part of the Kinderhook, the Louisiana limestone is in part represented by shales and sandstones; the succession in descending order below the Burlington in southern Iowa is as follows: 7, Buff limestone; 6, Oölitic bed; 5, Upper Yellow sandstone; 4, Louisiana limestone; 3, Chonetes bed; 2, Chonopectus sandstone; 1, Lower blue clay.[27]

In Calhoun County, Illinois, the series below the Burlington comprises: Vermicular sandstone, Blue shale, Hamburg limestone and shale, Brown sandy shales, Louisiana limestone, Soft green shale. This rests disconformably upon the Devonic. In Jefferson County, Missouri, the section below the Burlington comprises:

[26] Modified after E. O. Ulrich, U. S. G. S., Prof. Paper 36, p. 24.

[27] Weller, " Kinderhook Faunal Studies."

Reddish limestone, Fern Glen limestone, Red shale, Fossiliferous limestone, Bushberg sandstone, Glen Park limestone. This rests disconformably upon Upper Ordovicic (Maquoketa or Kimmswick limestone).

In Arkansas the Kinderhook is wanting through overlap or represented only by the basal black *Eureka* or *Noel shale* (possibly also the *Sylamore sandstone*). The section has been subdivided as follows:

Superformation.

  Early Pottsville (Morrow formation).

Upper Mississippic or Chesteran.

  Boston group.

    Pitkin limestone.

    Wedington sandstone.

    Fayetteville shale.

  Batesville sandstone.

Middle Mississippic or Meramecan.

  Moorefield shales and

  Spring Creek limestones.

Lower Mississippic.

  Osagean.

    Boone limestone and chert series.

      Boone chert.

      Carrollton limestone.

      St. Joe marble.

  Chouteauan.

    Eureka or Noel black shale.

      (Disconformity and hiatus.)

Subformation.

  St. Clair limestone (Siluric) or various Ordovicic beds.

The Boston group was originally subdivided in descending order into the *Kessler limestone, Coal-bearing shale, Pentremital limestone, Washington shale* and sandstone, *Archimedes limestone* and *Marshall shale,* the latter a part of the *Fayetteville shale* series.

In Oklahoma, the *Caney shale* and probably the *Woodford chert* below it, represent what there is of the Mississippic. The Woodford is often in part referred to the Devonic, but the fossil evidence is not conclusive. The basal part of the Caney is regarded by Girty as late Mississippic (possibly equivalent to the Moorefield, Batesville and Fayetteville beds of northern Arkansas) and continuing into the lower Carbonic (Pottsville). At the base of the Caney there is sometimes the *Sycamore limestone.*[28]

In the Ouachita mountain area, the Caney shale rests upon the *Jackfork sandstone,* and this in turn rests upon the *Standley shale,* below which, after a disconformity, occur Ordovicic cherts (*Talihina chert*). The fossil plants of the Standley shale suggest late Mississippic, or early Carbonic age.

In the Sierra Ladron of New Mexico, the *Lake Valley limestones* represent part of the Mississippic.

In the Front Range region of Colorado, the *Millsap limestone* represents what there is of the Mississippic. In the Black Hills, two limestones, the *Englewood,* resting disconformably on the Ordovicic, and the *Pahasapa,* next above, represent the Mississippic. In west central Colorado, the *Leadville limestone* bounded above and below by disconformities represents a part of this horizon, while in southwestern Colorado, the *Ouray limestone* in part Devonic, represents lower Mississippic and is disconformably overlain by Carbonic beds. In the Grand Canyon, the *Red Wall limestone* is referred to the Mississippic, resting disconformably on Devonic beds, while the *Escabrosa limestone* of the Bisbee Arizona regions holds a similar position. In the Wasatch Mountains, the lower part of the *Wasatch limestone* is referred to the Mississippic and in the Uintah Mountains, the same series is slightly represented, the *Lodore shale* of the eastern Uintahs, probably belonging here.

In central Montana, the *Madison limestone,* 1,000 ft., with a Choteau fauna, rests upon Devonic (?) beds and is succeeded by 1,400 feet of *Quadrant shales* and limestones above which lies the Jurassic. In central Nevada (Eureka district) the *White Pine shale,* with a fauna similar to that of the Caney shale of Oklahoma[29] succeeds the Devono-Mississippic *Nevada limestone,* and is succeeded by the *Diamond Peak Quartzite,* and this by coal-measure beds.

[28] Tishomingo Folio.

[29] Girty, Bull. 377, U. S. G. S., p. 10, footnote.

In eastern Illinois and Indiana, the *St. Louis limestone* proper is preceded by the *Salem limestone* also known as the *Bedford Oölite* or Spergen limestone.

In Indiana, the Black *New Albany shale* of late Devonic (or early Mississippic) age is succeeded by the *Rockford Goniatite* limestone and the shales and sandstones of the *Knobstone group.* This represents Osagean and lower divisions. Above the knobstone is the *Harrodsburg limestone,* the *Bedford Oölite* and the *Mitchell limestone* the latter of St. Louis age. Above this occur sandstones and limestones of Chester age.

Southeastward, in western Kentucky and western Tennessee, the upper part of the Knobstone constitutes the *Tullahoma formation* and rests with a basal black shale, probably of lower Waverly age, on earlier Palæozoic strata.

In Ohio, the lower Mississippic is mostly represented by sands and shales with some conglomerates, and constitutes the *Waverly series* or *Waverlyan.* It is in places disconformably succeeded by the *Maxville limestone* of upper Mississippic age. The Waverly series admits of the following subdivisions:

6. Logan sandstone.
5. Black Hand formation.
4. Cuyahoga shale.
3. Sunbury shale.
2. Berea grit.
1. Bedford shale.

These units are mostly very variable and of somewhat different values in different regions. In Michigan, the base of the series is formed by the *Richmondville sandstone,* probably combined Bedford-Berea. This rests disconformably on the *Antrim black shale* and is succeeded by the *Coldwater shales,* the equivalent of the Cuyahoga shales of Ohio. Above this comes the *Marshall sandstone*—in part representing the Logan and then, after a hiatus and disconformity, the *Grand Rapids series* of limestones and dolomites with gypsum. These latter are of Chester, or perhaps in part of St. Louis age. Above this the coal measure sandstone lies disconformably.

In western Pennsylvania, the Mississippic series comprises the following divisions:

SUPERFORMATION.

Sharon conglomerate (upper Pottsville).
(*Hiatus and disconformity.*)

UPPER MISSISSIPPIC.

Shenango shale	50 ft.

(*Hiatus and disconformity.*)

LOWER MISSISSIPPIC.

Meadville shales and limestones	66 ft.
Sharpsville shales and limestones	65 ft.
Orangeville shales	75 ft.
Corry sandstone	20 ft.
Cussewango shale	62 ft.

SUBFORMATION.

Upper Devonic (Chemung) shales.

The Corry sandstone is commonly correlated with the Berea of Ohio.

Further east, in the Appalachians of Pennsylvania, the entire series is represented by continental deposits. These comprise the *Pocono sandstone and conglomerates* and the *Mauch Chunk red shale,* the latter probably equivalent to middle and upper Mississippic time, the former to lower Mississippic. The Mauch Chunk includes southward, in Pennsylvania and Virginia, the *Greenbrier limestone,* the fauna of which is in part, upper Mississippic.

In southern Virginia, and West Virginia, the series is more strongly calcareous; the following subdivisions are recognized:[30]

SUPERFORMATION.

Pottsville conglomerate (Pocahontas beds).

UPPER AND MIDDLE MISSISSIPPIC (dividing line doubtful).

Bluestone formation (shales, sandstones and conglomerates)	800 ft.
Princeton conglomerate	40 ft.
Hinton formation (shales, sandstones and limestones)	1,250–1,300 ft.
Bluefield shale (siliceous and calcareous shales)	1,250–1,350 ft.

[30] Pocahontas Folio.

"Greenbrier" limestone............	1,500 ft.
Pulaski red shale..................	20– 300 ft.
(*Section probably incomplete.*)	

LOWER MISSISSIPPIC.

Price sandstone	200– 300 ft.
(*Possible hiatus.*)	

SUBFORMATION.

Devonic—Kimberling shale.

The value of the Greenbrier limestone of this section is probably quite different from that of the limestone known by the same name in southern Pennsylvania.

In southern Virginia and in eastern Tennessee, the partly Devonic *Grainger shale* (1,000–1,500 ft.) represents also the lower Mississippic: the *Newman limestone* (1,000 ft.) represents approximately the middle Mississippic and the *Pennington shale* (1,040–1,100 ft.) approximately the upper. The last two are united by Ulrich as his *Tennesseean division,* while the Mississippic part of the Grainger is referred to the Waverlyan. Elsewhere in eastern Tennessee[31] the base of the section is formed by the *Chattanooga black shale* (often referred to the Devonic) which rests disconformably upon the Siluric or Ordovicic and is succeeded by the *Fort Payne Chert* of Keokuk or even St. Louis age. Above this rests the *Bangor limestone* in part, probably, representing the upper Mississippic and disconformably succeeded by the *Lookout sandstone* of Pottsville age. In Alabama and northern Georgia[32] the *Floyd shale* replaces the lower part, if not the whole, of the Bangor limestone, the two, when occurring together being often separated by the *Oxmoor sandstone* and conglomerate, and perhaps a disconformity. In Nova Scotia the *Horton beds* and the *Riverdale* and *Union formations* are referred to the Mississippic.

VI AND VII. THE CARBONIC AND PERMIC SYSTEMS.

These two systems are not fully differentiated in North America, and so are best treated together. In the east, the deposits are mostly of the continental type; in the middle country alternating

[31] Pikeville, Chattanooga, etc., folios.

[32] Rome folio.

continental and marine and in the southwest largely of marine origin with a change toward continental sedimentation at the top. In the Appalachian region and the bituminous district of Ohio and western Pennsylvania, the following divisions are recognized (mostly continental sediments):

PERMIC.
- Dunkard formation (Upper Barren Coal Measures).

CARBONIC (Pennsylvanic).
- Monongahela formation (Upper Productive Coal Measures).
- Conemaugh formation (Lower Barren Coal Measures).
- Alleghany formation (Lower Productive Coal Measures).
- Kanawha formation (Eastern Lower Productive in part).
- Pottsville formation (Millstone grit).

The Pottsville of the type section admits of division into four parts: (1) Lower Lyckens, (2) Lower intermediate, (3) Upper Lyckens and (4) Upper intermediate. In the northern Appalachians a number of lithologic divisions are recognized. In the Great Flat Top region of Virginia and West Virginia and in the New River gorge these include:[33]

Fayette or Nuttall sandstone.......	110 ft.
Sewell formation	368 ft.
Raleigh sandstone	80–155 ft.
Quinnimont shale	300 ft.
Clark formation	380 ft.
Pocahontas formation	360 ft.

The *Lee conglomerate* and *Lookout sandstone* are partial representatives of the Pottsville in other parts of the southern Appalachians.

The *Kanawha series,* about 1,200 ft. thick in the type region, rests upon the Fayette or Nuttall sandstone and is capped by the *Charlestown sandstone.* It is of continental origin throughout and contains a number of workable coal beds.

In Ohio and western Pennsylvania, the beds below the Alleghany comprise:

[33] Pocahontas Folio.

SUPERFORMATION.

Alleghany series.

KANAWHA SERIES (upper).

Homewood sandstone.

Mercer group.

Connoquenessing group.

(*Probable hiatus and disconformity.*)

POTTSVILLE SERIES (upper).

Sharon conglomerate.

(*Hiatus and disconformity.*)

SUBFORMATION.

Upper Mississippic.

In southwestern New York and northern Pennsylvania the Mississippic-Carbonic succession is as follows:

POTTSVILLAN (upper).

Olean conglomerate.

(*Hiatus and disconformity.*)

MISSISSIPPIC.

Oswayo group.

Shenango shale.

(*Probable hiatus and disconformity.*)

Shenango conglomerate.

Oswayo shales.

Cattaraugus group (transitional).

Killbuck conglomerate lentil.

Salamanca conglomerate lentil.

Wolf Creek conglomerate.

SUBFORMATION.

Devonic—Chemung sandstone and Cuba conglomerate lentil:

The *Alleghany series* in the bituminous area, contains at intervals, coal beds and limestones, the latter mostly marine. In ascending order these beds are: (1) Brookville coal, (2) Clarion coal, (3) Ferriferous (Vanport) limestone, (4) Buhrstone iron ore, (5–6) Lower Kittanning sandstone and fire clay, (7–8) Lower and

Middle Kittanning coal, (9) Johnstown Cement lime, (10) Upper Kittanning coal, (11–13) Lower Freeport sandstone, limestone and coal, (14) Middle Freeport coal, (15) Upper Freeport sandstone, (16) Upper Freeport limestone, (17) Bolivar fire clay, (18) Upper Freeport coal, the Uffington shale (19) of West Virginia, forming the roof shale of the Upper Freeport; it is also a marine horizon.

The *Conemaugh series* contains a number of limestones but those above the *Ames* are generally non-marine. The more important members of the series are, in ascending order: (1–3) Lower and Upper Mahoning sandstone including Mahoning coal, (4) Mason coal, (5) Lower Cambridge limestone, (6) Buffalo sandstone, (7) Upper Cambridge limestone, (8) Bakerstown coal, (9) Saltzburg sandstone, (10) Pittsburg Red shale, (11) Friendsville coal, (12) Ames or Crinoidal limestone, (13) Birmingham shale and Skelly limestone (marine), (14) Elk Lick coal, (15) Morgantown sandstone, (16) Clarksburg limestone, (17) Little Clarksburg coal, (18) Connellsville sandstone, (19) Pittsburg limestones, (20) Little Pittsburg coals, (21) Lower Pittsburg sandstone.

The *Monongahela series* comprises a number of beds of greater or less distribution in the bituminous area of western Pennsylvania, Ohio and West Virginia. Some of them are in ascending order: (1) Pittsburg coal, (2) Pittsburg sandstone, (3) Redstone limestone, (4) Redstone coal, (5–7) Sewickley limestone, coal and sandstone, (8) Great limestone, (9) Uniontown coal, (10) Gilboy sandstone, (11) Little Waynesburg coal, (12) Waynesburg coal.

The *Dunkard series* includes the following important members (ascending order): (1) Cassville Plant shale, (2) Waynesburg sandstone, (3) Waynesburg "A" coal, (4) Marietta sandstones, (5) Washington limestones, (6) Jollytown coal, (7) Dunkard coal, (8) Fish Creek sandstone, (9–11) Nineveh limestone, coal and sandstone, (12) Gilmore sandstone, (13–14) Windy Gap coal and limestone.

In southwest Indiana, Illinois and part of Kentucky, various Mississippic beds are disconformably succeeded by the *Mansfield sandstone*, above which occurs the *Wabash group* (100–600 ft.) and the *Merom group* (0–400 ft.). The latter may be of Permic age.

In Missouri and Iowa, the coal measures rest disconformably upon the Mississippic, and are divisible into the *Des Moinian*, or lower coal measures, and the *Missourian* or upper coal measures. At the base in Missouri lies the *Jordan coal* the age of which corresponds approximately to the Kittanning (or somewhat higher). Of the same age or somewhat older is the well known *Morris coal* of Mazon Creek, Illinois. Several marine horizons are found in this series as, for example, the fossiliferous shales and limestones (92 ft.) forming the top of the Des Moinian of Iowa, and the *Bethany limestone* at the base of the Missourian in the same field. The *Plattsburg limestone*, about 300 ft. above the base of the Missourian, is one of a number of marine horizons in the coal measures of Missouri.

In Arkansas and Oklahoma[34] a deeper coal horizon (*Arkansan*) is interpolated between the Des Moinian and Mississippic. This in part corresponds to the Pottsvillan and Kanawhan of the Appalachian region. The succession is as follows:

Seminole conglomerate	50 ft.
Holdenville shale	260 ft.
Wewoka formation	700 ft.
Wetumka shale	120 ft.
Calvin sandstone	145–240 ft.
Senora formation	140–485 ft.
Stuart shale	90–280 ft.
Thurman sandstone	80–260 ft.
Boggy shale, limestone and coal	2,000–2,600 ft.
Savanna sandstone	1,000 ft.
McAlester shale and coals	1,800–2,000 ft.
Hartshorne sandstone	150 ft.
Atoka shales and sandstones	3,100 ft.
Wapanucka limestone	100 ft.
Caney shale (in part Mississippic).	

Near the base of the McAlester shales occurs the *Grady, Atoka* or *Hartshorn coal*, and about 250 ft. below their top, the *Lehigh coal;* 700 ft. below the top occurs the *McAlester coal*, and 50 ft. below it, a fossiliferous iron ore with a marine fauna of Des Moinian character. Marine fossils also occur in the roof shales of the Hartshorn, McAlester, and Lehigh coals, as well as in the shales above the latter. All these faunas have Des Moinian affinities. In the *Wapanucka limestone* the fossils are of an earlier (older) age,

[34] Coalgate Folio. Oklahoma geologists correlate the Calvin sandstone with the Fort Scott limestone of Kansas.

probably corresponding to Kanawhan. According to the testimony of the plants the *Grady coal* is near the horizon of the *Mazon Creek beds* (Morris coal), probably of Kittanning age, while the *McAlester* is nearer the Freeport horizon. In Arkansas, the McAlester shale is divided into three parts, the upper or *Paris* with the *Paris coal* (upper Kittanning) about 400 ft. below the top, a middle or *Fort Smith* with the *Coal Ridge* or *Charleston coal* (middle Kittanning) part way below the top, and a lower or *Spadra,* with the *Hartshorn* (lower Kittanning) coal at the base. The Hartshorn sandstone appears to be non-marine, while the Atoka contains scattered marine fossils in the upper part above the Atoka coal (Kanawha). The upper Atoka in the north is known as the *Winslow shale.* The Coal Hill or Upper Atoka beds correspond according to the evidence of the plants, to the *Cherokee shales* of Kansas, which there rest disconformably on late Mississippic.

The Kansas section includes the following divisions (according to Prosser and Haworth):

SUPERFORMATION.

Mesozoic or later.

(*Disconformity and hiatus.*)

Permic............	Cimarron stage. Sumner stage. Chase stage. Council Grove stage.
Carbonic..........	Wabaunsee stage. Shawnee stage. Douglas stage. Pottawatome stage. Marmaton stage. Cherokee stage.

(*Disconformity and hiatus.*)

SUBFORMATION.

Mississippic beds.

The Sumner and Chase have been united by Cragin as the *Big Blue Series,* for which Keyes later proposed the term *Oklahoman.*

Numerous subdivisions have been made many of these being of only local extent. In the following, the divisions of the Carbonic, are those recently published by Beede and Rogers,[35] who moreover slightly rearrange the classification into stages. The divisions of the Permic are according to Prosser[36] and Cragin.[37]

The CIMARRON[38] is divided into the *Kiger* (including the Taloga formation, Day Creek dolomite, and Red Bluff formation) and the *Salt Fork* (including the Dog Creek beds [Chapman and Amphitheatre dolomite] the Cave Creek Gypsum [Shimer Gypsum, Jenkins clay and Medicine Lodge Gypsum], the Glass Mountain beds [Flower pot shales, Cedar Hills sandstone] and the Kingfisher formation [Salt Plain, and Harper beds]).

The SUMNER is divided into the *Wellington shales,* and the *Marion formation,* the latter including: Upper variegated clays and marls with some limestones, Abilene conglomerate, Pearl shales, Herington limestone, Enterprise shales and Luta limestones. The CHASE is divided into the *Winfield limestone, Doyle shales, Fort Riley limestones, Florence Flint, Matfield shales* and *Wreford limestone.* The base of the Kansas Permic was provisionally placed here by Prosser in 1902, but further studies especially by Beede and Prosser have brought out faunal evidence which indicate that the base of the Permo-Carbonic is as low as the base of the *Elmdale formation.*

The coal measure series of Kansas below the Chase has recently been divided by Beede and Rogers into four series, and ten stages. In descending order SERIES IV. comprises *Stage J* (Council Grove stage of Prosser), which includes the Neosho formation, the Florena shales (these two together constituting the *Garrison formation*) and the Cottonwood limestone; and *Stage I* which includes: Eskridge shales, Neva limestone and Elmdale formation. This is now regarded as the base of the Permo-Carbonic. SERIES III. comprises *Stage H,* which includes the Americus limestone, Admire shales, Emporia limestone, Willard shales, Burlingame limestone and Scranton shales; *Stage G* including: Howard limestone, Severy shales, Topeka limestone, Calhoun shales, Deer Creek

[35] Kansas University Geol. Surv., IX., p. 336.

[36] *Journal of Geology,* Vol. X., p. 703, and chart opposite p. 718.

[37] *American Geologist,* XIX., pp. 351–363.

[38] All divisions are given in descending order.

limestone, Tecumseh shales, Lecompton limestone and Kanwaka shales and *Stage F,* including: Oread limestone, Lawrence shales, Kickapoo limestone, LeRoy shales, Stanton limestone, Vilas shales, Allen limestone and Lane shales. SERIES II. comprises *Stage E* including Iola limestone and Chanute shales; *Stage D* including only the Drum limestone; and *Stage C* including Cherryvale shales, Dennis limestone, Galesburg shales Mound Valley limestones, Ladore shales and Bethany Falls limestones.

Finally SERIES I. comprises *Stage B* which includes Pleasanton shales, Coffeyville limestones, Walnut shales, Altamont limestone, Bandera shales, Pawnee limestones, Labette shales and Fort Scott limestone and *Stage A* which includes the Cherokee shales.

In Prosser and Haworth's classification, Stage A corresponds to the *Cherokee stage;* B to the *Marmaton;* C, D, E and F to the base of the LeRoy shales, correspond to the *Pottawatomie;* the remainder of F to the *Douglas;* Stage G including the Scranton shales of Stage H to the *Shawnee,* the remainder of H, and Stage I to the *Wabaunsee,* and Stage J to the *Council Grove.* Stages I and J represent the European Permo-Carbonic (Beede). Where some of the limestones have thinned out, the overlying and underlying shales have often been united into one formation, with a distinct name; thus the *Pleasanton shales, Coffeyville limestone* and *Walnut shales* are replaced elsewhere by the *Dudley shales;* and the *Allen, Vilas* and *Stanton* beds by the *Garnett limestone.*

In northwestern Texas, the fossiliferous Permic beds are included under the term *Guadalupian* which is divided into the upper or *Capitan limestone* (1,800 ft.) and the lower or *Delaware Mountain formation* (2,300 ft.). Below this lies the *Hueconian* or Carbonic limestone. The base of the Capitan limestone according to Beede[39] corresponds in a general way with the base of the *Elmdale formation* of Kansas. This correlates the Delaware Mountain beds with the upper Carbonic beds of the Kansas section. The faunas however are markedly distinct, representing separate provinces. Overlying the Guadalupian are the *Pecos Valley Red*

[39] "The Correlation of the Guadalupian and the Kansas Sections," by J. W. Beede; also "The Bearing of the Stratigraphic History and Invertebrate Fossils on the Age of the Anthracolitic Rocks of Kansas and Oklahoma," *Journ. Geol.,* XVII., pp. 710–729. Also Prosser, C. S., "The Anthracolitic or Upper Paleozoic Rocks of Kansas and Related Regions," *Journ. Geol.,* XVIII., pp. 125–161.

beds, representing the higher Permic, and equivalent, according to Beede, to the beds below the *Quartermaster* and *White Horse* of northern Texas.

In the Panhandle of Texas and in Oklahoma the following formations represent the late Palæozoic.[40]

SUPERFORMATION.

Dockum beds—Triassic.

(*Disconformity or unconformity.*)

PERMIC.

DOUBLE MOUNTAIN BEDS.

Quartermaster (275 ft.) red clay shale and sandstones and some gypsum.

Greer (275 ft.) subdivided in descending order into Mangum dolomite, Collingsworth Gypsum, Cedar-Top Gypsum, Haystack Gypsum, Kiser Gypsum, and Chaney Gypsum.

CLEAR FORK BEDS.

Woodward (425 ft.) comprising Day Creek dolomites; White Horse sandstone and Dog Creek shales.

Blaine (100 ft.) comprising Shimer Gypsum, Medicine Lodge Gypsum, Ferguson Gypsum.

Enid (1,500 ft.) red shales.

WICHITA-ALBANY BEDS (1,800 ft.) (representing the Permo-Carbonic or Artinskian of Europe).

CARBONIC.

MISSIOURIAN.

Cisco (840 ft.).

Canyon (930 ft.).

DES MOINIAN.

Strawn.

ARKANSAN.

Millsap.

Bend.

(*Unconformity.*)

[40] Gould, Water Supply Paper 154, p. 16.

SUBFORMATION.

Early Palæozoic.

In the Rio Grande Valley of New Mexico, the Carbonic admits of the following subdivision:[41]

MANZANO GROUP.

San Andreas limestone (500 ft.).
Yeso formation (1,000 ft.) (shale, limestone and gypsum).
Abo red sandstone (800 ft.) (fossiliferous).
(*Hiatus and disconformity.*)

MAGDALENA GROUP.

Madera limestone (500 ft.).
Sandia formation (700 ft.) (limestones, shales and quartzitic sandstone).

The *Manzano group* appears to be the equivalent of the *Hueco formation* of Texas, and the *Aubrey group* of the Grand Canyon.

In Colorado, the late Palæozoics lie disconformably beneath the *Shinarump conglomerate* (Triassic) and include in descending order, the *Moencopie beds* (Permic), the *Rico beds* and the *Hermosa formation*. In the San Juan district the *Cutler red sandstone* and shales of Permo-Carbonic age overlie the Rico and are in turn succeeded after a mild unconformity by the Triassic *Dolores red beds*. In the Grand Canyon section of Arizona, the *Aubrey* and upper *Red Wall* approximately represent the Rico and Hermosa. Both Aubrey and Rico are correlated with the Manzano of New Mexico.

In Arizona (Bisbee region) an apparently continuous series of limestones forms the upper Palæozoic—lying disconformably on the Cambric (*Abrigo limestone*) and being unconformably succeeded by the Comanchic *Bisbee group*. The series is Devonic at the base (*Martin limestone,* 340 ft.) Mississippic farther up (*Escabrosa limestone,* 700 ft.) and Carbonic in the upper part (*Naco limestone,* 3,000 ft.). The upper part of the *Globe limestone* of Arizona (Globe Copper District) is also of upper Carbonic age, the lower part being of upper Devonic age.

In Utah, the *Bingham quartzite* series of upper Carbonic age includes the following limestone members, in descending order:

[41] Lee and Gordon, Bull. 389, U. S. G. S.

Phœnix limestone, 300 ft.; Tilden limestone lentil, 100 ft.; Yampa limestone, 300–400 ft.; Highland Boy limestone, 400 ft.; Commercial limestone, 200 ft.; Jordan limestone, 300 ft.; Lenox limestone, 200 ft.; Butterfield limestone, 300 ft. In the Wasatch and Uintah Mountains, the *Weber conglomerate* of the same age, overlies the upper *Wasatch limestone* which is Carbonic and is succeeded by Permo-Carbonic shales and limestones. Both the Weber and Bingham series have been correlated with the Hueconian of Texas, and the Aubrey of northern Arizona.

In Nevada, the *White Pine shale* possibly of lower Carbonic age (with a fauna according to Girty like that of the Caney shales) is succeeded by the *Diamond Peak Quartzite,* this by the "Lower Coal Measure" limestone, this by *Weber conglomerate* and this by the "Upper Coal Measure" beds. In the Canadian Rockies, the *Banff* limestone is in part at least of Carbonic age. Finally in northern California, the lowest Carbonic beds are the *Baird shales,* followed by the *McCloud limestone* which is correlated by J. P. Smith with the entire Carbonic series of central Texas from the Bend to the Cisco inclusive. The McCloud shales are correlated with the Wichita-Albany beds or the Artinskian of Europe.

Carbonic deposits are extensively developed in northwestern America including Alaska. In the different Alaskan provinces, the following formations have been assigned to the Carbonic (including Permic and Mississippic). In western British Columbia and Yukon territory: *Cache Creek group,* partly perhaps Devonic. In southeastern Alaska, *Ketchikan series,* probably in part Triassic. In Prince William Sound and lower Copper River basin: *Chitistone limestone.* In the upper Copper and the upper Tanana basin: *Mankomen group* (Permic) *Nabesna limestone,* and *Suslota limestone.* In northwestern Alaska: *Lisburne, Stuver* and *Fickett* series, the first Permic, the last partly Devonic.

In Nova Scotia and elsewhere in eastern Canada, the Coal measure series (including the Permic), have been divided in descending order into:[42] *Cape John Sandstone; Pictou Freestone; Smelt Brook shale; Merigomish limestone; New Glascow conglomerate; Coal measures* or *Stellarton formation;* Westville beds or *Millstone* grit; *Hopewell sandstone* and *Windsor formation.*

[42] Ami, H. M., *Can. Rec. Sci.,* VIII., 3, p. 163, 1900.

These rest unconformably on the *Union* and *Riverdale* and *Horton* beds, of Mississippic age.

The *Little River Group* of New Brunswick is regarded by Canadian geologists as Devonic, but palæobotanists on the strength of the fossil plants refer it to the Carbonic, approximately the Kanawha. Here it is also placed by Handlirsch, who regards the insects as Carbonic, though Scudder described them as Devonic.

Coal-measure beds also occur in Sydney, Cape Breton (Alleghanian) and in Rhode Island (Bristol, Cranston, East Providence, Pawtucket). Coal measure conglomerates also occur (*Newport* or *Naragansett Basin conglomerates*). Coal measures likewise occur in Massachusetts (*Worcester coal beds, Roxbury conglomerate,* etc.).

B. THE MESOZOIC SYSTEMS.

VIII. The Triassic System.

The Triassic system is represented by marine strata only in Pacific North America, the known deposits occurring in California, Oregon, Nevada, Idaho and British Columbia. The European subdivision is adopted, for it equally well fits the West American deposits. The following are the latest published American correlations:[43]

BAJUVARIC.

- Rhaetic, represented by the *Foreman plant beds* of California.
- Noric, represented by the upper *Hosselkus limestone* and the *Pseudomonotis beds* and *Juvavites beds* of California, and the *Pseudomonotis beds* of Nevada and British Columbia.

TIROLIC.

- Karnic, represented by the lower *Hosselkus limestone* and the *Halobia beds* of California; the *Star Peak limestone* of Nevada, and a part of the *Trachyceras beds* of British Columbia.

[43] Hyatt and Smith, Professional paper 40, U. S. Geol. Survey—Introduction.

Ladinic, represented by the upper *Pit formation* and a part of the overlaying *Trachyceras homfrayi beds* of California, the *Trachyceras homfrayi* and *Daonella beds* of Nevada, and the *Trachyceras beds* of British Columbia.

DINARIC.

Anisic, represented by the lower *Pit shales* of California and the Pelecypod beds of the Aspen Ridge, Idaho.

Hydaspic, represented by the upper *Ceratite limestone* of California.

SCYTHIC.

Jakutic, represented by unfossiliferous shales in California and Nevada and by the *Columbites beds* of Idaho.

Brahmanic, represented by the *Meekoceras beds* of California and the Aspen Ridge, Idaho.

Over most of North America the Triassic is chiefly represented by continental deposits. In the Grand Canyon region the *Shinarump* and the *Leroux* or *Petrified Forest beds* constitute the lower Triassic, said to be in part marine. The *Vermillion cliff* or *Painted Desert beds,* constitute the upper. In the Yellowstone region the *Teton formation* and in central Colorado and Utah, the *Dolores beds* represent a part of the continental Triassic. In some cases, the relationship of these to the underlying Permic is an unconformable one, while in others it is disconformable. In the Front Range region and the Black Hills and Big Horns, the Triassic *Red beds* are variously known as the *Spearfish, Chugwater* or *Upper Wyoming beds.*

In the Texas-New Mexico region, the *Dockum* gray-brown and red beds represent the Triassic.

The only Triassic of eastern North America is the *Newark formation* of Nova Scotia, the Connecticut valley, New Jersey and Pennsylvania to Virginia and the Carolinas. This consists of red sandstones and shales with volcanoes in the northern, and coal beds in the southern regions.

IX. The Jurassic System.

The Jurassic, like the Triassic, is sparingly represented by marine deposits in North America, these being confined chiefly to the Pacific region of the United States and to Mexico. The European classification is adopted for these marine beds, the equivalency being as follows:

UPPER JURASSIC.

Tithonian—comprising

Purbeckian, represented by the non-marine *Como beds* of Wyoming, and (?) the *Morrison beds* of the Front Range, though these are sometimes classed as Comanchic.

Portlandian, represented by the upper 25 meters of the Mazapil section, Mexico, and probably by the *Shirley beds* of Wyoming and the *Sundance* of the Black Hills, etc. The Upper Jurassic of Vancouver Island and Arctic America also seems to belong here. With the Tithonian as a whole is placed also the *Malone series* of western Texas and probably the *Belemnites* and *Pentremites beds* of the Aspen Mountain, Idaho, and the upper part of the Gold Belt slates (*Mariposa formation*) of California, and some of the Upper Jurassic beds of San Luis Potosi and other localities in Mexico.

Kimeridgian: represented by the middle part (60 meters) of the Mazapil section of Mexico, by the lower part of the Jurassic beds of San Luis Potosi, and by a part of the *Mariposa formation,* or Gold Belt slates of California.

Sequanian and Corallian: represented by the *Hinchman tuff* of Shasta County, California, and the lower beds of the Mazapil section of Mexico.

Oxfordian: representation not definitely known.

MIDDLE JURASSIC.

Callovian: represented by the *Bicknell sandstone* of Shasta County, California.

BATHONIAN: representation not definitely known.

BAJOCIAN: represented by the *Mormon sandstone* of Shasta County, California, and in part perhaps by the *Tordrillo series* of the Alaska Range.

LOWER JURASSIC OR LIAS (in broad sense).

TOARCIAN: represented by the *Hardgrave sandstone* of Shasta County, California, and by equivalent beds of Nevada and Alaska.

LIASSIAN
SINEMURIAN } (representation not definitely known).
HETTANGIAN

Of Jurassic age but doubtful correlation, are further a number of non-marine deposits of the Rocky Mountain region, especially such as the *La Plata* and overlying *McElmo formations* lying between the Dakota and the Triassic in the San Juan district of Colorado, and the *White Cliff* (Lower Jurassic) and *Flaming Gorge group* (Upper Jurassic) of Arizona and Utah, the latter marine, as is also the *Ellis formation* of the Yellowstone.

On the Atlantic coast, the lower two divisions of the *Potomac Group*, the *Patuxent* (lowest) and *Arundel* (upper) are referred to the Jurassic.

X. THE COMANCHIC SYSTEM.

The Comanchic system is typically developed in the Gulf region of North America, and in the Pacific coast. In the former region, the three-fold division is:

3. UPPER OR WASHITA (or Washitan).
2. MIDDLE OR FREDERICKSBURG (or Fredericksburgian).
1. LOWER OR TRINITY (or Trinitan).

The Trinity division comprises in descending order: *Paluxey sands, Glen Rose limestone* and *Travis Peak beds* (including *Hensel* sand and conglomerate, *Cow Creek beds* and *Sycamore sands*).

The Fredericksburg is divided in descending order into the *Edwards limestone, Comanche Peak limestone,* and *Walnut clay.* The latter often replaces some of the limestones, and in northern

Texas, together with the *Goodland limestone,* represents what remains of the Fredericksburg.

The Washita of northern Texas includes, in descending order, the *Grayson shale, Main St. limestone, Pawpaw* and *Weno beds, Denton beds, Fort Worth limestone, Duck Creek beds* and *Kiamitia shales.* In Oklahoma, the series comprises the *Bennington limestone, Bokchito shale, Caddo limestone* and *Kiamitia shales.* In Kansas, the Kiamitia alone is represented by the *Kiowa shale* and *Cheyenne sandstone.* In all the sections, the *Dakota* (*Woodbine* or *Silo*) sandstone terminates the sections. In the Austin, Texas, region the members are more calcareous and comprise in descending order beneath the Eagle Ford: *Buda limestone, Del Rio clays* and *Georgetown limestone.*

On the Pacific coast, the Comanchic series is comprised in the *Shasta group,* separable into the upper or *Horsetown* and the lower or *Knoxville series.* In the Queen Charlotte Island, the series is represented by the *Queen Charlotte formation.* East of the Canadian Rockies the *Kootenay* non-marine series represents the greater part of this system.

In Alaska, Comanchic strata are well developed, being represented by the *Kennicott formation* of Prince William Sound and the Copper River region; and the *Anaktuvuk series* and the *Koyukuk series* of northern Alaska.

On the Atlantic coast the *Patapsco* and *Raritan* in the northern sections, and the *Tuscaloosa* in the southern sections represent this system.

In Arizona, the *Bisbee group* nearly 4,500 ft. thick, represents the Comanchic. It is divided in descending order into: *Centura formation* (shales, sandstones and limestones); *Mural limestone; Morita formation* (sandstones, shales and limestones); and *Glance conglomerate.* This rests unconformably upon the Naco limestone of Carbonic age.

Finally in Mexico the *Tehuacan limestone* represents basal Comanchic.

XI. The Cretacic System.

The general subdivision of the American Cretacic, as developed in the interior, is as follows:

Upper Cretacic or Laramian.

Middle Cretacic or Montanan.

Fox Hill series.

Pierre series.

Lower Cretacic or Coloradoan.

Niobrara series.

Benton series.

Dakota sandstone (upper).

At the base of the Benton series lies the *Dakota sandstone,* which marks a period of emergence, followed by one of submergence.[44] The upper part of this sandstone must be considered an integral part of the Coloradoan, while the lower part in Kansas, etc., is believed to be of upper Comanchic (Washita) age.

In southern Alberta, the Montanan is divided into the *Bearpaw, Judith River* and *Claggett formations,* the last resting on upper Coloradoan *Cardium sandstone.* The Bearpaw is succeeded by the *Edmonton.* These formations are all more or less non-marine, especially the Judith River (Belly River) formation. The Bearpaw is of upper Pierre and Fox Hills age. Elsewhere in Canada and in northwestern United States the *Bear River formation* of non-marine origin, represents the whole or a part of the Coloradoan. The *Livingston* of Montana (3,300 ft.) is separated from the lower Laramie by an unconformity. In central Colorado this horizon is represented by the *Ruby formation* (3,500 ft.) with sometimes the *Ohio formation* (200 ft.) at its base. In the Front Range region of Colorado, the Laramie is disconformably succeeded by the *Arapaho series* (600 ft.) and this by the *Denver* (1,400 ft.), which is in part volcanic. All of these formations are non-marine, or with some brackish water beds intercalated (lower Livingston formation).

In the Big Horn Mountains the following subdivisions of the Cretacic have been made (Darton):

Upper Cretacic.

Laramian.

DeSmet formation .... 5,000 ft.

[44] Grabau, A. W., *Bull. Geol. Soc. of America,* Vol. 17, p. 620.

Kingsbury conglomerate ..... 2,000 ft. +
Piney formation .... 2,000 ft. +

MIDDLE CRETACIC.

MONTANAN.

Parkman sandstone .... 300 ft. +
Pierre shale .... 3,500 ft.

LOWER CRETACIC OR COLORADOAN.

Colorado shales, mostly shales including the *Mowry* and other sandstone formations—Niobrara and Benton not separable (2,200 ft. maximum).
Cloverly formation (in part perhaps Comanchic) resting disconformably upon the Morrison.

In Texas marine beds of Coloradoan age but somewhat older than those of the Rocky Mountains constitute the *Eagle Ford formation.* The lower Benton series is known in Colorado as the *Graneros shales,* often non-marine, which is succeeded by the marine *Greenhorn limestone* and the succeeding *Carlisle shales* and sands, also marine. The *Niobrara limestone series* (divisible into an upper series of shales, the *Apishapa,* and a lower limestone, the *Timpas*) is represented in Texas by the *Austin chalk,* while the Pierre beds and the Fox Hills are represented in part at least by the *Taylor marls.* These latter are succeeded in Texas by the *Eagle Pass* or *Navarro formation* which probably represents to some extent the marine equivalent of the Laramie.

In the Rio-Grande Valley of New Mexico, the Cretacic is divided in descending order into: (4) the *Galisteo group* (2,000 ft. or more of yellow and red sandstones and conglomerates), (3) the *Madrid group* (2,000 ± ft. of coal-bearing sandstone and shale), (2) the *Pierre* and (1) the *Coloradoan.*[45]

On the Atlantic coast of North America, the following subdivisions are recognized:

SUPERFORMATION.

Shark River beds—Eocenic.

UPPER CRETACIC OR JERSEYAN.

Manasquan.

[45] Johnson, D. W., *Sch. Mines Quart.*, 24, p. 36, 1903.

Rancocas (divided into *Vincentown sand,* and the *Hornerstown* or *Sewell marls*).

MIDDLE CRETACIC OR RIPLEYAN.

Monmouth (including in descending order: *Tinton beds, Red Bank sands, Navesink marls, Mt. Laurel sands*).

Matawan (including *Wenonah sands, Marshalltown marls, Englishtown* or *Columbus sands, Woodbury clay, Merchantville beds, Magothy* and *Cliffwood clays*).

LOWER CRETACIC (wanting).

(*Disconformity.*)

SUBFORMATION—Raritan clays and sands (Upper Comanchic).

On the gulf coast, the Lower Cretacic (Coloradoan) appears to be represented by the *Rotten limestone group* of Alabama and Mississippi, and perhaps the *Tombigbee sands.*

On the Pacific coast, Cretacic beds are represented by the *Chico series* of California, the *Phœnix* and *Henley formations* of Oregon, and the *Nanaimo group* of Vancouver Islands. All of these correspond approximately to the Lower Cretacic or Coloradoan. In northern Alaska, the *Bergman series* and the *Nonushuk series* of sandstones, shales and conglomerates, with seams of lignite (2,000 ft.) represent the Cretacic.

C. THE CENOZOIC OR TERTIARY SYSTEMS.[46]

XII. THE EOCENIC SYSTEM.

The most typical development of Marine Eocenic, is on the Gulf Coast of North America, where the section comprises:

UPPER EOCENIC OR JACKSONIAN FORMATION, including: the *Jackson beds* of Mississippi, the *Zeuglodon beds* of Alabama, the *Moody's branch beds* of Mississippi and the *Mark's Mill beds* of Arkansas.

MIDDLE EOCENIC OR CLAIBORNIAN FORMATION, including the *Whitebluff marls* of Arkansas, and the *Claiborne sands, Ostræa sellæformis beds, Lisbon beds* and *Tallahatta beds* of Alabama.

[46] Dall, W. H., 18th Annual Report U. S. Geol. Survey, Part II., p. 323.

LOWER EOCENIC.

CHICKASAWAN or LIGNITIC FORMATION including: *Hatchetigbee beds, Bashi series* or *Wood's Bluff beds, Tuscahoma* or *Bell's Landing beds, Gregg's Landing beds* and *Nanafalia beds,* all from Alabama.

MIDWAYAN or CLAYTONIAN FORMATION including: *Naheola* or *Matthew's Landing beds, Sucarnochee* or *Black Bluff beds, Midway limestone* and *Prairie Bluff beds.*

On the Atlantic coast, the lowest Eocenic appears to be represented by the *Shark River marls* of New Jersey which appear to rest conformably upon the Upper Cretacic (Jerseyan). In Maryland and Virginia, the *Pamunkey formation,* with the following subdivision, represents early Eocenic:

PAMUNKEY FORMATION (Lower Eocenic).

NANJEMOY SERIES.

Woodstock formation.
Potapaco formation.

AQUIA SERIES.

Paspotansa formation.
Piscataway formation.

This rests disconformably upon the late Cretacic.

To the middle Eocenic are referred the *Orangeburg beds* (Buhrstone) of South Carolina, the *Wilmington beds* of North Carolina and the *Gatun beds* of the Isthmus of Panama.

To the Upper Eocenic are referred the *Manzanilla beds* of Trinidad and the *Santee formation* of the Carolinas.

On the Pacific coast in California the Lower Eocenic is called the *Martinez group,* and the Upper the *Tejon group.* The *Topatopa group* locally represents this series in Ventura county, California. In western Oregon, the Eocenic includes in descending order: the *Tyee, Coaledo, Pulaski* and *Umpqua* formations. The Coaledo and Pulaski formations are united into the *Arago formation.* In eastern Oregon, the *Clarno group* represents a part of this series while in western Washington and western British Columbia, the Eocenic and Oligocenic beds together constitute the *Puget Group.* In central Washington the *Manastash beds* and the *Roslyn beds* represent this series in part. In southeastern Alaska and the Yukon region, the *Kenai series* of sandstones, conglomerates, shales and coals (sometimes called Oligocenic) represents this horizon while the *Gakona group* and the *Cantwell formation* represents this horizon in other parts of Alaska.

In Greenland, the *Atane* or *Atanekerdluk* leaf beds belong to the Lower Eocenic.

In the interior of the continent of North America, the Tertiary beds are represented by continental deposits, chiefly fluviatile, or eolian, more rarely by beds of lacustrine origin. The Eocenic is represented in descending order as follows:

IV. Upper Eocenic: the *Uinta beds* of Utah.
All of these overlap more or less.[47]

III. Middle Eocenic: the *Green River bed* (2,000 ft.); *Bridger beds* (1,800 ft.) and *Washakie beds* of Wyoming.

II. Lower Eocenic: the *Wasatch formation* (2,500 ft.) of the Bighorn Basin, Wyoming; the *Knight formation* of Evanston, Wyoming (1,750 ft.); the *Wind River beds* of Wyoming (partly Middle Eocenic) (1,700 ft.) and the *Huerfano beds* of Colorado (800 ft.).

I. Basal Eocenic: including the *Fort Union* of Montana and the *Puerco* and *Torrejon* of New Mexico (850 ft.).

XIII. The Oligocenic System.

This is typically developed in the Gulf coast region, where the following divisions are recognized:[48]

Upper Oligocenic.

Alum Bluff beds.
Oak Grove beds.

Middle Oligocenic or Chipolan.

Chipola marls.
Chattahoochee beds.

[47] See Bull. 361, U. S. Geol. Survey, p. 23.
[48] Maury, C. J., *Bull. Am. Pal.*, III., p. 391.

Lower Oligocenic or Vicksburgian.

Ocala limestone.
Vicksburg limestone.

The Vicksburg limestone is also known as the *Orbitoides limestone,* from the abundance of *Orbitoides mantelli;* the Ocala limestone is also called the *Nummulitic limestone* from the abundance of *Nummulites willcoxi* Heilprin.

In central Florida the Chipolan or Middle Oligocenic includes in descending order—*Tampa limestone, Orthaulax beds* and *Hawthorne beds.* In Georgia, the Vicksburg limestone is succeeded by the *Altamaha grits* which form basal Mid-Oligocenic and this by the *Bainbridge residual beds,* representing the remainder of the Oligocenic. In Alabama, Mississippi, Louisiana and Texas, the *Grand Gulf beds* represent the Middle Oligocenic or Chipolan. In the last two of the states mentioned, the *Frio clays* overlying, also belong to the Middle Oligocenic.

Typical Oligocenic beds are mostly wanting on the Atlantic coast of the United States though the *Cooper River marls* of South Carolina are placed here. The *Shiloh marls* of New Jersey also have some Oligocenic elements. In the West Indies, however, Oligocenic deposits are well developed. Here belong the *Bowden beds* of Jamaica, the *Hayti marls* of Hayti, the *Monkey Hill beds* of the Isthmus of Darien, the *Coroni beds* of Trinidad and the *Bonilla beds* of Costa Rica. These are all referred to the Chipolan. The *Naparima* or *San Fernando series* of Trinidad and the *Gual-lava sandstone* of Costa Rica, are referred to the Vicksburgian.

On the Pacific coast, the *San Lorenzo beds* of California, the upper part of the *Puget group* of Washington and the *Astoria shales* of western Oregon, represent the Oligocenic. The *Sespe beds* of southern California are more doubtfully referred to the Oligocenic.

The continental deposits of Oligocenic age are represented by the *John Day beds* of eastern Oregon, the *White River beds* of South Dakota, Nebraska, etc. (*Brule* and *Chadron formations*), and the *Florissant* " lake beds " of Florissant, Colorado, celebrated for their rich insect fauna.

XIV. The Miocenic System.

Marine Miocenic strata are well developed in the Atlantic coastal plain of North America, the Gulf region and on the Pacific coast. In the east the succession is:

Upper Miocenic or Oakvillian, including
- Oakville beds of Texas.
- Duplin beds of North Carolina and probably the *Gayhead osseous* conglomerate and green sands of Martha's Vineyard, Mass.

Middle Miocenic or Chesapeakean including the *Pascagoula beds* of Mississippi, and the *Chesapeake group* of Maryland and Virginia, with its subdivision in ascending order into: *Calvert formation, Choptank formation* and *St. Mary's formation.*

Lower Miocenic or Ashleyan including Ashley River marls of South Carolina and probably the *Shiloh marls* of New Jersey.

On the Pacific coast, the succession of Miocenic beds is as follows:

Superformation.
- Pliocenic (San Diego beds).

Upper Miocenic.
- San Pablo beds.
  - (*Disconformity.*)
- Santa Margarita beds.
  - (*Disconformity or unconformity.*)

Middle Miocenic.
- Monterey formation (5,000 ft.).
  - (*Disconformity.*)

Lower Miocenic.
- Vaqueros formation (3,000 ft.).
  - (*Generally an unconformity.*)

Subformation.
- Oligocenic (San Lorenzo) or older.

In central Washington, the *Ellensburg beds* (1,000–1,500 ft.) and the *Yakima basalt* represent Miocenic. The *Columbia River basalt* of eastern Oregon and the Upper *Astoria sandstone* and the *Empire formation* of western Oregon are of Miocenic age.

Elsewhere in California the Santa Margarita beds are succeeded by the *Jacalitos formation* and this after a disconformity (?) by the *Etchegoin formation.* The *Ione formation* of northern California, the *Esmeralda formation* of Nevada and the *Bozeman formation* of Montana are continental deposits of Miocenic age in the western states. Other non-marine Miocenic beds are:

III. Upper Miocenic (in part Pliocenic): *Loup Fork beds* of the Great Plains region; *Lower Ogalalla beds* of Nebraska.

II. Middle Miocenic: *Mascall beds* of Oregon; *Deep River beds* of Montana; and Pawnee Creek beds of Colorado.

I. Lower Miocenic: Upper *John Day beds* of Oregon; *Fort Logan beds* of Montana; and *Arikaree group* (*Gering* and *Rosebud formations*) of Nebraska.

XV. The Pliocenic System.

Marine Pliocenic strata are found in Florida and the Gulf region, in some of the southern Atlantic states, and on the Pacific coast. The Atlantic succession is:

Upper Pliocenic or De Sotan (Reynosan).

Reynosa limestone of Texas.
De Sota beds of Florida.
Upper Gayhead sands (?) of Martha's Vineyard, Mass.

Middle Pliocenic or Limonan.

Limon clays of Costa Rica.
Croatan beds of North Carolina.

Lower Pliocenic or Caloosahatchian.

Caloosahatchie marls of Florida.
Waccama beds of Carolinas.

On the Pacific coast the *Merced* (upper) and *San Diego* (lower) series represent the Pliocenic. In the Mount Diablo region, the *Siestan* and *Orindan* formations separated by a disconformity (?), represent the Pliocenic. In southern California, the *Fernando* beds are of lower Pliocenic age and the *Paso Robles* of about the age of the Merced series. In the Santa Cruz Mountains, the *Merced* and *Santa Clara* beds form the higher, and the *Purisima beds* the lower Pliocenic.

In northern Alaska, the upper *Colville formation* of silts contains a Pliocenic fauna, and the *Horsefly gravels* of the Yukon Territory are referred to the same horizon.

The Pliocenic of the interior of North America, is of continental origin, and includes as Lower Pliocenic, the *Upper Ogalalla beds* of Nebraska and the *Palo Duro beds;* and as Middle Pliocenic, the *Blanco beds* of Texas. The upper *Rattlesnake beds* of eastern Oregon are also of Pliocenic age. The *Lafayette formation* (Orange sands) also probably represent a late Pliocenic river deposit of southern and eastern United States, occurring between the Piedmont plateau and the Atlantic, in the upper coastal plain of the Gulf region, the southern Mississippi basin and perhaps in the valleys west of the Appalachians (Chamberlin and Salisbury).

D. THE PSYCHOZOIC OR QUATERNARY SYSTEMS.

XVI. The Pleistocenic System.

The deposits of this system in North America are largely continental, glacial material predominating. The glacial and interglacial stages and substages commonly recognized in North America are:[49]

11. Champlain substage (marine).
10. Glacio-lacustrine substage.
9. Wisconsin or fifth glacial stage (sometimes divided into later and earlier Wisconsin substages).
8. Peorian or fourth interglacial stage.
7. Iowan or fourth glacial stage.
6. Sangamon or third interglacial stage.
5. Illinoian or third glacial stage.
4. Yarmouth (Buchanan)? or second interglacial stage.
3. Kansan or second glacial stage.
2. Aftonian or first interglacial stage.
1. Sub-Aftonian or Jerseyan, or first glacial stage.

The marine Champlain beds are found in northeastern New

[49] Chamberlin and Salisbury, "Geology," Vol. III., p. 383.

York, Ontario and Quebec, in New England, and in New Brunswick. They are sometimes divided into *Leda clays* below and *Saxicava sands* above. The *Sankaty Head beds* of Nantucket are regarded by Wilson as pre-Wisconsin in age.

The *San Pedro beds* of California and the *Admiralty beds* (below) and the *Vashon beds* (above) of western Wasington represent other marine Pleistocenic deposits. The *Toronto interglacial beds* of pre-Wisconsin age are famous for their insect and molluscan faunas and their plants. The lower part of the series constitutes the *Don formation* with a warm-temperate fauna and flora, and the upper part the *Scarboro formation* with a cold-temperate flora and fauna, the latter including 72 species of beetles.

On the Atlantic coast, the *Columbia formation* represents a fluviatile deposit outside of the glaciated area. It is subdivided in ascending order into the *Bridgeton formation, Pensauken formation* and *Cape May formation.* The two higher formations occasionally contain marine fossils. The *Sheridan* or *Equus beds* of the Great Plains region are western non-marine Pleistocenic.

The *Prairie Loess,* west of the Mississippi River, is believed to be mostly of the age of the Illinoisan drift sheet; but somewhat earlier and later deposits of Loess also occur. Its fauna is terrestrial and fresh water.

Pleistocenic deposits of lacustrine origin are found in Lake Bonneville and Lake Lahonton, and of the Glacio-lacustrine stage in Lake Agassiz and other glacial lakes. Here also belong the fossiliferous high beaches of the Great Lakes and the Shell gravels of Goat Island in Niagara River.

XVII. The Holocenic or Recent System.

The modern deposits off the coast of North America are for the most part still submerged. From dredgings, however, these deposits often become accessible and are then found to be crowded with the shells of still living species of mollusks, etc. Raised coral reefs, such as those on Cuba and Florida, show modern species of corals, and the shell limestones (Coquina) of Florida and elsewhere are of living species. Modern continental deposits—fluviatile, eolian, lacustrine, etc., preserve remnants of the living fauna. The Kitchenmidden deposits of New England, New York, the California coast, etc., are rich in shells of living species of molluscs.

APPENDIX B.

FAUNAL SUMMARY. TABLES SHOWING DISTRIBUTION OF SPECIES DESCRIBED.

All the described or figured fossils noted in this work are included in the following tables. North America is divided into faunal provinces for each system from the Cambric through the Pliocenic, and the species are recorded in the province or provinces where they are known to occur. The letters **L, M** and **U** in the first column, refer respectively to lower, middle and upper; the letter **X** indicates that the species ranges more or less throughout the entire system. When no letter is given, the exact range of the species is not known. An asterisk (*) indicates that the species ranges through more than one system. In that case the species is listed separately under each system. The range given in the first column refers to the known entire range, which may not be that for each locality cited.

The geographic and geologic ranges given in the table may sometimes differ from those of the same species in the text. In such a case the range given in the table is to be regarded as the true one based on more recent knowledge.

I. Cambric Faunas.

The following provinces and subprovinces are recognized:

I. Atlantic.

(*a*) Eastern Newfoundland, New Brunswick and Cape Breton.

(*b*) Eastern Massachusetts.

II. Pacific (including Appalachian embayment).

(*c*) Northern Appalachians (western Newfoundland, Labrador, Quebec, Vermont, eastern New York.

(*d*) Southern Appalachians (New Jersey and Pennsylvania to Alabama).

(*e*) Gulf coast (Texas, Oklahoma, Missouri).
(*f*) Northern Mississippi (Wisconsin, Minnesota, etc.)
(*g*) Adirondacks.
(*h*) Black Hills and Rocky Mountains.
(*i*) Pacific (Nevada, Utah, Idaho, British Columbia).

GRAPTOLITES.

1. Dictyonema flabelliforme, **U**, a, c
2. Staurograptus dichotomus, **U**, a, c

BRACHIOPODA.

1. Obolella atlantica, **L**, a, b
2. O. crassa, **L**, b, c
3. O. gemma, **L**, c
4. O. nitida, **L**, a, c
5. Dicellomus politus, **M**, **U**, e, f, h
11. Lingulella aurora, **U**, f
12. L. ella, **L**, **M**, i
13. Lingulepis pinniformis, **U**, f, g, h
14. L. prima, **U**, g, h
34. Acrotreta gemma, X, a, h, i
35. Acrothele matthewi, **M**, a
36. A. subsidua, **L**, **M**, i
37. A. gamagei, **M**, b
38. Linnarsonia pretiosa, **U**, c
39. Iphidea bella, **L**, b, c
40. I. pannulus, **L**, **M**, c, i
41. I. swantonensis, **L**, c
64. Kutorgina cingulata, **L**, c
66. Billingsella coloradoensis, **U**, e, f, h
67. Nisusia festinata, **L**, c, d
68. Protorthis billingsi, **M**, a
165. Plectorthis indianola, **M**, **U**, e
166. P. remnicha, **U**, e, f, h
217. Syntrophia calcifera, **U**, a, e, i

PELECYPODA.

45. Fordilla troyensis, **L**, b ?, c

GASTROPODA.

1. Triblidium rectilaterale, **U**, f
2. T. convexum, **U**, f
*6. Hypseloconus recurvus, **U**, f
7. H. cornutiformis, **U**, f
8. H. franconiensis, **U**, f
14. Palæacmæa acadica, **M**, a, b
15. P. typica, **U**, c
16. P. irvingi, **U**, f
19. Helcionella rugosa, **L**, c
20. Scenella reticulata, **L**, a, b
21. S. retusa, **L**, c
28. Owenella antiquata, **U**, f
84. Raphistomina attleboroughensis, **L**, b
159. Straparollina remota, **L**, a, b
160. S. primæva, **L**, b, c
705. Pelagiella atlantoides, **M**, a

CONULARIDA.

1. Hyolithes americanus, **L**, a, b, c
2. H. billingsi, **L**, c, i
3. H. impar, **L**, b, c
4. H. princeps, **L**, a, b
5. H. quadricostatus, **L**, a, b
6. H. similis, **L**, a
7. H. communis, **L**, a, c
8. H. terranovicus, **L**, a
9. H. decipiens, **M**, a
10. H. acadicus, **M**, a
11. H. danianus, **M**, a
12. H. shaleri, **M**, b
14. Orthotheca emmonsi, **L**, **M**, b, c
15. O. cylindrica, **L**, b
16. Helenia bella, **L**, a
17. Hyolithellus micans, **L**, a, b, c
18. Coleoloides typicalis, **L**, a
21. Urotheca perveta, **L**, a, b
22. Salterella pulchella, **L**, c
23. S. rugosa, **L**, c
24. S. curvata, **L**, b, c

CEPHALOPODA.

1. Volborthella tenuis, **M**, a

ANNELIDA.

64. Nereites deweyi, c
65. N. gracilis, c
66. N. jacksoni, c

67. N. lanceolatus, c
68. N. loomisi, c
69. N. pugnus, c
70. N. robustus, c
71. Scolithus linearis, **U**, a, b, c, d
72. S. canadensis, **U**, c
74. Arenicolitis woodi, **U**, f
78. Climatichnites wilsoni, **U**, c

TRILOBITA.

1. Agnostus interstrictus, **M**, i
2. A. acadicus, **M**, a
3. A. pisiformis, **M**, a
4a. A. trisectus ponepunctus, **U**, a
4b. A. trisectus germanus, **U**, a
5. Microdiscus speciosus, **L**, c
6. M. lobatus, **L**, c
7. M. pulchellus, **M**, a
13. Conocoryphe baileyi, **M**, a
14. C. elegans, **M**, a
15. Ctenocephalus matthewi, **M**, a
16. Atops trilineata, **L**, c
17. Bathynotus holopyga, **L**, c
18. Olenellus thompsoni, **L**, c, d
19. O. gilberti, **L**, i
20. O. iddingsi, **L**, i
21. Holmia bröggeri, **L**, a, b
22. Mesonacis vermontana, **L**, c
23. M. asaphoides, **L**, c
24. Ellipsocephalus grandis, **M**, a
25. E. galeatus, **M**, a
26. Protolenus paradoxoides, **M**, a
27. Bergeronia elegans, **M**, a
28. B. arcticephalus, **M**, a
29. Paradoxides harlani, **M**, b
30. P. lamellatus, **M**, a
31. P. eteminicus, **M**, a
32. P. abenacus, **M**, a
33. P. davidis, **M**, a
34. P. forchhammeri, **M**, a
37. Neolenus serratus, **M**, i
38. N. superbus, **M**, i
39. N. inflatus, **M**, i
40. N. intermedius, **M**, i
41. Oleonoides marcoui, **L**?, c
42. O. wasatchensis, **M**, i
43. O. curticii, **M**, d
44. O. nevadensis, **M**, i
45. Zacanthoides typicalis, **M**, i
46. Z. spinosus, **M**, i
47. Z. idahoënsis, **M**, i
48. Albertella helena, **M**?, h
49. Ptychoparia adamsi, **L**, c
50. P. kingi, **M**, i
51. P. housensis, **M**, i
52. P. piochensis, **M**, i
53. P. robbi, **M**, a
54. P. ouangondiana, **M**, a
*55. P. oweni, **M**, **U**, h, i
56. P. (Lonchocephalus) wisconsinensis, **M**, **U**, f, h
57. Solenopleura acadica, **M**, a
58. S. jerseyensis, **M**, d
59. Agraulos quadrangularis, **M**, b
60. Strenuella strenua, **L**, a, b
61. Ptychaspis miniscaënsis, **U**, f
62. Chariocephalus whitfieldi, **U**, f
63. Parabolina spinulosa, **U**, a
64. Parabolinella quadrata, **U**, a
65. Peltura scarabeoides, **U**, a
66. Ctenopyge pecten, **U**, a
67. C. acadica, **U**, a
68. Sphæropthalmus fletcheri, **U**, a
69. S. alatus var. canadensis, **U**, a
70. Leptoplastus spinosus, **U**, a
71. Crepicephalus augusta, **M**?, i
72. C. texanus, **M**, **U**, d, e, h, i
73. Dikellocephalus minnesotensis, **U**, f
74. D. osceola, **U**, f, i
75. D. pepinensis, **U**, f
76. D. newtonensis, **U**, d
79. Bathyuriscus productus, **M**, i
80. B. howelli, **M**, i
81. B. rotundatus, **M**, i
87. Asaphiscus wheeleri, **M**, i
88. Ogygopsis klotzi, **M**, i
89. Asaphellus homfrayi, macropyga, **U**, a

PHYLLOPODA.

8. Protocaris marshi, **L**, c
9. Anomalocaris canadensis, **M**, i

OSTRACODA.

1. Hipponicharion cavatum, **M**, a
2. H. minus, **M**, a
3. Beyrichona tinea, **M**, a
4. B. planata, **M**, a

MALACOSTRACA.

1. Stenotheca abrupta, **L**, b
2. S. curvirostra, **L**, b
3. S. pauper, **L**, a, b
4. S. levis, **L**, a, b
9. Nothozoe vermontana, **L**, c
16. Aristozoe troyensis, **L**, c

MEROSTOMATA.

9. Aglaspis eatoni, **U**, f
11. Strabops thatcheri, **U**, e

CYSTOIDEA.

1. Eocystites longidactylus, **M**?, i
2. E. primævus, **M**, a

ORDOVICIC FAUNAS.

The following provinces are recognized:

(*a*) New York, eastern Canada, Newfoundland, and Arctic extension.

(*b*) Southern Appalachians (New Jersey and Pennsylvania to Alabama).

(*c*) Gulf (Oklahoma, Missouri).

(*d*) Cincinnati-Nashville domes.

(*e*) Upper Mississippi (Illinois, Iowa, Michigan, Wisconsin, Minnesota, and Canadian extension).

(*f*) Black Hills and Rocky Mountains.

(*g*) Pacific (Nevada to Alaska).

PORIFERA.

*3. Hindia fibrosa, **M**, **U**
7. Brachiospongia digitata, **U**, d
9. Receptaculites oweni, **U**, e
12. R. mammillaris, **L**, g
13. R. iowensis, **U**, e

GRAPTOLITES.

5. Desmograptus cancellatus, **M**, a
6. Dendrograptus flexuosus, **L**, a
7. Ptilograptus plumosus, **L**, **M**, a
9. Cœnograptus gracilis, **M**, a
10. Dichograptus octobrachiatus, **L**, a
11. D. logani, **L**, a
12. D. thureaui, **L**, a
13. Tetragraptus bigsbyi, **L**, a
14. T. quadribrachiatus, **L**, a
15. Phyllograptus typus, **L**, a, c
16. P. ilicifolius, **L**, a
17. P. angustifolius, **L**, a
18. P. anna, **L**, a, c, g
19. Didymograptus bifidus, **L**, a
20. D. nitidus, **L**, a
21. D. patulus, **L**, a
22. Climacograptus bicornis, **M**, a, d
23. C. typicus, **U**, a, d
24. Dicranograptus ramosus, **M**, a
25. Dicellograptus complanatus, **M**, a
26. D. divaricatus, **M**, a
27. D. sextans, **M**, a
28. Diplograptus pristis, **U**, a, b
29. D. foliaceus, **M**, a
30. D. whitfieldi, **M**, a
31. D. dentatus, **L**, a, c

HYDROCORALLINES.

19. Stromatocœrium rugosum, **M**, a
20. S. eatoni, **M**, a
21. Cryptozoön proliferum, **L**, a
22. Labechia ohioensis, **U**, e
23. Beatricea nodulosa, **U**, a, d
24. B. undulata, **U**, a

ANTHOZOA.

1. Streptelasma profundum, **M**, a e
2. S. corniculum, **U**, a, d, e
3. S. rusticum, **U**, d, e
49. Columnaria halli, **M**, a, e

50. C. alveolata, **U**, a, d
*124. Halysites catenulatus, **U**, a, e, f
129a. Tetradium fibratum, **M**, a, d

BRYOZOA.

1. Rhopalonaria venosa, **U**, d
6. Vinella repens, **M**, e
8. Stomatopora inflata, **U**, a, d, e
9. S. delicatula, **M**, **U**, d, e
10. Proboscina frondosa, **U**, d, e
11. P. tumulosa, **M**, e
12. Berenicea minnesotensis, **M**, e
13. Diastoporina flabellata, **U**, e
17. Mitoclema mundulum, **U**, e
18. Phacelopora pertenuis, **U**, e
20. Ceramoporella inclusa, **M**, **U**, e
21. C. distincta, **U**, d
22. C. ohioensis, **U**, d, e
23. Crepipora simulans, **U**, d, e
24. Cœloclema trentonense, **U**, a, e
25. Anolotichia impolita, **M**, e
26. Ceramophylla frondosa, **M**, e
27. Bythotrypa laxata, **M**, **U**, e
36. Monticulipora mammulata, **U**, d
37. M. arborea, **U**, d, e
38. Atactoporella typicalis, **U**, d, e
38a. —— var. præcipta, **M**, e
39. Homotrypa subramosa, **M**, e
40. H. obliqua, **U**, d
41. H. curvata, **U**, d
42. H. flabellaris, **U**, d
43. H. minnesotensis, **M**, d, e
44. Prasopora simulatrix, **M**, **U**, d, e
45. P. lycoperdon, **U**, a
46. Aspidopora elegantula, **U**, e
47. A. newberryi, **U**, d
48. Mesotrypa quebecensis, **U**, a, d, e
49. Amplexopora cingulata, **U**, d
50. Monotrypella quadrata, **U**, d, e
53. Dekayella prænuntia, **M**, e
54. D. obscura, **U**, d
55. D. ulrichi, **U**, d
56. Dekayia aspera, **U**, d
59. Bythopora delicatula, **U**, d, e
60. B. herricki, **M**, e
62. Eridotrypa mutabilis, **U**, d, e
65. Constellaria varia, **U**, d, e
66. C. florida, **U**, d
67. Nicholsonella vaupeli, **U**, d
68. N. pulchra, **M**, d
69. Batostoma winchelli, **M**, e
70. B. fertile, **M**, e
71. B. tenuimurale, **U**, e
72. B. whitfieldi, **U**, d
73. Stromatotrypa ovata, **M**, e
77. Callopora multitabulata, **M**, **U**, d, e
78. C. ramosa, **U**, d
79. C. dalei, **U**, d
80. C. rugosa, **U**, d
82. Phylloporina reticulata, **M**, **U**, a, e
115. Arthrostylus obliquus, **M**, e
116. Helopora spiniformis, **M**, d
118. Arthroclema armatum, **U**, e
119. A. billingsi, **U**, a
120. Nematopora ovalis, **U**, a, e
128. Escharopora falciformis, **U**, d
129. E. subrecta, **M**, e
130. E. pavonia, **U**, d
132. Arthropora simplex, **M**, e
133. A. shafferi, **U**, d
134. Stictoporella cribrosa, **M**, e
137. Rhinidictya mutabilis, **M**, **U**, e
138. R. trentonensis, **M**, d, e
139. Phyllodictya varia, **M**, e
140. Pachydictya fimbriata, **M**, d, e
141. P. acuta, **U**, a, d, e

BRACHIOPODA.

15. Leptobolus insignis, **U**, a
16. L. occidentalis, **U**, a, e
17. Lingula cobourgensis, **U**, a, e
18. L. curta, **U**, a, b
19. L. trentonensis, **U**, a, e
20. L. rectilateralis, **U**, a
21. L. eva, **M**, e
22. L. elderi, **U**, e
23. L. modesta, **U**, d, e
24. L. iowaensis, **U**, e
33. Lingulasma galenaense, **U**, e
42. Trematis ottawaensis, **U**, a, d, e
43. T. terminalis, **U**, a
44. T. millepunctata, **U**, d
45. Schizœrania filosa, **U**, a, e
48. Orbiculoidea lamellosa, **U**, a, e
53. Schizotreta pelopea, **U**, a, e
56. Crania scabiosa, **U**, d, e
57. C. setigera, **U**, e
58. C. trentonensis, **U**, a, e
59. C. lælia, **U**, d

69. Rafinesquina alternata, **U**, a, b, c, d, e
70. R. deltoidea, **U**, a, e
71. R. minnesotensis, **U**, d, e
95. Strophomena billingsi, **U**, a, e
96. S. incurvata, **U**, a, d, e
97. S. trentonensis, **U**, a, d, e
98. S. trilobata, **U**, e
99. S. neglecta, **U**, d
100. S. rugosa, **U**, a, d, e
100a. S. subtenta, **U**, a, d, e
*101. Leptæna rhomboidalis, **U**, a, b, c, d, e, f, g
102. L. unicostata, **U**, e
*103. Plectambonites sericeus, **U**, a, b, d, e
162. Orthis costalis, **M**, a
163. O. tricenaria, **U**, a, d, e, g
167. Plectorthis plicatella, **U**, a, d, e
168. P. whitfieldi, **U**, e
169. P. fissicosta, **U**, d
170. Dinorthis deflecta, **U**, d, e
171. D. meedsi, **U**, e
172. D. pectinella, **U**, a, b, e
173. D. subquadrata, **U**, a, d, e
174. Hebertella borealis, **M**, **U**, a, d, e
175. H. bellirugosa, **U**, d, e
176. H. insculpta, **U**, d, e
177. H. occidentalis, **U**, d, e, f
178. H. sinuata, **U**, d
181. Platystrophia crassa, **U**, d, e
182. P. acutilirata, **U**, d, e
183. P. lynx, **U**, a, d
184. P. laticosta, **U**, d
*185. P. biforata, **U**, a
188. Dalmanella testudinaria, **M**, **U**, a, b, c, d, e, f, g
189. D. emacerata, **U**, a, c, d
190. D. subæquata, **U**, a, c, e
215. Clitambonites diversus, **U**, a, e
216. Scenidium anthonense, **U**, d, e
218. Camarella varians, **L**, **M**, a
219. Parastrophia hemiplicata, **U**, a, b
239. Orthorhynchula linneyi, **U**, d
240. Rhynchotrema inequivalve, **U**, a, b, d, e, f
241. R. dentatum, **U**, a, b, d, e
242. R. capax, **U**, a, c, d, e
243. R. ainslii, **U**, e
245. Camarotœchia plena, **M**, a
307. Zygospira recurvirostris, **U**, a, d, e
308. Z. modesta, **U**, a, d, e
308a. Z. cincinnatiensis, **U**, d
309. Z. nicolletti, **U**, e
310. Cyclospira bisulcata, **U**, a, e

PELECYPODA.

11. Cuneamya miamiensis, **U**, d
12. C. truncatula, **U**, e
15. Orthodesma rectum, **U**, d
16. O. subnasutum, **U**, e
17. O. canaliculatum, **U**, b, d, e
31. Saffordia modesta, **U**, e
32. S. ventralis, **U**, e
37. Psiloconcha grandis, **U**, d
38. P. inornata, **U**, d
56. Ctenodonta nasuta, **M**, a, b, d, e
57. C. gibberula, **M**, a, d, e
58. C. logani, **M**, a, e
59. C. socialis, **M**, e
60. C. alta, **U**, e
61. C. levata, **U**, a, b, e
62. C. astartiformis, **U**, a, g
63. C. fecunda, **U**, e
64. C. calvini, **U**, e
65. C. obliqua, **U**, d, e
66. C. albertina, **U**, d, e
80. Nuculites planulatus, **U**, a, b
81. N. neglectus, **U**, e
121. Cyrtodonta billingsi, **M**, **U**, b, e
122. C. grandis, **U**, b, d, e
123. C. subovata, **M**, d, e
131. Ortonella hainesi, **U**, d
132. Vanuxemia terminalis, **M**, e
133. V. dixonensis, **M**, e
134. V. rotundata, **M**, e
135. V. umbonata, **M**, d, e
136. V. hayniana, **U**, b, d, e
137. Whitella megambona, **M**, e
138. W. scofieldi, **M**, e
139. W. ventricosa, **M**, **U**, a
140. W. obliquata, **U**, d, e
141. W. quadrangularis, **U**, d, e
142. Plethocardia umbonata, **M**, a, d, e
143. Ischyrodonta unionoides, **U**, d
144. I. modioliformis, **U**, d
145. I. truncata, **U**, d
152. Pterinea demissa, **U**, a, d, e
183. Ambonychia bellistriata, **U**, a, d, e
184. A. amygdalina, **U**, a, e

185. Anomalodonta alata, **U**, d
186. Byssonychia intermedia, **U**, e
187. B. byrnesi, **U**, d
188. B. præcursa, **U**, a, d
189. B. radiata, **U**, a, d, e
190. Allonychia jamesi, **U**, d
195. Clionychia lamellosa, **M**, c, e
196. C. undata, **U**, a, e
315. Lyrodesma acuminatum, **M**, d, e
316. L. major, **U**, d, e
317. L. poststriatum, **U**, a, b
406. Modiolopsis faba, **U**, a, b, e
407. M. mytiloides, **U**, a, e
408. M. concentrica, **U**, d
409. M. modiolaris, **U**, a, b, d
419. Modiolodon oviformis, **U**, d
420. M. patulus, **U**, d, e
421. Colpomya constricta, **U**, d
422. Whiteavesia modioliformis, **M**, e
423. W. cincinnatiensis, **U**, d
424. Eurymya plana, **M**, e
425. Aristerella nitidula, **M**, e
452. Rhytimya radiata, **U**, d
453. R. producta, **U**, d
454. R. mickleboroughi, **U**, d
455. Endodesma orthonotum, **M**, e
456. E. gesneri, **M**, **U**, a
457. E. cuneatum, **U**, e

GASTROPODA.

3. Triblidium barabuense, **L**, e
4. T. nycteis, **L**, a
5. Helcionopsis striata, **U**, d
*6. Hypseloconus recurvus, **L**, e
9. Archinacella deformata, **M**, a
10. A. deleta, **M**, e
11. A. patelliformis, **U**, a
12. A. simulatrix, **M**, **U**, d, e
13. A. cingulata, **U**, d
17. Palæacmæa quebecensis, **L**, a
18. P. humilis, **M**, e
22. Scenella superba, **M**, a, e
23. S. montrealensis, **M**, a
25. Cyrtolites ornatus, **U**, a, b, d
26. C. retrorsus, **M**, **U**, d
27. C. carinatus, **U**, d, e
29. Protowarthia rectangularis, **M**, e
30. P. pervoluta, **M**, d, e
31. P. cancellata, **U**, a, d, e
34. Tetranota bidorsata, **M**, **U**, d
35. T. sexcarinata, **M**, **U**, d, e
36. T. obsoleta, **M**, **U**, d, e
37. Bucania sulcatina, **M**, a
38. B. halli, **M**, d, e
39. B. punctifrons, **U**, a, d
40. Salpingostoma buelli, **L**, e
41. S. expansum, **U**, a
42. S. richmondense, **U**, a, d
45. Oxydiscus subacutus, **U**, d
48. Phragmolithes triangularis, **M**, d, e
49. P. fimbriatus, **M**, e
50. P. compressus, **U**, a
51. P. dyeri, **U**, d, e
52. Bellerophon troosti, **U**, d
53. B. platystoma, **U**, e
64. Bucanopsis carinifera, **U**, d
75. Carinaropsis carinata, **U**, a
76. C. cunulæ, **U**, d
77. C. cymbula, **U**, d
80. Raphistoma striatum, **M**, a
81. R. stamineum, **M**, a
82. R. planistrium, **M**, a
83. R. peracutum, **M**, e
85. Raphistomina lapicida, **M**, a, d
88. Scalites angulatus, **M**, a
89. Ormospira laticincta, **M**, d
90. O. alexandra, **M**, a, d
91. Lophospira rectistriata, **M**, a
92. L. bicincta, **M**, **U**, a, d, e
93. L. quadrisulcata, **U**, e
94. L. helicteres, **M**, e
95. L. wisconsinensis, **M**, e
96. L. perangulata, **M**, a, d, e
97. L. acuminata, **U**, d, e
98. L. medialis, **U**, a, d, e
99. L. pulchella, **M**, **U**, d, e
100. L. oweni, **M**, d, e
101. L. ampla, **U**, d
102. L. tropidophora, **U**, d
103. L. sumnerensis, **U**, d, e
104. L. bowdeni, **U**, d
105. L. augustina, **M**, **U**, a, e
106. L. serrulata, **M**, a, d, e
110. Schizolopha moorei, **U**, d
117. Liospira micula, **U**, d, e
118. L. progne, **M**, d, e
119. L. vitruvia, **M**, **U**, a, d, e
120. L. americana, **M**, **U**, a, d, e
121. L. eugenia, **M**, a

122. L. mundula, **M**, **U**, a, d
123. Euconia ramsayi, **L**, a
124. E. etna, **L**, a
126. Eotomaria dryope, **M**, d, e
127. E. vicina, **M**, e
128. E. supracingulata, **M**, e
131. Clathrospira subconica, **M**, **U**, a, d, e
132. C. conica, **M**, **U**, d, e
144. Hormotoma gracilis, **M**, **U**, a, b, d, e
145. H. salteri, **M**, **U**, a, d
146. H. bellicincta, **U**, a, e
147. H. trentonensis, **U**, a, d, e
148. H. major, **U**, e
152. Cœlidium lineare, **L**, a
153. C. œhlerti, **U**, e
155. Solenospira prisca, **L**, **M**, a, d, e
156. S. pagoda, **M**, e
171. Ophileta complanata, **L**, a, b, c, e, f
172. O. bella, **L**, a
173. Ophilitina sublaxa, **M**, **U**, e
174. Eccyliopteris beloitensis, **M**, d, e
175. E. owenensis, **U**, e
176. Helicotoma planulata, **M**, **U**, a, c, e
176a. H. umbilicata, **M**, e
177. H. tennesseensis, **M**, d
185. Calaurops lituiformis, **L**, a
186. Eccyliomphalus distans, **L**, a
187. E. undulatus, **M**, d, e
188. E. triangulus, **L**, a
189. Maclurea magna, **M**, a, b, e
190. M. bigsbyi, **M**, d, e
191. M. logani, **M**, a
192. M. manitobaensis, **U**, e
193. M. cuneata, **U**, e, f
197. Cyclonema bilix, **U**, d, e
198. C. mediale, **U**, d
199. C. varicosum, **U**, d
200. C. sublæve, **U**, d
201. Trochonema umbilicatum, **U**, a, d, e
202. T. beloitensis, **M**, e
203. T. vagrans, **M**, e
204. T. nitidum, **U**, d
204a. T. salteri, **U**, e
205. T. pulchellum, **M**, d, e
206. T. duplicatum, **M**, e
210. Cyclora minuta, **U**, d
219. Holopea ampla, **M**, e
220. H. similis, **M**, **U**, d, e
221. H. rotunda, **M**, **U**, d, e
222. H. textilis, **M**, **U**, d, e
295. Subulites elongatus, **U**, a
296. S. regularis, **M**, d, e
297. S. nanus, **M**, d
298. Fusispira inflata, **U**, e
299. F. subbrevis, **U**, e
300. F. subfusiformis, **U**, a, d, e
301. F. convexa, **U**, a, e
302. F. angusta, **U**, d, e

CEPHALOPODA.

2. Cameroceras brainardi, **L**, a
3. C. tenuiseptum, **M**, a
4. Vaginoceras oppletum, **M**, a
5. Endoceras consuetum, **L**, a, e
6. E. montrealense, **L**, a
7. E. proteiforme, **M**, **U**, a, d, e
8. Cyclendoceras annulatum, **U**, a
9. Nanno noveboracum, **M**, a
10. N. aulema, **M**, e
11. Piloceras explanator, **L**, a
11a. P. triton, **L**, a
12. P. wortheni, **L**, a
13. Orthoceras primigenium, **L**, a
14. O. modestum, **M**, a
15. O. recticameratum, **M**, a
16. O. multicameratum, **M**, **U**, a, d, e
17. O. junceum, **M**, **U**, a, d, e
18. O. amplicameratum, **M**, **U**, a, d
19. O. shumardi, **M**, a
20. O. sociale, **U**, d, e
39. Protocycloceras lamarcki, **L**, a
40. Cycloceras lesueuri, **M**, d, e
41. C. olorus, **M**, **U**, a, d, e
42. C. nicolletti, **M**, e
52. Orygoceras cornu-oryx, **L**, a
53. Spyroceras bilineatum, **M**, **U**, a, d, e
54. S. anellus, **M**, **U**, a, d, e
58. Aphetoceras farnsworthi, **L**, a
59. A. americanum, **L**, a
60. Barrandeoceras natator, **M**, a
61. B. convolvans, **M**, a
62. Tarphyceras seeleyi, **L**, a
63. T. clarkii, **L**, a
64. T. multicameratum, **M**, a

65. Eurystomites kelloggi, **L**, a
66. E. virginianus, **L**, a, b
67. E. undatus, **M**, a, e
68. Schrœderoceras eatoni, **L**, a
69. S. cassinense, **L**, a
70. Trocholites ammonius, **U**, a
71. T. planorbiformis, **U**, a
74. Plectoceras jason, **M**, a
75. P. bondi, **M**, d
81. Zitteloceras hallianum, **M**, **U**, a, e
82. Z. billingsi, **M**, d, e
129. Tripteroceras planoconvexum, **M**, **U**, d, e
130. T. oweni, **M**, d, e
131. T. planidorsatum, **U**, e
132. T. lambi, **U**, e
146. Loxoceras moniliforme, **M**, a
150. Actinoceras bigsbyi, **M**, **U**, a, d, e
151. A. tenuifilum, **M**, a
152. A. remotiseptum, **M**, **U**, a, e
154. Cyrtactinoceras boycii, **M**, a
155. C. champlainense, **M**, a
156. Gonioceras anceps, **M**, a, d, e
157. G. occidentale, **U**, e
158. Mælonoceras neleus, **M**, e
160. Cyclostomiceras cassinense, **L**, a
165. Oncoceras pristinum, **M**, a
166. O. lycus, **M**, e
167. O. carveri, **M**, e
168. O. pandion, **M**, e
169. O. exiguum, **U**, e
171. Ooceras seeleyi, **M**, a
172. O. lativentrum, **M**, a
173. Clionoceras mumiæforme, **M**, d, e
174. Poterioceras apertum, **U**, e

ANNELIDA.

12. Conchicolites corrugatus, **U**, d
13. C. gregarius, **U**, d
17. Ortonia minor, **U**, d
19. Arabellites hamatus, **U**, a
20. A. cuspidatus, **U**, a
21. A. gibbosus, **U**, a
22. A. lunatus, **U**, a
23. A. cristatus, **U**, a
26. Eunicites major, **U**, a
27. E. varians, **U**, a
28. E. contortus, **U**, a
29. E. simplex, **U**, a
30. E. gracilis, **U**, a
35. Lumbriconereites dactylodus, **U**, a
39. Oenonites serratus, **U**, a
40. O. rostratus, **U**, a
41. O. cuneatus, **U**, a
43. Glycerites sulcatus, **U**, a
54. Prioniodus radicans, **U**, a
55. P. elegans, **U**, a
63. Drepanodus arcuatus, **U**, a
73. Scolithus minutus, **L**, a

TRILOBITA.

8. Harpes ottawaënsis, **M**, **U**, a, b, e
9. Trinucleus concentricus, **U**, a, b, c, g
10. Ampyx normalis, **M**, a
11. A. halli, **M**, a
35. Remopleurides canadensis, **M**, a
36. R. lingualis, **U**, a
*55. Ptychoparia oweni, **L**, g
77. Triarthrus fischeri, **M**, a
78. T. becki, **U**, a, b
82. Bathyurus conicus, **L**, a
83. B. amplimarginatus, **L**, a, b
84. B. extans, **M**, **U**, a
85. B. smithi, **M**, a
86. B. spiniger, **M**, **U**, a, d, e
90. Asaphus marginalis, **L**, **M**, a, b
91. Isoteles canalis, **L**, a
92. I. obtusus, **M**, a
93. I. gigas, **M**, **U**, a, b, d, e
94. I. maximus, **U**, b, e
95. Illænus consimilis, **M**, a
96. I. globosus, **M**, a
97. I. angusticollis, **M**, a
98. I. latiaxiatus, **M**, a
99. I. americanus, **U**, a, e
100. I. crassicauda, **U**, a, b, g
105. Bumastus indeterminatus, **M**, **U**, a, e
106. B. milleri, **M**, a
107. B. trentonensis, **U**, a, b, c, e
109. Thaleops arctura, **M**, a
110. T. ovata, **M**, **U**, a, e
111. Nileus vigilans, **M**, **U**, c, e
121. Cyphaspis matutina, **M**, a, b
122. C. trentonensis, **U**, b
133. Bronteus lunatus, **U**, a, b, e
138. Amphilichas minganensis, **M**, a
139. A. trentonensis, **U**, a, b, d
149. Odontopleura parvula, **U**, a, b, e

150. Glaphurus pustulatus, **M**, a
151. Encrinurus trentonensis, **U**, b, e
153. Calymene senaria, **U**, a, b, d, e
154. C. callicepha, **U**, a, b, d, e
162. Ceraurus hudsoni, **M**, a
163. C. pompilius, **M**, a
164. C. pleurexanthemus, **U**, a, b, d, e
165. Pseudosphærexochus vulcanus, **M**, a
167. Pliomera canadensis, **M**, a
168. Sphærexochus parvus, **M**, a
174. Pterygometopus callicephalus, **M**, **U**, a, b, d, e
175. P. intermedius, **U**, b, e
176. P. eboraceus, **U**, a
177. Dalmanites achates, **U**, a, d

Ostracoda.

5. Leperditella inflata, **M**, d
6. Leperditia fabulites, **M**, a, b, d, e
7. L. cæcigena, **U**, d
12. Isochilina subnodosa, **U**, d
13. I. jonesi, **U**, d
16. Schmidtella crassimarginata, **M**, d, e
17. S. umbonata, **M**, e
18. Aparchites fimbriatus, **U**, e
21. Primitiella unicornis, **U**, d, e
22. Primitia cincinnatiensis, **U**, d
23. P. tumidula, **U**, e
29. Ulrichia nodosa, **U**, d
31. Halliella labiosa, **U**, e
33. Dilobella typa, **M**, e
34. Eurychilina reticulata, **M**, e
35. E. equalis, **M**, d
36. E. striatomarginata, **U**, d
37. Macronotella scofieldi, **M**, d, e
38. Jonesella crepidiformis, **U**, d
39. J. pedigera, **U**, d
40. Dicranella bicornis, **M**, e
41. Drepanella crassinoda, **M**, d
42. D. elongata, **M**, d
43. M. macra, **M**, d, e
50. Placentula marginata, **U**, d
51. Bollia unguloidea, **U**, e
52. B. pumila, **U**, d
57. Ceratopsis chambersi, **M**, **U**, d, e
58. C. oculifera, **U**, d
59. Tetradella quadrilirata, **M**, **U**, d, e
60. T. lunatifera, **U**, d, e

61. Ctenobolbina fulcrata, **M**, e
62. C. ciliata, **U**, d
70. Klœdinia initialis, **M**, e
76. Scofieldia bilateralis, **U**, e
101. Krausella arcuata, **M**, d, e
102. Entomis madisonensis, **U**, d
112. Bythocypris robusta, **M**, e
113. B. cylindrica, **U**, d, e
117. Cytherella rugosa, **M**, **U**, e

Cirripedia.

1. Lepidocoleus jamesi, **U**, d

Malacostraca.

5. Ribeiria calcifera, **L**, a, b
6. R. compressa, **L**, a
7. R. ventricosa, **L**, a
17. Aristozoe canadensis, **U**, a

Cystoidea.

6. Palæocystites tenuiradiatus, **M**, a
7. Amygdalocystites florealis, **U**, a
8. Glyptocystites forbesi, **M**, a
9. G. multiporus, **U**, a
10. G. logani, **U**, a
13. Pleurocystites squamosus, **U**, a
14. P. filitextus, **U**, a
15. P. elegans, **U**, a
24. Malocystites murchisoni, **M**, a
25. M. barrandii, **M**, a
26. M. emmonsi, **M**, a
27. Camarocystites punctatus, **U**, a
28. Agelacrinus cincinnatiensis, **U**, d
33. Hemicystites stellatus, **U**, d
34. H. granulatus, **U**, d
35. Porocrinus conicus, **U**, a

Blastoidea.

1. Blastoidocrinus carchariædens, **M**, a

Crinoidea.

7. Hybocrinus pristinus, **M**, a
8. H. tumidus, **U**, a
9. Anomalocrinus incurvus, **U**, d
10. Heterocrinus simplex, **U**, a, d
11. H. tenuis, **U**, a
15. Carabocrinus geometricus, **M**, a
16. C. radiatus, **U**, a
17. Dendrocrinus conjugans, **U**, a

18. D. cylindricus, **U**, a
19. D. latibrachiatus, **U**, a
20. D. cincinnatiensis, **U**, d
21. D. caduceus, **U**, d
22. D. casei, **U**, d
152. Retiocrinus stellaris, **U**, a
157. Hercocrinus elegans, **M**, a
158. H. ornatus, **M**, a
160. Archæocrinus pyriformis, **U**, a
166. Glyptocrinus ramulosus, **U**, a
167. G. decadactylus, **U**, d
168. Periglyptocrinus priscus, **M**, a
191. Cleiocrinus regius, **U**, a
194. Taxocrinus elegans, **U**, a

Siluric Faunas.

The following provinces are recognized:

(*a*) Maine to Anticosti and Arctic extension.
(*b*) New York to Ontario.
(*c*) Southern Appalachians.
(*d*) Cincinnati-Nashville domes.
(*e*) Michigan basin (Michigan, Wisconsin, and Canadian extension and northern parts of Ohio, Indiana, and Illinois).
(*f*) Ozark dome, and Iowa extension.
(*g*) Winnipeg and Hudson Bay.
(*h*) Rocky Mountains and Northwest.

Porifera.

1. Astylospongia præmorsa, **L**, d
2. A. inciso-lobata, **L**, d
*3. Hindia fibrosa, **L**, d
8. Astræospongia meniscus, **L**, d
10. Receptaculites hemisphæricus, **L**, e
11. R. ohioensis, **L**, e

Graptolites.

2. Dictyonema retiforme, **L**, b
3. D. gracilis, **L**, b
32. Monograptus clintonensis, **L**, b
33. Retiolites venosus, **L**, b

Hydrocorallines.

4. Clathrodictyon vesiculosum, **L**, a, b, e
5. C. striatellum, **L**, b
6. C. ostiolatum, **L**, **U**, b, e
13. Stromatopora antiqua, **L**, b

Anthozoa.

4. Streptelasma caliculum, **L**, b
10. Zaphrentis stokesi, **L**, a, e
14. Amplexus shumardi, **L**, d, e, f
21. Pycnostylus guelphensis, **L**, e
22. Chonophyllum niagarense, **L**, b, d
24. Ptychophyllum stokesi, **L**, d, e
30. Palæocyclus rotuloides, **L**, b
46. Strombodes pentagonus, **L**, d, e
47. S. striatus, **L**, d, e
48. S. mamillatus, **L**, d, e, f
51. Eridophyllum rugosum, **L**, d
56. Diplophyllum cæspitosum, **L**, b, e
61. Duncanella borealis, **L**, e
64. Calceola tennesseensis, **L**, d
69. Romingeria umbellifera, **U**, e
75. Syringopora verticillata, **L**, e
76. S. retiformis, **L**, b, d
82. Favosites venustus, **L**, b, c, d, e
83. F. favosus, **L**, b, d, e, f
84. F. niagarensis, **L**, b, d, e, f
105. Thecia major, **L**, d, e
106. T. minor, **L**, d, e
108. Alveolites niagarensis, **L**, d, e
111. Cladopora laqueata, **L**, d, e
114. C. seriata, **L**, b
120. Striatopora flexuosa, **L**, b

*124. Halysites catenulatus, L, U, a, b, d, e
125. Lyellia americana, L, a, d, e
126. Heliolites megastoma, L, b, e, f
127. H. interstinctus, L, d, e
128. H. elegans, L, b, d, e
129. Plasmopora follis, L, d, e

BRYOZOA.

2. Rhopalonaria attenuata, L, b, c
19. Ceramopora imbricata, L, b, d
28. Fistulipora neglecta, L, d
32. Chilotrypa osteolata, L, b
51. Monotrypella arbuscula, U, b
57. Batostomella granulifera, L, b, e
61. Bythopora spinulosa, L, b
63. Eridotrypa similis, L, b
76. Trematopora tuberculosa, L, b
81. Callopora elegantula, L, b
83. Phylloporina asperato-striata, L, b
84. Drymotrypa diffusa, L, b
85. Fenestella elegans, L, b
90. Semicoscinium tenuiceps, L, b
103. Polypora incepta, L, b
117. Helopora fragilis, L, b
131. Clathropora frondosa, L, b
142. Pachydictya crassa, L, a, b
160. Lichenalia concentrica, L, b
161. Diamesopora dichotoma, L, b
162. Stictotrypa punctipora, L, b

BRACHIOPODA.

6. Dinobolus conradi, L, e, f
7. Monomerella prisca, L, b, e
8. Trimerella acuminata, L, b, e
9. T. ohioensis, L, b, e
10. T. grandis, L, b, e
25. Lingula cuneata, L, b
26. L. clintoni, L, a, b, c
54. Schizotreta tenuilamellata, L, a, b
65. Dictyonella reticulata, L, e
72. Stropheodonta corrugata, L, b, d
73. S. profunda, L, b, d, e
*74. S. varistriata, U, a, b, c
88. Strophonella patenta, L, b, c
89. S. striata, L, b, d
*101. Leptæna rhomboidalis, L, a, b, c, d, e, f, g, h
*103. Plectambonites sericeus, L, b, d, e
104. P. transversalis, L, a, b, e
105. Schuchertella subplana, L, U, a, b, d, e
106. S. interstriata, U, b, e
118. Chonetes jerseyensis, U, b, c
164. Orthis flabellites, L, b, e
179. Orthostrophia fasciata, L, b
*185. Platystrophia biforata, L, b, d
186. Bilobites bilobus, L, b, e
191. Dalmanella elegantula, L, a, b, c, d, f
194. Rhipidomella hybrida, L, a, b, d, f
220. Anastrophia interplicata, L, b, d, e
221. A. internascens, L, d, e
223. Conchidium occidentale, L, b, e
224. C. nettlerothi, L, a
225. C. laqueatum, L, e
226. Stricklandinia davidsoni, L, a, c
227. S. castellana, L, f
228. Pentamerus oblongus, L, a, b, d, e, f
228a. P. subrectus, L, f
228b. P. cylindricus, L, d, e
229. Clorinda fornicata, L, b, e
230. C. ventricosa, L, d, e
244. Rhynchotreta cuneata americana, L, b, d, e
246. Camarotœchia neglecta, L, a, b, d, e
247. C. acinus, L, b, d
248. C. indianensis, L, d
249. C. whitei, L, d
250. C. lamellata, U, b, c
251. C. litchfieldensis, U, b
*252. C. semiplicata, U, e
265. Uncinulus stricklandi, L, d
311. Atrypa nodostriata, L, b, d, e
312. A. marginalis, L, d, e
313. A. rugosa, L, a, b, d
*314. A. reticularis, L, U, a, b, c, d, e, f, g, h
326. Spirifer radiatus, L, a, b, d, e
327. S. eudora, L, d, e
328. S. niagarensis, L, b, d
329. S. sulcatus, L, b
330. S. crispus, L, a, b, d
331. S. vanuxemi, U, b, c, e
332. S. eriensis, U, b
333. S. corallinensis, U, b
391. Homeospira evax, L, d

393. Trematospira camura, **L**, b
397. Whitfieldella cylindrica, **L**, a, b
398. W. intermedia, **L**, b
399. W. nitida, **L**, a, b, d
400. W. nucleolata, **U**, b, c, e
401. W. sulcata, **U**, b
402. Hyattella congesta, **L**, b, d
403. Nucleospira pisiformis, **L**, b, d, f
405. Anoplotheca hemispherica, **L**, a, b, c, d
406. A. plicatula, **L**, b, e
410. Meristina maria, **L**, d, e

Pelecypoda.

13. Ilionia galtensis, **L**, **U**, b
14. I. sinuata, **U**, b
46. Panenka canadensis, **U**, e
67. Ctenodonta machæriformis, **L**, b
68. C. equilatera, **U**, b
124. Cyrtodonta undulostriata, **L**, b
125. C. canadensis, **L**, b, e
127. Megambonia aviculoidea, **U**, b, c
153. Pterinea emacerata, **L**, **U**, b, c
154. P. striæcosta, **L**, d, e
155. P. lanii, **U**, e
*156. P. securiformis, **U**, b
167. Leiopteria subplana, **L**, **U**, b
201a. Conocardium monroicum, **U**, e
410. Modiolopsis orthonota, **L**, b
411. M. primigenia, **L**, b
412. M. dubia, **U**, b
426. Goniophora dubia, **U**, b, e
483. Cypricardinia arata, **L**, e, f, h

Gastropoda.

33. Bucaniella trilobata, **L**, b, c
43. Trematonotus alpheus, **L**, b, e
54. Bellerophon exiguus, **L**, d
86. Euomphalopterus valerius, **L**, **U**, b, e
87. E. elora, **L**, b
107. Lophospira bispiralis, **L**, **U**, b, e
111. Phanerotrema occidens, **L**, e
125. Euconia pervetusta, **L**, b
129. Eotomaria areyi, **L**, **U**, b, e
130. E. galtensis, **L**, **U**, b, e
149. Hormotoma subcarinata, **U**, e
154. Cœlidium macrospira, **L**, b, e
157. Solenospira minuta, **U**, b, e
195. Poleumita scamnata, **L**, b
196. P. crenulata, **L**, b
209. Pycnomphalus solarioides, **L**, b
223. Holopea antiqua, **U**, b, c, e
224. H. pervetusta, **U**, b, c, e
226. Strophostylus cyclostomus, **U**, e
231. Diaphorostoma niagarense, **L**, b
234. Platyceras niagarense, **L**, b
272. Acanthonema holopiforme, **U**, e
273. A. laxum, **U**, e
274. A. newberryi, **U**, e
657. Hercynella canadensis, **U**, e

Conularida.

25. Tentaculites gyracanthus, **U**, b, c
31. Conularia niagarensis, **L**, b

Cephalopoda.

21. Orthoceras simulator, **L**, d
22. O. rectum, **L**, b, e
44. Dawsonoceras annulatum, **L**, e
44a. var. americanum, **L**, **U**, e
45. Protokionoceras medullare, **L**, e
46. P. crebescens, **L**, b, e
47. P. trusitum, **L**, **U**, b, e
49. Kionoceras angulatum, **L**, e
50. K. orus, **L**, e
51. K. darwini, **L**, b
72. Discoceras graftonense, **L**, e
73. D. marshii, **L**, d
76. Plectoceras bickmoreanum, **L**, d
77. Sphyradoceras desplainense, **L**, b, e
78. S. costatum, **L**, b, e
80. Mitroceras gebhardi, **U**, b
84. Halloceras hercules, **L**, e
159. Mælonoceras arcticameratum, **L**, b, e
161. Cyclostomiceras orodes, **L**, **U**, b, e
162. C. brevicorne, **L**, b, e
170. Oncoceras orcas, **L**, e
175. Poterioceras sauridens, **L**, **U**, b, e
185. Trimeroceras gilberti, **L**, e
186. Hexameroceras herzeri, **L**, e
187. H. cacibiforme, **L**, e
188. Septameroceras septoris, **L**, e
189. Phragmoceras nestor, **L**, e
190. P. parvum, **L**, d, e
191. P. angustum, **L**, e
192. P. ellipticum, **L**, e

ANNELIDA.

3. Spirorbis laxus, **U**, b, e
14. Cornulites proprius, **L**, d
15. C. bellistriatus, **L**, b
16. C. arcuatus, **L**, **U**, b, e
24. Arabellites elegans, **L**, b
25. A. similis, **L**, b
31. Eunicites clintonensis, **L**, b
36. Lumbriconereites triangularis, **L**, b
37. L. armatus, **L**, b
38. L. basalis, **L**, b
42. Œnonites amplus, **L**, b
76. Arthrophycus alleghaniensis, **L**, b, c, d
77. Dædalus archimedes, **L**, b, c

TRILOBITA.

12. Ampyx niagarensis, **L**, f
101. Illænus ioxus, **L**, b, d, e, f
102. I. insignis, **L**, d, e
103. I. imperator, **L**, e
104. I. armatus, **L**, e
108. Bumastus niagarensis, **L**, d, e, f
112. Proëtus pachydermatus, **U**, c
115. P. crassimarginatus, **U**, e
134. Bronteus acamas, **L**, e
135. Arctinurus boltoni, **L**, b
136. A. occidentalis, **L**, d
137. A. nereus, **L**, b, f
142. Corydocephalus phlyctainodes, **L**, b, d, e, f
143. Dicranopeltis decipiens, **L**, e
144. Metopolichas breviceps, **L**, d
145. Acidaspis quinquespinosa, **L**, f
152. Encrinurus ornatus, **L**, a, b, c, d, f
155. Calymene vogdesi, **L**, b, c, d
156. C. rostrata, **L**, b, c
157. C. niagarensis, **L**, b, d, e
159. Homalonotus delphinocephalus, **L**, b, d
165. Ceraurus niagarensis, **L**, b, d, e
169. Sphærexochus romingeri, **L**, d, e, f
170. Phacops pulchella, **L**, d
178. Dalmanites limulurus, **L**, b, d
179. D. danæ, **L**, e
180. D. vigilans, **L**, e, f

OSTRACODA.

8. Leperditia angulifera, **U**, e
9. L. scalaris, **U**, b, c
10. L. alta, **U**, b, c, e
14. Isochilina cylindrica, **L**, b
26. Æchmina spinosa, **L**, b
27. A. abnormis, **L**, b
47. Octonaria curta, **L**, b
53. Bollia symmetrica, **L**, b
54. B. lata, **L**, b
66. Beyrichia granulosa, **L**, e
67. B. waldronensis, **L**, d
68. B. moodeyi, **U**, c
*71. Klœdenia manliensis, **U**, c
*72. K. sussexensis, **U**, c
86. Klœdenella pennsylvanica, **U**, c
87. K. halli, **M**, b
103. Entomis waldronensis, **L**, d

CIRRIPEDIA.

2. Lepidocoleus sarlii, **L**, b

MALACOSTRACA.

8. Ceratiocaris acuminata, **U**, b
18. Emmelezoe decora, **M**, e

MEROSTOMATA.

10. Pseudoniscus roosevelti, **M**, b
12. Eurypterus maria, **M**, b
13. E. myops, **M**, b
14. E. pittsfordensis, **M**, b
15. E. eriensis, **U**, e
16. E. lacustris, **U**, b
17. E. remipes, **U**, b
18. E. robustus, **U**, b
19. E. dekayi, **U**, b
21. Eusarcus grandis, **U**, b
22. E. scorpionis, **U**, b
23. Dolichopterus macrocheirus, **U**, b
24. Pterygotus macrophthalmus, **U**, b
27. Hughmilleria shawangunk, **M**, b
28. H. socialis, **M**, b

ARACHNIDA.

Proscorpius osborni, **U**, b

CYSTOIDEA.

3. Holocystites cylindricus, **L**, e
4. H. alternatus, **L**, e
5. Gomphocystites glans, **L**, e
11. Caryocrinus ornatus, **L**, b
12. C. bulbulus, **L**, d

17. Jækelocystes hartleyi, **U**, c
18. Pseudocrinites gordoni, **U**, c
19. P. clarki, **U**, c
20. Callocystites jewetti, **L**, b
21. C. canadensis, **L**, b
22. Sphærocystites multifasciatus, **U**, c
23. S. bloomfieldensis, **U**, c
36. Zophocrinus howardi, **L**, e

BLASTOIDEA.

2. Troostocrinus reinwardti, **L**, d

CRINOIDEA.

1. Pisocrinus milligani, **L**, d
2. P. gorbyi, **L**, d
3. Stephanocrinus angulatus, **L**, b
12. Calceocrinus radicula, **L**, b
23. Botryocrinus polyxo, **L**, e
24. Cyathocrinus cora, **L**, e
57. Coccocrinus bacca, **L**, d
58. Marsipocrinus tennesseensis, **L**, d
59. M. præmaturus, **L**, d
119. Periechocrinus christyi, **L**, d
120. P. chicagoensis, **L**, e
121. P. marcouanus, **L**, e
122. P. ornatus, **L**, d
123. P. tennesseensis, **L**, d
153. Thysanocrinus inornatus, **L**, e
154. T. occidentalis, **L**, e
155. T. pentangularis, **L**, e
156. Lampterocrinus tennesseensis, **L**, d
161. Lyriocrinus dactylus, **L**, b
162. L. melissa, **L**, d
169. Siphonocrinus nobilis, **L**, e
170. Macrostylocrinus striatus, **L**, d
171. Melocrinus oblongus, **L**, d
172. M. rœmeri, **L**, d
180. Eucalyptocrinus milligani, **L**, d
181. E. cœlatus, **L**, b
182. var. levis, **L**, b
183. E. crassus, **L**, d
184. E. elrodi, **L**, d
185. E. magnus, **L**, d
186. E. tuberculatus, **L**, b, d, e
187. Callicrinus longispinus, **L**, e
188. Crotalocrinus americanus, **L**, e
189. Camarocrinus stellatus, **U**, b, c
192. Ichthyocrinus lævis, **L**, b
193. Lecanocrinus macropetalus, **L**, b

DEVONIC FAUNAS.

The following geographic provinces are recognized:

(*a*) Maine and eastern Canada.
(*b*) Eastern New York, eastern Pennsylvania and New Jersey.
(*c*) Southern Appalachians.
(*d*) Central and western New York.
(*e*) Michigan Basin (Michigan, western Ontario, northern Ohio, northern Indiana, northern Illinois, and Wisconsin).
(*f*) Falls of the Ohio and southern Ozarks (including Oklahoma).
(*g*) Northern Ozark and Iowa.
(*h*) Winnipeg and Mackenzie River.
(*i*) Rocky Mountains (including Nevada and Utah).

FORAMINIFERA.

*14. Calcisphæra robusta, **M**, e, f

PORIFERA.

4. Dictyospongia sceptum, **U**, d
5. Prismodictya prismatica, **U**, d
6. Hydnoceras tuberosum, **U**, d

GRAPTOLITES.

4. Dictyonema hamiltoniæ, **M**, d, e

HYDROCORALLINES.

1. Actinostroma expansum, **U**, g, h
2. A. fenestratum, **U**, h
3. A. nodulatum, **M**, e
7. Clathrodictyon cellulosum, **M**, d
8. Stylodictyon columnare, **M**, e
9. Stromatoporella granulata, **M**, d
10. S. tuberculata, **M**, d
11. S. incrustans, **U**, g
12. Idiostroma cæspitosum, **M**, e
14. Stromatopora monticulifera, **M**, e
15. S. pustulifera, **M**, e
16. S. densa, **M**, e
17. S. centrota, **L**, b
18. S. barretti, **L**, b

ANTHOZOA.

5. Streptelasma rectum, **M**, d
6. Zaphrentis gigantea, **M**, d, e, f
7. Z. prolifica, **M**, e, f
8. Z. convoluta, **M**, f
9. Z. simplex, **M**, d
15. Amplexus yandelli, **M**, e, f
16. A. hamiltoniæ, **M**, d
17. Aulacophyllum sulcatum, **M**, f
18. Acrophyllum oneidaënse, **M**, f
19. Blothrophyllum decorticatum, **M**, e, f
20. B. promissum, **M**, f
23. Chonophyllum magnificum, **M**, e, f
25. Cystiphyllum vesiculosum, **M**, d, e, f
26. C. conifollis, **M**, d
27. C. varians, **M**, d
28. C. sulcatum, **M**, d, e, f
29. C. aggregatum, **M**, e
31. Microcyclus discus, **M**, d, e
32. Hadrophyllum d'orbignyi, **M**, f
33. Cyathophyllum robustum, **M**, d, e, f
34. C. conatum, **M**, d
35. C. alpenense (= *C. traversense* Winch.), **M**, e
37. Heliophyllum halli, **M**, d, f
38. H. confluens, **M**, d
39. H. tenuiseptatum, **M**, d
40. H. corniculum, **M**, d, e, f
41. Acervularia rugosa, **M**, e, f
42. A. davidsoni, **M**, e, g
43. Phillipsastræa gigas, **M**, d, e, f
44. P. verneuilli, **M**, d, e
45. Pachyphyllum woodmani, **U**, g
52. Eridophyllum vernuillianum, **M**, e
53. E. colligatum, **M**, e, f
54. Synaptophyllum simcoense, **M**, d, e
55. S. stramineum, **M**, d, e
57. Diplophyllum panicum, **M**, e
58. D. arundinaceum, **M**, d
59. Craspedophyllum archiaci, **M**, d, e
60. C. subcæspitosum, **M**, d, e
65. Aulopora subtenuis, **L**, b
66. A. serpens, **M**, d
67. A. tubæformis, **M**, d
68. A. cornuta, **M**, d
69. Romingeria umbellifera, **M**, d, e
70. Ceratopora jacksoni, **M**, d
71. C. dichotoma, **M**, d, e, f
72. C. intermedia, **M**, d, e
73. Monilopora antiqua, **M**, d, f
77. Syringopora tubiporoides, **M**, f
78. S. maclurei, **M**, d, e
79. S. hisingeri, **M**, d, e, f
80. S. tabulata, **M**, f
81. S. perelegans, **M**, f
85. Favosites helderbergiæ, **L**, b, c
86. F. winchelli, **M**, d, e, f
87. F. basalticus, **M**, d, e
88. F. tuberosus, **M**, d, e, f
89. F. epidermatus, **M**, d, e, f
90. F. emmonsi, **M**, d, e, f
91. F. turbinatus, **M**, d, e, f
92. F. hamiltoniæ, **M**, d
93. F. alpenensis, **M**, e, h
94. F. canadensis, **M**, d, e, f
95. F. placenta, **M**, d, e
96. F. digitatus, **M**, e
97. F. clausus, **M**, d, e, f
98. F. limitaris, **M**, d, e, f
99. Pleurodictyum stylopora, **M**, d, e
100. Michelinia convexa, **M**, e, f
101. M. cylindrica, **M**, e, f
102. M. favositoidea, **M**, d, f
103. Chonostegites clappi, **M**, d, f
104. C. ordinatus, **M**, d
107. Thecia ramosa, **M**, e, f
109. Alveolites squamosus, **M**, d, e, f
110. A. goldfussi, **M**, d, e, f, g
112. Cladopora lichenoides, **M**, d, e, f
113. C. fisheri, **M**, d, f

115. C. cryptodus, **M**, d, e
116. C. labiosa, **M**, d, e, f
117. C. roemeri, **M**, d, f
118. C. pulchra, **M**, e, f
119. C. robusta, **M**, e, f
121. Striatopora linnæana, **M**, d, e, f
122. Trachypora ornata, **M**, d, e
123. T. elegantula, **M**, e

BRYOZOA.

3. Rhopalonaria tenuis, **M**, d, e
4. Ascodictyon stellatum, **M**, d
5. A. floreale, **M**, e
7. Allonema fusiforme, **M**, d, e, f
14. Hederella canadensis, **M**, d, e, f
15. Hernodia humifusa, **M**, d, f
16. Reptaria stolonifera, **M**, d
29. Fistulipora torta, **L**, b
33. Buskopora dentata, **M**, f
35. Botryllopora socialis, **M**, d, e, f
52. Petalotrypa compressa, **M**, g
74. Monotrypa tabulata, **L**, b
75. M. amplectans, **M**, d, e
86. Fenestella crebripora, **L**, b
87. F. emaciata, **M**, d
91. Semicoscinium planodorsatum, **M**, f
92. Fenestrapora occidentalis, **M**, g
93. Unitrypa scalaris, **M**, d
94. U. acaulis, **M**, f
95. Loculipora perforata, **M**, d
97. Reteporidra perundata, **M**, d
104. Polypora fistulata, **M**, d
105. P. shumardi, **M**, f
110. Pinnatopora carinata, **M**, d
112. Ptilopora striata, **M**, d
125. Streblotrypa hamiltonensis, **M**, d
127. Ptilodictya nebulosa, **L**, b
135. Intrapora puteolata, **M**, f
136. Coscinella elegantula, **M**, d
143. Cystodictya gilberti, **M**, d, f
144. C. hamiltonensis, **M**, d, e, g
145. C. incisurata, **M**, d
147. Tæniopora exigua, **M**, d
148. T. penniformis, **M**, d
149. Coscinium cribriforme, **M**, f
151. Acrogenia prolifera, **M**, d
152. Prismatopora triquetra, **M**, f
153. Scalaripora scalariformis, **M**, f
163. Paleschara incrustans, **L**, b

BRACHIOPODA.

27. Lingula ligea, **M**, **U**, d, i
28. L. spatulata, **U**, d
*29. L. cuyahoga, **U**, d
47. Schizobolus concentricus, **U**, d
49. Orbiculoidea lodiensis, **U**, d, i
55. Roemerella grandis, **M**, d, f
60. Crania crenistriata, **M**, d, e, f
62. Craniella hamiltoniæ, **M**, d, h
63. Pholidops hamiltoniæ, **M**, d
*74. Stropheodonta varistriata, **L**, b, c
75. S. beckii, **L**, a, b
76. S. magnifica, **L**, c, d
77. S. magniventer, **L**, b, d
78. S. patersoni, **L**, **M**, d, e
79. S. inæquiradiata, **M**, a, b, d
80. S. hemispherica, **M**, d, f
81. S. concava, **M**, d
82. S. inæquistriata, **M**, d, e, f
83. S. costata, **M**, e
84. S. demissa, **M**, **U**, b, d, e, f, g, h, i
85. S. perplana, **M**, **U**, a, b, c, d, e, f, g, h, i
86. S. arcuata, **U**, d, g, h
87. Pholidostrophia iowaënsis, **M**, d, e, f, g
90. Strophonella headleyana, **L**, a, b
91. S. leavenworthana, **L**, b
92. S. punctulifera, **L**, a, b, c, i
93. S. ampla, **M**, d
94. S. reversa, **U**, d, f
*101. Leptæna rhomboidalis, **X**, a, b, c, d, e, f, g, h, i
*105. Schuchertella subplana, **L**, a, b, e, f
107. S. woolworthana, **L**, b
108. S. pandora, **M**, d, i
109. S. arctostriata, **M**, d, f, i
110. S. perversa, **M**, d, i
111. S. chemungensis, **U**, b, d, h, i
117. Hipparionyx proximus, **L**, b, d
119. Chonetes hemisphericus, **M**, d, i
120. C. mucronatus, **L**, **M**, a, d, i
121. C. vicinus, **M**, d, e, i
122. C. coronatus, **M**, b, d, e, i
123. C. pusillus, **M**, h
124. C. scitulus, **M**, **U**, d
*125. C. setigerus, **M**, **U**, d, f
126. C. lepidus, **M**, **U**, d
*127. C. aurora, **U**, d, f, h

135. Chonostrophia complanata, **L**, b, c, d
137. Strophalosia truncata, **M**, **U**, d, i
138. Productella navicella, **M**, d, i
139. P. spinulicosta, **M**, d, e, f, h, i
140. P. subalata, **M**, e, g
141. P. hallana, **U**, d, g, h, i
*142. P. speciosa, **U**, d
180. Orthostrophia strophomenoides, **L**, a, b, f
187. Bilobites varicus, **L**, a, b, f
192. Dalmanella perelegans, **L**, b, f
193. D. subcarinata, **L**, a, b, e, f
195. Rhipidomella oblata, **L**, b
196. R. alsa, **M**, b, e
197. R. livia, **M**, a, b, f
198. R. vanuxemi, **M**, b, d, e, f, g
199. R. leucosia, **M**, b, c
200. R. penelope, **M**, d
*201. R. thiemei, **U**, d
206. Schizophoria multistriata, **L**, d
207. S. propinqua, **M**, d
208. S. tulliensis, **U**, d, i
209. S. striatula, **M**, **U**, d, e, f, g, h, i
210. S. macfarlani, **M**, **U**, d, g, h, i
211. S. tioga, **U**, d
222. Anastrophia verneuili, **L**, a, b, f
231. Pentamerella arata, **M**, d, e, f
232. P. pavilionensis, **M**, d, e, f
233. Gypidula galeata, **L**, a, b, c, h
234. G. pseudogaleata, **L**, b
235. G. comis, **M**, e, g, h
236. G. romingeri, **M**, e
237. Amphigenia elongata, **L**, **M**, d, e
252. Camarotœchia semiplicata, **L**, b
253. C. tethys, **M**, d, f, i
254. C. dotis, **M**, d
255. C. horsfordi, **M**, d, i
*256. C. sappho, **M**, d
*257. C. contracta, **U**, d
259. Stenochisma formosum, **L**, a, b
260. Leiorhynchus mysia, **M**, d
261. L. limitare, **M**, d
262. L. laura, **M**, d, i
263. L. quadricostatum, **U**, d, f, i
264. L. sinuatum, **U**, d, i
266. Uncinulus campbellanus, **L**, b
267. U. nucleolatus, **L**, a, b
268. U. mutabilis, **L**, b
269. U. abruptus, **L**, b
270. U. vellicatus, **L**, a, b
271. U. nobilis, **L**, b
272. Wilsonia ventricosa, **L**, b
273. Hypothyris emmonsi, **M**, g, h, i
274. H. cuboides, **U**, b, h
275. Pugnax pugnus, **U**, b, f, h, i
279. Eatonia medialis, **L**, a, b
280. E. peculiaris, **L**, a, b, c, g
288. Centronella glansfagea, **L**, **M**, d, e, f
289. C. impressa, **M**, d
290. Rensselæria æquiradiata, **L**, a, b
291. R. ovoides, **L**, a, b, c
292. R. cayuga, **L**, d
293. Cryptonella planirostris, **M**, d
294. C. rectirostris, **M**, d, f
295. Dielasma romingeri, **M**, d, e, f, g
296. D. calvini, **U**, g, h
299. Eunella lincklæni, **M**, d, e, f
303. Tropidoleptus carinatus, **M**, b, d, f
*314. Atrypa reticularis, **X**, a, b, c, d, e, f, g, h, i
315. A. impressa, **M**, b
316. A. spinosa, **M**, **U**, b, c, e, f, h
317. A. hystrix, **U**, c, d, e, g
317a. A. occidentalis, **M**, e, g
318. Cyrtina dalmani, **L**, a, b, f
319. C. hamiltonensis, **M**, b, c, d, h, i
320. C. umbonata, **M**, e, f, g
321. C. alpenensis, **M**, e
334. Spirifer macropleura, **L**, a, b, c
335. S. perlamellosus, **L**, a, b, c, f
336. S. cyclopterus, **L**, a, b, c
337. C. concinnus, **L**, b
338. S. murchisoni, **L**, b, c, d
339. S. arenosus, **L**, b, c, d
340. S. duodenarius, **M**, d, f
341. S. gregarius, **M**, d, f
342. S. grieri, **M**, d, f
343. S. raricosta, **M**, a, d, f, i
344. S. varicosus, **M**, a, d, f, i
345. S. acuminatus, **M**, b, d, f
346. S. divaricatus, **M**, b, d, f
347. S. euryteines, **M**, d, e, g, i
348. S. fornacula, **M**, e, f
349. S. oweni, **M**, e, f
350. S. granulosus, **M**, b, c, e, f
351. S. iowensis, **M**, e, f, g
352. S. audaculus, **M**, d, e, f
353. S. angustus, **M**, **U**, d, e

354. S. mucronatus, **M**, **U**, b, c, d, e
355. S. asper, **M**, d, e, g
356. S. consobrinus, **M**, d, e, f
357. S. sculptilis, **M**, d, f
358. S. tullius, **M**, d, h
359. S. mesistrialis, **U**, d
360. S. mesicostalis, **U**, d
361. S. disjunctus, **U**, d, g, h
*362. S. subattenuatus, **U**, d, g, h
374. Reticularia fimbriata, **X**, b, c, d, e, f, g, h, i
375. R. nevadaënsis, **U**, i
376. R. lævis, **U**, d
381. Martinia maia, **M**, d, i
385. Ambocœlia præumbona, **M**, d
386. A. umbonata, **M**, **U**, d, f
387. A. nana, **M**, d
389. Metaplasia pyxidata, **L**, c, d
390. Rhynchospira formosa, **L**, a, b, d
394. Trematospira multistriata, **L**, b
395. Parazyga hirsuta, **M**, d, f
404. Nucleospira concinna, **M**, b, c, d, f, i
407. Anoplotheca concava, **L**, b
408. A. flabellites, **L**, **M**, a, b, c, d, e
409. Vitulina pustulosa, **M**, d
411. Athyris fultonensis, **M**, e, f, g, h
412. A. spiriferoides, **M**, b, c, d
413. A. angelica, **U**, d, i
421. Meristella bella, **L**, a, b
422. M. lævis, **L**, a, b, f
423. M. princeps, **L**, a, b
424. M. arcuata, **L**, a, b
425. M. nasuta, **M**, b, d, f, i
426. M. barrisi, **M**, d
427. Pentagonia unisulcata, **L**, **M**, d, f

PELECYPODA.

1. Solemya vetusta, **M**, f
3. Clinopistha subnasuta, **M**, f
5. Phthonia cylindrica, **M**, d
7. Prothyris lanceolata, **M**, **U**, d
9. Orthonota undulata, **M**, **U**, d
10. O. carinata, **M**, d
18. Grammysia ovata, **M**, e
19. G. bisulcata, **M**, d
20. G. globosa, **M**, d
21. G. nodocostata, **M**, d
22. G. obsoleta, **M**, d
23. G. alveata, **M**, b, c, d
24. G. lirata, **M**, b, c, d
25. G. arcuata, **M**, b, c, d, f
26. G. circularis, **M**, **U**, b, d
27. G. communis, **U**, d
28. G. undata, **U**, d
30. Glossitis lingualis, **U**, d
33. Palæanatina typa, **U**, d
34. Tellinopsis subemarginata, **M**, b, d
41. Edmondia philippi, **U**, d
42. E. subovata, **U**, d
47. Panenka dichotoma, **M**, b
48. P. ventricosa, **M**, b
49. P. hero, **M**, d
50. P. costata, **M**, d
51. P. potens, **M**, d
52. P. robusta, **U**, d
53. Ontaria suborbicularis, **U**, d
54. Paracardium doris, **U**, d
55. Buchiola retrostriata, **U**, c, d
69. Nucula lirata, **M**, b, d, f
70. N. randalli, **M**, b, d
71. N. bellistriata, **M**, b, d
72. N. corbuliformis, **M**, b, d
*73. N. houghtoni, **U**, g
82. Nuculites oblongatus, **M**, **U**, b, c, d
83. N. triqueter, **M**, **U**, b, c, d
84. Palæoneilo muta, **M**, b, c, d
85. P. tenuistriata, **M**, c, d
86. P. fecunda, **M**, c, d
87. P. plana, **M**, **U**, d
88. P. emarginata, **M**, **U**, c, d
89. P. constricta, **M**, **U**, b, c, d
90. P. brevis, **U**, d
92. P. sulcatina, **U**, g
93. Leda rostellata, **M**, d
*94. L. diversa, **M**, **U**, b, d
103. Parallelodon chemungensis, **U**, d
*104. P. hamiltoniæ, **M**, b, c, d
126. Megambonia lata, **L**, b, f
127. M. aviculoidea, **L**, b
128. M. suborbicularis, **L**, b
129. M. ovata, **L**, b
130. M. lamellosa, **L**, b, c
156. Pterinea securiformis, **L**, b, f
157. P. naviformis, **L**, a, b
158. P. gebhardi, **L**, b
159. P. flabellum, **M**, **U**, b, c, d, e, f
160. P. chemungensis, **U**, d
161. P. consimilis, **U**, d

162. Limoptera cancellata, **M**, f
163. L. macroptera, **M**, d
164. L. obsoleta, **M**, d
165. Actinodesma occidentale, **M**, f
166. A. erectum, **M**, d, f
168. Leiopteria lævis, **M**, b, d
169. L. rafinesquii, **L**, **M**, d, i
170. L. dekayi, **M**, b, d
171. L. chemungensis, **U**, d
172. Leptodesma rogersi, **M**, b, d, g
173. L. sociale, **U**, d
174. L. maclurii, **U**, d
175. Loxopteria lævis, **U**, d
176. L. dispar, **U**, d
177. Lunulicardium curtum, **M**, d
178. L. ornatum, **M**, **U**, d
179. L. acutirostrum, **U**, d
180. Pterochænia fragilis, **M**, **U**, d, f
181. P. sinuosa, **U**, d
182. Honeoyea erinacea, **U**, d
191. Mytilarca chemungensis, **U**, d
192. M. fibristriata, **U**, g
193. Plethomytilus ponderosus, **M**, d
194. P. oviformis, **M**, b, d, i
201. Conocardium cuneus, **M**, d, f
202. C. ohioense, **M**, f
227. Pteronites profundus, **U**, d
228. Actinopteria communis, **L**, a, b, f
229. A. textilis, **L**, a, b
230. A. textilis arenaria, **L**, a, b, c, d
231. A. muricata, **M**, b, d
232. A. subdecussata, **M**, d
233. A. decussata, **M**, b, d
234. A. boydi, **M**, **U**, b, d, f, i
235. Ptychopteria sinuosa **U**, d
236. P. sao, **U**, d
255. Ptychodesma knappianum, **M**, d, f
256. Modiella pygmæa, **M**, d
303. Amnigenia catskillensis, **U**, b, d
307. Nyassa arguta, **U**, d
318. Schizodus chemungensis, **U**, d
319. S. gregarius, **U**, d
320. S. rhombeus, **U**, d
*321. S. quadrangularis, **U**, d
333. Aviculopecten fasciculatus, **M**, b, d, f
334. A. princeps, **M**, b, d, e, f
335. A. scabridus, **M**, d
336. A. striatus, **U**, d
337. A. duplicatus, **U**, d
338. A. cancellatus, **U**, d
356. Pterinopecten exfoliatus, **M**, d
357. P. intermedius, **M**, d
358. P. vertumnus, **M**, b
359. P. undosus, **M**, d
360. P. dispandus, **U**, d
361. P. suborbicularis, **U**, d
362. Lyriopecten orbiculatus, **M**, d
363. L. tricostatus, **U**, d
413. Modiomorpha complanata, **M**, d, f
414. M. mytiloides, **M**, b, d
415. M. alta, **M**, b, d, f
416. M. concentrica, **M**, b, c, d, e, f
417. M. subalata, **M**, **U**, b, d
417a. var. chemungensis, **U**, d
418. M. quadrula, **U**, d
427. Goniophora perangulata, **M**, b, i
428. G. modiomorphoides, **M**, d
429. G. hamiltonensis, **M**, b, d
430. G. truncata, **M**, d
431. G. ida, **M**, d
432. G. carinata, **M**, d
433. G. chemungensis, **U**, d
448. Sphenotus truncatus, **U**, d
449. S. cuneatus, **U**, d
450. S. contractus, **U**, d
458. Pholadella radiata, **M**, **U**, b, c, d
459. Cimitaria corrugata, **M**, d
460. C. recurva, **M**, d
461. C. angulata, **U**, d
479. Cypricardella tenuistriata, **M**, b, d
480. C. gregaria, **M**, **U**, b, d
*481. C. bellistriata, **M**, **U**, b, c, d
484. Cypricardinia lamellosa, **L**, b
485. C. indenta, **L**, **M**, b, c, d, f, i
530. Paracyclas ohioensis, **M**, f
531. P. elliptica, **M**, d, e, f
532. P. lirata, **M**, **U**, b, d, f, g
533. P. chemungensis, **U**, d

SCHAPHOPODA.

1. Dentalium martini, **M**, f

GASTROPODA.

32. Protowarthia acutilirata, **M**, d
44. Trematonotus profundus, **L**, b
46. Oxydiscus curvilineatus, **L**, **M**, b
55. Bellerophon pelops, **M**, b, f
56. B. newberryi, **M**, f
57. B. nactus, **U**, d

65. Bucanopsis leda, **M**, d
66. B. lyra, **M**, b, f
67. B. koeneni, **U**, d
71. Ptomatis patulus, **M**, b, c, d, f
72. P. rudis, **M**, b
73. Phragmostoma natator, **U**, d
74. P. chautauquæ, **U**, d
108. Lophospira adjutor, **M**, d
109. L. trilix, **M**, b, c
112. Phanerotrema labrosum, **L**, b
133. Euryzone rugulata, **M**, d
134. E. itys, **M**, c, d, f
135. E. lucina, **M**, d, f
136. Spiroraphe arata, **M**, b, d
138. Gyroma capillaria, **M**, b, d
*139. Bembexia sulcomarginata, **M**, b, c, d, f
141. Trepospira rotalia, **M**, d
150. Hormotoma desiderata, **M**, f
151. H. maia, **M**, f
161. Straparollus clymenioides, **M**, b, d
162. S. rudis, **M**, d
163. S. cyclostomus, **M**, g
164. S. hecale, **U**, d
168. Phanerotinus laxus, **M**, b, d
169. P. eboracensis, **M**, d
178. Pleuronotus decewi, **M**, d, e
208. Anomphalus minutissimus, **U**, d
215. Trachydomia præcursor, **U**, c
218. Turbonopsis shumardi, **M**, f
227. Strophostylus expansus, **L**, b
232. Diaphorostoma ventricosum, **L**, b
233. D. lineatum, **M**, b, d, f
235. Platyceras gebhardi, **L**, b, c
236. P. ventricosum, **L**, b, c
237. P. tenuiliratum, **L**, b
238. P. multisinuatum, **L**, b
239. P. unguiforme, **L**, b
240. P. dilatatum, **L**, b
241. P. spirale, **L**, b
241a. P. tortuosum, **L**, b
241b. P. dentalium, **M**, d
242. P. magnificum, **L**, c
243. P. reflexum, **L**, c
244. P. arkonense, **M**, d, e, f, g
245. P. erectum, **M**, d
246. P. carinatum, **M**, d, f
247. P. symmetricum, **M**, d
248. P. thetis, **M**, d, f
249. P. bucculentum, **M**, d, f
250. P. nodosum, **L**, b
251. P. dumosum, **M**, b, d, e, f
257. Palæocapulus expansus, **L**, b, e
260. Orthonychia subrecta, **M**, d
265. Igoceras plicatum, **L**, b
266. I. conicum, **M**, d, f
275. Callonema bellatulum, **M**, e, f
276. C. lichas, **M**, d, f
277. C. humile, **M**, f
278. Isonema depressum, **M**, f
279. Loxonema robustum, **M**, b, d
280. L. pexatum, **M**, d
281. L. hamiltoniæ, **M**, d
282. L. delphicola, **M**, d
283. L. noe, **U**, d
284. L. terebra, **U**, d
317. Sphærodoma hamiltoniæ, **M**, b

Conularida.

13. Hyolithes neapolis, **U**, d
19. Coleolus tenuicinctus, **M**, d, f
20. C. gracilis, **M**, **U**, d
26. Tentaculites scalariformis, **M**, b, d, f
27. T. gracilistriatus, **M**, b, d
28. T. bellulus, **M**, d
29. T. attenuatus, **M**, b, d
30. T. spiculus, **U**, d
32. Conularia huntiana, **L**, b
33. C. undulata, **M**, b, d

Pteropoda.

1. Styliolina fissurella, **M**, **U**, c, d, e

Cephalopoda.

23. Orthoceras procerum, **M**, b
24. O. pelops, **M**, b, f
25. O. tentalus, **M**, b
26. O. fluctum, **M**, b
27. O. molestum, **M**, b, d, f
28. O. stylus, **M**, b
29. O. constrictum, **M**, b, c, d
30. O. exile, **M**, c, d
31. O. eriense, **M**, d
32. O. subulatum, **M**, d
33. O. leander, **U**, d
38. Trematoceras ohioense, **M**, f
48. Protokionoceras marcellense, **M**, d
55. Spyroceras thoas, **M**, b, f
56. S. crotalum, **M**, b, f

57. S. nuntium, **M**, d
79. Sphyradoceras clio, **M**, b, f
83. Zitteloceras nereus, **M**, d
85. Halloceras undulatum, **M**, b
86. H. paucinodum, **M**, b
87. Ryticeras jason, **M**, b
88. R. eugenium, **M**, b
89. R. æmulum, **M**, b, f
90. R. citum, **M**, b, d
91. R. trivolve, **M**, e
92. R. matheri, **M**, b
93. R. cyclops, **M**, d, e
94. R. spinosum, **M**, b
95. R. columbiense, **M**, f
96. Nephriticeras bucinum, **M**, c, d
97. N. liratum, **M**, b, d
98. N. magister, **M**, d
99. N. maximum, **M**, d, f
111. Centroceras ohioense, **M**, e
112. C. marcellense, **M**, d
147. Loxoceras luxum, **M**, b
148. Nædyceras eugenium, **M**, b, e
149. Gigantoceras inelegans, **M**, e
163. Cyclostomiceras cretaceum, **M**, f
164. C. metula, **M**, d
176. Poterioceras hyatti, **M**, f
177. P. amphora, **M**, f
178. P. eximium, **M**, d
179. P. oviforme, **M**, d
180. P. lunatum, **M**, d
181. P. turbiniforme, **M**, f
182. P. minum, **M**, f
183. P. raphanus, **M**, d
184. P. tumidum, **U**, d
193. Acanthoclymenia neapolitana, **U**, d
194. Platyclymenia americana, **U**, i
195. Bactrites clavus, **M**, d
196. B. arkonensis, **M**, d
197. B. gracilior, **U**, d, e
198. B. aciculum, **U**, d
199. Agoniatites expansus, **M**, c, d
200. Tornoceras uniangulare, **M**, d
201. Manticoceras intumescens, **U**, d, e, g, h
202. M. rhynchostoma, **U**, d
203. M. sororium, **U**, d
204. Probeloceras lutheri, **U**, d
205. Parodiceras discoideum, **M**, d

ANNELIDA.

4. Spirorbis angulatus, **M**, d
5. S. arkonensis, **M**, d
6. S. omphalodes, **M**, d
18. Ortonia intermedia, **M**, d
25a. Arabellites similis var. arcuatus, **M**, d
32. Eunicites tumidus, **M**, d
33. E. palmatus, **M**, d
34. E. nanus, **M**, d
*44. Polygnathus dubius, **U**, d
45. P. coronatus, **U**, d
46. P. solidus, **U**, d
47. P. crassus, **U**, d
48. P. pennatus, **U**, d
49. P. truncatus, **U**, d
50. P. punctatus, **U**, d
51. P. tuberculatus, **U**, d
52. P. cristatus, **U**, d
53. P. palmatus, **U**, d
56. Prioniodus abbreviatus, **U**, d
57. P. clavatus, **U**, d
58. P. erraticus, **U**, d
59. P. armatus, **U**, d
60. P. angulatus, **U**, d
61. P. panderi, **U**, d
62. P. alatus, **U**, d
79. Taonurus caudagalli, **L**, b
80. T. velum, **M**, b

TRILOBITA.

113. Proëtus protuberans, **L**, b, f
114. P. latimarginatus, **M**, f
115. P. crassimarginatus, **M**, d
116. P. folliceps, **M**, d, e
117. P. macrocephalus, **M**, **U**, d
118. P. rowi, **M**, d
123. Cyphaspis ornata, **M**, d
140. Amphilichas pustulosus, **L**, b
141. Conolichas eriopis, **M**, b
146. Acidaspis hamata, **L**, b
147. A. tuberculata, **L**, b
148. A. callicera, **M**, d
158. Calymene platys, **M**, b, f
160. Homalonotus vanuxemi, **L**, b
161. H. dekayi, **M**, b, d
171. Phacops logani, **L**, b, f
172. P. cristata, **L**, **M**, b, d
173. P. rana, **M**, b, c, d, e, f, i
181. Dalmanites dentatus, **L**, b

182. D. nasutus, **L**, b
183. D. micrurus, **L**, b
184. D. pleuroptyx, **L**, **M**, a, b
185. D. anchiops, **L**, **M**, b, d, e, f
186. D. calypso, **M**, b, f
187. D. selenurus, **M**, b
188. Cryphæus boothi, **M**, d, e
188a. var. calliteles, **M**, **U**, d

PHYLLOPODA.

1. Estheria membranacea, **U**, d
5. Schizodiscus capsa, **M**, d

OSTRACODA.

11. Leperditia hudsonica, **M**, b
15. Isochilina fabacea, **M**, d
24. Primitia seminulum, **M**, d
25. Primitiopsis punctulifera, **M**, d
28. Æchmina marginata, **M**, d
32. Halliella retifera, **M**, f
44. Moorea bicornuta, **M**, d
45. Strepula plantaris, **M**, d
46. S. sigmoides, **M**, d
48. Octonaria clavigera, **M**, f
49. O. stigmata, **M**, f
55. Bollia obesa, **M**, f
56. B. ungula, **M**, f
63. Ctenobolbina granosa, **L**, b
64. Ctenobolbina minima, **M**, d
69. Beyrichia hamiltonensis, **M**, d
*71. Kloedinia manliensis, **L**, a
*72. K. sussexensis, **L**, a
73. K. marginalis, **L**, a
74. K. centricornis, **L**, c
75. K. fimbriata, **L**, b
77. Treposella lyoni, **M**, f
78. Hollina insolens, **M**, f
79. H. antispinosa, **M**, f
80. H. armata, **M**, f
81. H. cavimarginata, **M**, f
82. H. spiculosa, **M**, f
83. H. kolmodini, **M**, f
84. H. tricollina, **M**, b
88. Kloedenella turgida, **L**, c
92. Kirkbya cymbula, **M**, f
93. K. germana, **M**, f
94. K. subquadrata, **M**, f
99. Barychilina punctostriata, **M**, f
100. Pachydomella tumida, **M**, f
104. Entomis rhomboidalis, **M**, d
107. Bairdia devonica, **M**, f
108. B. leguminoides, **M**, d

CIRRIPEDIA.

3. Lepidocoleus polypetalus, **L**, b
4. Turrilepas devonica, **M**, d
5. T. squama, **M**, d
6. Strobilepis spinigera, **M**, d
12. Palæocreusia devonica, **M**, d

MALACOSTRACA.

10. Echinocaris punctata, **M**, b
11. E. socialis, **U**, d
12. E. sublævis, **U**, e
13. E. pustulosa, **U**, e
14. E. multinodosa, **U**, e
15. Pephricaris horripilata, **U**, d
19. Eleutherocaris whitfieldi, **U**, d
20. Elymocaris siliqua, **U**, d
21. Tropidocaris bicarinata, **U**, d
23. Rhinocaris columbina, **M**, b
24. R. scaphoptera, **M**, **U**, d
25. R. capsella, **M**, **U**, d
26. Mesothyra oceani, **U**, d
27. Dipterocaris procne, **U**, d
*28. Palæopalæmon newberryi, **U**, e
49. Amphipeltis paradoxus, **U** ?, a

MEROSTOMATA.

8. Protolimulus eriensis, **U**, d
25. Eurypterella ornata, **U** ?, a
29. Stylonurus lacoanus, **U**, b, d

CYSTOIDEA.

16. Lepocrinites gebhardi, **L**, b
29. Agelacrinus hamiltonensis, **M**, b
30. A. alleghanius, **U**, d

BLASTOIDEA.

7. Pentremitidea filosa, **M**, d, e
8. P. americana, **M**, e
18. Elæacrinus verneuili, **M**, f
18a. —— var. pomum, **M**, f
19. E. elegans, **M**, b
20. E. obovatus, **M**, d, e, g
26. Codaster pyramidatus, **M**, d, f
27. C. alternatus, **M**, f

CRINOIDEA.

4. Haplocrinus clio, **M**, d
56. Edriocrinus sacculus, **L**, c
69. Arthracantha punctobrachiata, **M**, d
125. Megistocrinus abnormis, **M**, f
126. M. depressus, **M**, d, f
127. M. spinulosus, **M**, f
130. Gennæocrinus kentuckiensis, **M**, f
131. G. eucharis, **M**, d
132. G. carinatus, **M**, f
163. Gilbertsocrinus spinigerus, **M**, d
173. Melocrinus nobilissimus, **L**, b
174. M. bainbridgensis, **M**, d
175. M. pachydactylus, **L**, b
176. Dolatocrinus excavatus, **M**, f
177. D. triadactylus, **M**, e
178. D. glyptus, **M**, d
179. D. liratus, **M**, d
190. Camarocrinus saffordi, **L**, f
203. Aspidocrinus scutelliformis, **L**, b
204. Ancyrocrinus spinosus, **M**, f
205. A. bulbosus, **M**, d

MISSISSIPPIC FAUNAS.

The following geographic provinces are recognized:

(*a*) Appalachian and Arctic extension.
(*b*) Waverly (Western Pennsylvania, Ohio and Michigan).
(*c*) Tennessee province (Tennessee, Kentucky, Georgia, Alabama, etc.).
(*d*) Mississippi valley and western Ozark (including Indiana and Illinois to Texas and New Mexico).
(*e*) Rocky Mountains and Pacific.

FORAMINIFERA.

13. Endothyra baileyi, **M**, c

ANTHOZOA.

11. Zaphrentis cliffordana, **X**, b, d
12. Z. calcareformis, **M**, d
13. Z. spergenensis, **M**, d
63. Lithostrotion mamillare, **M**, a, b, d
74. Monilopora beecheri, **L**, d

BRYOZOA.

31. Chilotrypa hispida, **U**, c, d
34. Meekopora clausa, **U**, c, d
58. Batostomella spinulosa, **U**, c, d
88. Fenestella cestriensis, **U**, c, d
89. F. tenax, **L**, **U**, b, c, d
96. Hemitrypa proutana, **L**, **M**, c, d
98. Archimedes communis, **U**, c, d
99. A. wortheni, **M**, d
100. A. laxus, **U**, c, d
101. A. sublaxus, **U**, d
102. A. terebriformis, **U**, c, d
107. Thamniscus furcillatus, **U**, c, d
108. Lyropora quincuncialis, **U**, c, d
109. Fenestralia sancti-ludovici, **L**, **M**, d
111. Pinnatopora conferta, **L**, d
113. Ptilopora cylindracea, **L**, c, d
114. Diploporaria bifurcata, **U**, d
121. Rhombopora tenuirama, **U**, c, d
123. Cœloconus granosus, **U**, d
124. Bactropora simplex, **L**, d
126. Streblotrypa nicklesi, **U**, c, d
146. Dichotrypa lyroides, **M**, c
150. Coscinium latum, **L**, d
154. Glyptopora sagenella, **L**, d
155. G. megastoma, **L**, b, d
156. Evactinopora grandis, **L**, d
157. E. radiata, **L**, c, d
158. Actinotrypa peculiaris, **L**, d
159. Worthenopora spinosa, **L**, d

BRACHIOPODA.

*29. Lingula cuyahoga, **L**, b
30. L. melie, **L**, b
46. Lingulodiscina newberryi, **L**, b, e
*101. Leptæna rhomboidalis, **L**, b

112. Schuchertella inæqualis, **L**, a, b, e
113. S. crenistria, **X**, a, b, e
114. Orthothetes koekuk, **L**, d, e
*125. Chonetes setigerus, **L**, b
*127. C. aurora, **L**, d
128. C. logani, **L**, b, d
129. C. illinoisensis, **L**, b, d
136. Chonopectus fischeri, **L**, a, c, d
*142. Productella speciosa, **L**, b, d
143. P. arcuata, **L**, b, d
144. P. pyxidata, **L**, d
145. P. shumardana, **L**, b, d
146. P. concentrica, **L**, b, d
147. Productus lævicosta, **L**, d, e
148. P. burlingtonensis, **L**, d, e
149. P. biseriatus, **M**, c, d
150. P. marginicinctus, **M**, d
151. P. fasciculatus, **U**, a, b, c, d, e
*152. P. semireticulatus, **L**, a, b
*201. Rhipidomella thiemei, **L**, d
202. R. michelini, **L**, a, b, c, e
203. R. burlingtonensis, **L**, d
204. R. dubia, **M**, c, d
212. Schizophoria swallovi, **L**, d
238. Camarophoria subcuneata, **M**, b, d
*256. Camarotœchia sappho, **L**, b
*257. C. contracta, **L**, b
258. C. sageriana, **L**, b, c
276. Pugnax striatocostata, **L**, d
277. P. grosvenori, **M**, c, d
281. Rhynchopora pustulosa, **L**, d, e
282. Rhynchonella eurekaënsis, **M**, d, e
283. R. hubbardi, **L**, b
297. Dielasma turgidum, **M**, b, d
322. Cyrtina acutirostris, **L**, d
323. Cyrtia alta, **L**, b
*324. Spiriferina spinosa, **U**, c, d, e
*362. Spirifer subattenuatus, **L**, b
363. S. keokuk, **L**, b, d, e
364. S. centronatus, **L**, b, e
365. S. marionensis, **L**, b, d
366. S. grimesi, **L**, a, d
367. S. neglectus, **L**, d, e
368. S. logani, **L**, c, d
369. S. leidyi, **M**, c, d, e
370. S. increbescens, **U**, c, d
377. Reticularia cooperensis, **L**, c, d
378. R. pseudolineata, **L**, d
379. R. setigera, **U**, c, d, e
382a. Martinia contracta, **U**, d
383. Syringothyris carteri, **L**, b, d, e
384. S. texta, **L**, b, d
396. Eumetria marcyi, **M**, **U**, c, d, e
414. Athyris lamellosa, **L**, b, c, d, e
415. Cliothyris roissii, **X**, b, c, d, e
416. C. hirsuta, **M**, **L**, c, d, e
417. Seminula subquadrata, **U**, b, c, d, e
418. S. trinucleus, **M**, c, d

Pelecypoda.

6. Sanguinolites æolus, **L**, b, e
29. Grammysia hannibalensis, **L**, b, d, e
36. Cardiopsis radiata, **L**, d
43. Edmondia burlingtonensis, **L**, b, d
*44. E. aspinwallensis, e
*73. Nucula houghtoni, **L**, b
91. Palæoneilo marshallensis, **L**, b
*92. P. sulcatina, **L**, b
*94. Leda diversa, **L**, b
95. L. pandoriformis, **L**, b
*96. L. bellistriata, **L**, b, c
*104. Parallelodon hamiltoniæ, **L**, b, e
*105. P. tenuistriatus, **L**, b
*106. P. obsoletus, **M**, d
*192. Mytilarca fibristriata, **L**, b, d
245. Myalina sancti-ludovici, **L**, c, d
246. M. keokuk, **L**, d, e
247. M. angulata, **L**, d
*248. M. congeneris, e
*321. Schizodus quadrangularis, **L**, b
322. S. medinaensis, **L**, b
*323. S. cuneatus, e
339. Aviculopecten caroli, **L**, b, d
*364. Crenipecten winchelli, **L**, b
*392. Pecten aviculatus, **L**, b, e
451. Sphenotus æolus, **L**, b
*481. Cypricardella bellistriata, **L**, b
482. C. oblonga, **M**, c, d
486. Cypricardinia consimilis, **L**, b

Gastropoda.

24. Lepetopsis levettii, **M**, c
47. Oxydiscus cryptolites, **L**, b, d
*58. Bellerophon sublævis, **M**, **U**, b, d
68. Bucanopsis textilis, **M**, d
78. Porcellia crassinoda, **L**, d
79. P. nodosa, **L**, d
137. Mourlonia mississippiensis, **L**, b, d
*139. Bembexia sulcomarginata, **L**, b

158. Solenospira turritella, **L**, d
165. Straparollus ammon, **L**, b, d
166. S. planispira, **M**, d
167. S. spergenensis, **M**, d
170. Phanerotinus paradoxus, **L**, d
179. Euomphalus latus, **L**, b, d
180. E. similis, **M**, **U**, b, d
181. E. planidorsatus, **U**, d
194. Omphalotrochus springvalensis, **L**, d
211. Naticopsis ziczac, **U**, b
*212. N. ventricosa, **L**, d
225. Holopea proutana, **M**, d
228. Strophostylus carleyanus, **M**, d
252. Platyceras vomerium, **L**, b, d
253. P. tribulosum, **L**, d
254. P. haliotoides, **L**, b, d
255. P. paralium, **L**, b, d
258. Palæocapulus equilateralis, **L**, a, d
259. P. lodiensis, **L**, b
261. Orthonychia formosa, **L**, d
262. O. cyrtolites, **L**, d
263. O. chesterensis, **U**, c, d
*264. O. acutirostris, **X**, d
267. Igoceras capulus, **L**, d
268. I. quincyense, **L**, d
269. I. fissurella, **L**, d
270. I. pabulocrinus, **L**, d
271. I. subplicatum, **L**, **U**, b, d
285. Loxonema yandellanum, **M**, d
306. Bulimorpha bulimiformis, **M**, d

CONULARIDA.

34. Conularia newberryi, **L**, b
35. C. micronema, **L**, b
36. C. missouriensis, **M**, d, e
37. C. byblis, **L**, b, c, d
38. C. subulata, **M**, d

CEPHALOPODA.

34. Orthoceras indianense, **L**, b, c
35. O. epigrus, **M**, d
*36. O. rushense, **L**, b
43. Cycloceras randolphense, **U**, d, e
100. Stroboceras trisulcatum, **L**, b
102. Apheleceras disciforme, **L**, d
105. Triboloceras digonum, **L**, d
107. Leuroceras chesterense, **U**, d
113. Temnocheilus coxanus, **M**, d
117. Endolobus spectabilis, **U**, d
*128. Solenocheilus collectus, **M**, d
133. Edaphoceras niotense, **L**, d
134. Remeleoceras clarkense, **L**, c
206. Aganides rotatorius, **L**, b, c
207. Muensteroceras oweni, **L**, b, c
208. M. parallelum, **L**, b, c
212. Goniatites crenistria, **M**, **U**, d
213. G. striatus, **M**, **U**, d
214. G. subcircularis, **M**, c, d
215. Glyphioceras calyx, **M**, d
216. Gastrioceras branneri, **U**, d
218. G. entogonum, **U**, d
*224. Paralegoceras iowense, **M**, d
230. Prodromites gorbyi, **L**, d
231. Prolecanites greeni, **L**, d
232. P. lyoni, **L**, b, d
233. P. marshallensis, **L**, b
235. Pronorites cyclolobus var. arkansasensis, **U**, d

ANNELIDA.

7. Spirorbis annulatus, **M**, d
8. S. nodulosus, **M**, d
*44. Polygnathus dubius, **L**, b
75. Scalaritula missouriensis, **L**, d

TRILOBITA.

119. Proetus missouriensis, **L**, b, d
120. P. peroccidens, e
124. Phillipsia tuberculata, **L**, d
125. P. immatura, **L**, b, d
126. P. lodiensis, **L**, b
127. P. meramecensis, **L**, b, d
*128. P. missouriensis, **L**, b
130. Griffithides portlocki, **L**, d, e

PHYLLOPODA.

2. Estheria dawsoni, **U**, a

OSTRACODA.

19. Paraparchites nicklesi, **L**, d
30. Ulrichia emarginata, **U**, c
65. Ctenobolbina loculata, **L**, c
89. Beyrichiella confluens, **U**, c
95. Kirkbya costata, **L**, d
96. K. lindahli, **L**, d
97. K. venosa, **U**, c
105. Cypridina herzeri, **L**, b
109. Bairdia cestriensis, **U**, c

111. Pontocypris acuminata, **L**, b
118. Cytherella ovatiformis, **U**, c

Malacostraca.

22. Tropidocaris alternata, **L**, a
*28. Palæopalæmon newberryi, **L**, d

Cystoidea.

31. Agelacrinus squamosus, **L**, d
32. A. kaskaskiensis, **L**, d

Blastoidea.

3. Metablastus lineatus, **L**, d
4. M. wortheni, **L**, d
5. Tricœlocrinus woodmani, **L**, d
6. T. obliquatus, **M**, c, d
9. Pentremites elongatus, **L**, d
10. P. conoideus, **M**, d
11. P. elegans, **U**, b
12. P. globosus, **U**, c, d
13. P. godoni, **U**, c, d
14. P. obesus, **U**, c, d
15. P. pyriformis, **U**, c, d
16. P. sulcatus, **U**, d
17. P. cervinus, **U**, c
21. Schizoblastus melonoides, **L**, d
22. S. sayi, **L**, d
23. Cryptoblastus melo, **L**, d
24. Granatocrinus neglectus, **L**, d
25. G. norwoodi, **L**, d
28. Orophocrinus stelliformis, **L**, d
29. O. campanulatus, **L**, d

Crinoidea.

5. Symbathocrinus dentatus, **L**, d
6. S. robustus, **L**, c
13. Halysiocrinus ventricosus, **L**, d
14. H. bradleyi, **L**, d
25. Cyathocrinus enormis, **L**, d
26. C. iowensis, **L**, d
27. C. multibrachiatus, **L**, d
28. C. parvibrachiatus, **L**, d
29. C. maxvillensis, **U**, b
31. Barycrinus meekianus, **L**, d
32. B. sculptilis, **L**, d
33. B. hoveyi, **L**, c, d
34. B. magnificus, **L**, d
35. Poteriocrinus agnatus, **L**, d
36. P. amænus, **L**, d
37. Scaphiocrinus swallovi, **L**, d
38. S. unicus, **L**, d
39. S. crineus, **L**, b
40. S. subcarinatus, **L**, b
41. Scytalocrinus robustus, **L**, d
42. Decadocrinus pleias, **L**, b
43. D. ægina, **L**, b
44. Woodocrinus troostanus, **L**, d
45. W. æqualis, **L**, d
46. W. merope, **L**, b
47. W. elegans, **L**, d
48. Eupachycrinus orbicularis, **L**, d
54. Agassizocrinus dactyliformis, **U**, d
55. A. conicus, **U**, d
60. Platycrinus americanus, **L**, d
61. P. burlingtonensis, **L**, d
62. P. halli, **L**, d
63. P. discoideus, **L**, d
64. P. subspinosus, **L**, d
65. P. bonoënsis, **L**, d
66. P. hemisphericus, **L**, d
67. P. huntsvillæ, **L**, **M**, d
68. P. saræ, **M**, c, d
70. Dichocrinus ficus, **L**, c, d
71. D. polydactylus, **L**, d
72. D. striatus, **L**, d
73. D. inornatus, **L**, d
74. Talarocrinus cornigerus, **M**, c
75. T. simplex, **L**, c, d
76. Pterotocrinus depressus, **U**, c
77. P. pyramidalis, **U**, c
78. Acrocrinus shumardi, **U**, c
79. Actinocrinus verrucosus, **L**, d
80. A. tenuisculptus, **L**, d
81. A. scitulus, **L**, d
82. A. multiradiatus, **L**, d
83. A. lobatus, **L**, d
84. A. lowei, **L**, d
85. A. pernodosus, **L**, d
86. Cactocrinus glans, **L**, d
87. C. limabrachiatus, **L**, d
88. C. proboscidialis, **L**, d
89. C. reticulatus, **L**, d
90. C. cœlatus, **L**, d
91. Amphoracrinus divergens, **L**, d
92. A. spinobrachiatus, **L**, d
93. Teleiocrinus liratus, **L**, d
94. T. umbrosus, **L**, d
95. Steganocrinus araneolus, **L**, d
96. S. sculptus, **L**, d

97. S. concinnus, **L**, d
98. S. pentagonus, **L**, d
99. Physetocrinus ornatus, **L**, d
100. P. ventricosus, **L**, d
101. Strotocrinus regalis, **L**, d
102. Eretmocrinus coronatus, **L**, d
103. E. leucosius, **L**, d
104. E. magnificus, **L**, c
105. Dorycrinus unicornis, **L**, d
106. D. cornigerus, **L**, d
107. D. gouldi, **L**, c, d
108. D. mississippiensis, **L**, c, d
109. Agaricocrinus brevis, **L**, d
110. A. planoconvexus, **L**, d
111. A. pyramidatus, **L**, d
112. A. bullatus, **L**, d
113. A. americanus, **L**, c, d
114. A. tuberosus, **L**, c, d
115. A. coreyi, **L**, c
116. A. crassus, **L**, c, d
117. A. nodulosus, **L**, c, d
118. A. splendens, **L**, c
124. Periechocrinus whitei, **L**, d
128. Megistocrinus evansi, **L**, d
129. M. nobilis, **L**, d
133. Batocrinus clypeatus, **L**, d
134. B. laura, **L**, d
135. B. subæqualis, **L**, d
136. B. irregularis, **L**, c
137. B. icosadactylus, **L**, c
138. Alloprosallocrinus conicus, **L**, c
139. Eutrochocrinus christyi, **L**, d
140. Dizygocrinus rotundus, **L**, d
141. D. whitii, **L**, c, d
142. D. biturbinatus, **L**, d
143. D. montgomeryensis, **L**, d
144. D. originarius, **L**, d
145. D. euconus, **L**, c, d
146. D. unionensis, **L**, a, c, d
147. Lobocrinus pyriformis, **L**, d
148. L. æquibrachiatus, **L**, d
149. L. nashvillæ, **L**, c, d
150. Macrocrinus verneuilianus, **L**, d
151. Aorocrinus parvus, **L**, d
159. Rhodocrinus whitii, **L**, d
164. Gilbertsocrinus typus, **L**, d
165. G. tuberosus, **L**, c, d
195. Taxocrinus thiemii, **L**, d
196. T. kelloggi, **L**, b
197. T. communis, **L**, b
198. Onychocrinus exculptus, **L**, c
199. Forbesiocrinus agassizi, **L**, d
200. F. wortheni, **L**, c, d

ECHINOIDEA.

*2. Archæocidaris agassizi, **L**, d
3. A. shumardana, **L**, d, e
4. A. wortheni, **M**, d, e
8. Lepidocidaris squamosus, **L**, d
9. Lepidochinus rarispinum, **L**, b
10. Rhoëchinus burlingtonensis, **L**, d
11. R. gracilis, **L**, c, d
12. Oligoporus nobilis, **L**, d
13. O. danæ, **L**, d
14. Melonites multiporus, **M**, c, d
15. Lepidesthes wortheni, **L**, c
16. L. colletti, **L**, c
17. Pholidocidaris irregularis, **L**, d

CARBONIC FAUNAS.

The following provinces are recognized.

(*a*) Eastern Canada and New England.
(*b*) Appalachian (including the bituminous district).
(*c*) Mississippi valley and Michigan (including Kansas).
(*d*) Southwestern (Texas, Oklahoma, New Mexico, Arizona).
(*e*) Rocky Mountains.
(*f*) Pacific (including Alaska).

ANTHOZOA.

36. Campophyllum torquium, c
*62. Lophophyllum profundum, c, d

BRYOZOA.

30. Fistulipora carbonaria, c
*64. Stenopora carbonaria, c

106. Polypora submarginata, c
*122. Rhombopora lepidodendroides, c

BRACHIOPODA.

*31. Lingula umbonata, c
*50. Orbiculoidea convexa, c
51. O. missouriensis, c
*61. Crania modesta, c
*114. Orthothetes keokuk, c
*115. O. crassa, c, d, f
*116. Meekella striatocostata, c, d, f
130. Chonetes glaber, c, e
*131. C. granulifer, c, e, f
*132. C. mesolobus, c, d, e
*133. C. variolatus, c, e
134. C. verneuilianus, c, e
*152. Productus semireticulatus, a, b, c, d, e, f
*153. P. cora, a, b, c, d, e, f
154. P. costatus, a, b, c, d, e, f
155. P. inflatus, c, e
*156. P. longispina, b, c, d, e, f
157. P. mexicoanus, d, f
*158. P. muricatus, b, c, d, e, f
*159. P. nebraskensis, b, c, d, e, f
160. P. punctatus, a, b, c, d, e, f
161. P. symmetricus, c
*205. Rhipidomella pecosi, c, d, f
213. Schizophoria resupinoides, c, e
*214. Enteletes hemiplicata, c, e
*278. Pugnax utah, c, f
*298. Dielasma bovidens, c, d, f
*324. Spiriferina spinosa, f
*325. S. kentuckiensis, b, c, d, f
371. Spirifer striatus, a, e, f
*372. S. cameratus, b, c, d, f
373. S. rockymontanus, b, c, d, e, f
*380. Reticularia perplexa, b, c, d, f
382. Martinia glabra, a
*388. Ambocœlia planoconvexa, b, c, d, f
*392. Hustedia mormoni, c, d, f
*419. Seminula argentea, b, c, d, e, f
420. S. dawsoni, a

PELECYPODA.

4. Clinopistha radiata, b, c
8. Prothyris elegans, c
35. Cardiomorpha missouriensis, c, f
*39. Chænomya leavenworthensis, c, e
*40. C. minnehaha, c
*44. Edmondia aspinwallensis, b, c, f
*74. Nucula ventricosa, b, c, d, e
75. N. beyrichi, c
*96. Leda bellistriata, c, e
*105. Parallelodon tenuistriatus, c, d, f
*106. P. obsoletus, b, c, d, e
197. Aviculopinna americana, c
*198. A. peracuta, b, c, d, e
*203. Bakewellia parva, c, d
*221. Pteria sulcata, c
*222. P. longa, c
237. Monopteria longispina, c, e
238. M. gibbosa, b, c
*239. Pseudomonotis hawni, b, c, e
*240. P. kansasensis, b, c, d, e
*241. P. equistriata, c, e
*248. Myalina congeneris, c
*249. M. swallovi, c, d, e
250. M. recurvirostris, c
*251. M. subquadrata, e
*252. M. perattenuata, c, e
304. Naiadites carbonarius, a
305. Anthracomya elongata, a
306. A. lævis, a
*321. Schizodus quadrangularis, b
*323. S. cuneatus, b, c, e, f
*324. S. curtus, c
*325. S. wheeleri, b, c, e
340. Aviculopecten coxanus, b, c, d
341. A. rectilaterarius, b, c, d, e
342. A. pellucidus, c, e
343. A. providencesis, b, c
344. A. interlineatus, b, c, d
345. A. curtocardinalis, e
346. A. occidaneus, e
347. A. parvulus, e
348. A. weberensis, e
*349. A. occidentalis, b, c, d, e
*350. A. germanus, c, d
*351. A. maccoyi, c, d
354. Acanthopecten carboniferus, b, c, d, e
355. Euchondria neglecta, b, c
*364. Crenipecten winchelli, b
*392. Pecten aviculatus, b, c, d, e
398. Lima retifera, b, c, d
404. Placunopsis carbonaria, b, c
444. Allorisma geinitzi, c
*445. A. costatum, c

*446. A. granosum, c
*447. A. terminale, b, c, d, e
474. Pleurophorus tropidophorus, c
475. P. oblongus, c
*476. P. subcostatus, c, d, e
*477. P. occidentalis, c, e
487. Cypricardinia carbonaria, c, e
488. Astartella vera, c, d
489. A. newberryi, c, d

GASTROPODA.

*58. Bellerophon sublævis, b
*59. B. crassus, b, c, e
60. B. percarinatus, b, c
*61. Euphemus carbonarius, b, c, d
62. E. nodocarinatus, b, c
63. E. subpapillosus, e
69. Bucanopsis marcouana, b, c
*70. B. montfortiana, b, c, d, e
113. Phanerotrema grayvillensis, b, c, d
114. Worthenia tabulata, b, c, d
115. W. subscalaris, c
116. W. speciosa, c, d
140. Euconospira turbiniformis, c
142. Trepospira sphærulata, b, c, d
143. T. illinoisensis, c
182. Euomphalus pernodosus, c, d
*183. E. catilloides, c, e
184. E. subquadratus, c, d
207. Anomphalus rotulus, c
*212. Naticopsis ventricosa, c
213. N. altonensis, c, d
214. N. torta, c
216. Trachydomia wheeleri, c, d
217. T. nodosa, c
229. Strophostylus nanus, c, e
230. S. remex, c, d, e
256. Platyceras parvum, c, d
*264. Orthonychia acutirostris, b
286. Loxonema multicostatum, c
287. L. rugosum, c, d
288. L. scitulum, c
289. L. whitfieldi, c
290. Aclisina robusta, c
291. A. stevensana, c, d
292. A. minuta, c
293. Orthonema conicum, c
294. O. subtæniatum, c
303. Meekospira peracuta, c
304. M. nitidula, c
305. M. inornata, c
307. Bulimorpha minuta, c
308. Soleniscus typicus, c
309. S. fusiformis, c
310. S. planus, c, d
311. S. newberryi, c
312. S. paludinæformis, c
313. S. brevis, c, d
314. S. gracilis, c
315. S. regularis, c
316. S. klipparti, c
*318. Sphærodoma intercalare, b, c
*319. S. mediale, c
320. S. texanum, c, d
321. S. primigenium, b, c
322. S. ponderosum, c
695. Pupa vermilionensis, c
697. Anthracopupa ohioensis, c
698. Dendropupa vetusta, a
699. Archæozonites priscus, a

CONULARIDA.

39. Conularia crustula, c, d

CEPHALOPODA.

*36. Orthoceras rushense, c
*37. O. cribrosum, b, c, d
101. Stroboceras hartti, c
103. Ephippioceras divisum, c, d
104. E. ferratum, c
106. Stearoceras gibberum, d
108. Phacoceras dumbli, c
109. Thrincoceras depressum, c
110. T. kentuckiense, c
114. Temnocheilus forbesianus, c, d
115. T. latus, c
*116. T. winslowi, c
118. Endolobus ortoni, b
119. E. missouriensis, c
120. Metacoceras subquadrangulare, b
121. M. walcotti, d
*122. M. sangamonense, c
123. M. cavatiforme, c
124. Tainoceras cavatum, d
*125. T. occidentale, b, c, d
126. Domatoceras lasellense, c
127. Asymtoceras newloni, c
*128. Solenocheilus collectus, d
135. Diodoceras avonense, a
153. Actinoceras inops, a

209. Gonioloboceras goniolobus, d
210. G. welleri, c, d
211. Dimorphoceras texanum, d
217. Gastrioceras carbonarium, c
219. G. globulosum, c, d
220. G. listeri, c
221. G. nolinense, c
222. G. subcavum, c, d
223. Schistoceras hildrethi, c, d
*224. Paralegoceras iowense, c
225. Popanoceras parkeri, d
227. Shumardites simondsi, d
334. Prolecanites compactus, c

ANNELIDA.

9. Spirorbis anthracosia, b

TRILOBITA.

*128. Phillipsia missouriensis, c
129. P. major, c, e
*131. Griffithides scitulus, c
132. G. sangamonensis, c

PHYLLOPODA.

3. Estheria ortoni, b
6. Leaia tricarinata, c
7. L. leidyi, **L**, b

OSTRACODA.

*20. Paraparchites humerosus, c, d
85. Hollina radiata, c
90. Jonesina gregaria, c
*91. J. bolliaformis, c, d
*98. Kirkbya centronota, c
106. Cypridina subovata, c
*110. Bairdia beedei, c

MALACOSTRACA.

29. Anthrapalæmon gracilis, c
30. Palæocaris typus, c
33. Acanthotelson stimpsoni, c

MEROSTOMATA.

1. Cyclus americanus, c
2. C. limbatus, c
3. C. minutus, c
4. C. communis, c
5. Belinurus lacœi, c
6. Prestwichia danæ, c
7. P. longispina, b
20. Eurypterus mansfieldi, b
26. Anthraconectes mazonensis, c

ARACHNIDA.

Arthrolycosa antiqua, **M**, c
Geraphrynus carbonarius, **M**, c
Architarbus rotundatus, **M**, c
Anthracomartus pustulosus, **M**, c
A. trilobitus, **L**, c
Geralinura carbonaria, **M**, c
Eoscorpius carbonarius, **M**, c
E. (Mazonia) woodanus, **M**, c

MYRIOPODA.

Palæocampa anthrax, **M**, c
Acantherpestes major, **M**, c
Euphoberia armigera, **M**, c
E. granosa, **M**, c
Amynilispes wortheni, **M**, c
Eileticus anthracinus, **M**, c
Trichiulus villosus, **M**, c
Archiulus xylobioides, **M**, a
Xylobius sigillariæ, **M**, a

INSECTA.

Haplophlebium barnesii, b
Titanodictya jucunda, **L**, b
Homothetus fossilis, **L**, a
Eubleptus danielsi, **M**, c
Paolia vetusta, **L**, c
Geroneura wilsoni, **L**, a
Spaniodera ambulans, **M**, c
Gyrophlebia longicollis, **M**, c
Propteticus infernus, **M**, c
Dieconeura arcuta, **M**, c
Genentomum validum, **M**, c
Oryctoblattina laqueata, **M**, c
Blattinopsis anthracina, **M**, b
Eucænus ovalis, **M**, c
Gerapompus blattinoides, **M**, c
Adiphlebia lacoana, **M**, c
Anthracothremma robusta, **M**, c
Adeloblatta columbiana, **M**, c
Asemoblatta mazona, **M**, c
Etoblattina (Dicladoblatta) tenuis, b
Hemimylacris clintoniana, **M**, c
Orthomylacris antiqua, **M**, c
Mylacris anthracophila, **M**, c

Hadentomum americanum, **M**, c
Palæotherates pennsylvanicus, **L**, b
Paralogus æschnoides, **M**, a
Adiaphtharsia ferrea, **M**, c

CRINOIDEA.

30. Cyathocrinus stillativus, c
49. Eupachycrinus mooresi, b
50. E. tuberculatus, c
*51. Ceriocrinus hemisphericus, c
52. C. inflexus, c, d, e
53. Erisocrinus typus, c, e

ECHINOIDEA.

1. Eocidaris halliana, c, e
*2. Archæocidaris agassizi, d
5. A. dininnii, c
6. A. megastylus, c
*7. A. aculeata, c, d

PERMIC FAUNAS.

The following provinces are recognized.

(*a*) Eastern continental (Pennsylvania, Ohio, etc.).
(*b*) Kansas-Oklahoma.
(*c*) Southwestern (Arizona, New Mexico, Texas).
(*d*) Rocky Mountain (continental).

ANTHOZOA.

*62. Lophophyllum profundum, **L**, b

BRYOZOA.

*64. Stenopora carbonaria, **L**, b
*122. Rhombopora lepidodendroides, **L**, b

BRACHIOPODA.

*31. Lingula umbonata, **L**, b
*50. Orbiculoidea convexa, **L**, b
*61. Crania modesta, **L**, b
*114. Orthothetes keokuk, **L**, b
*115. O. crassus, **L**, b
*116. Meekella striatocostata, **L**, b
*131. Chonetes granulifer, **L**, b
*132. C. mesolobus, **L**, b
*133. C. variolatus, **L**, b
*152. Productus semireticulatus, **L**, b
*153. P. cora, **L**, b
*156. P. (Marginifera) longispina, **L**, b
*158. P. (Marginifera) muricatus, **L**, b
*159. P. nebraskensis, **L**, b
*205. Rhipidomella pecosi, **L**, b
*214. Enteletes hemiplicata, **L**, b
*278. Pugnax utah, **L**, b
*298. Dielasma bovidens, **L**, b
*325. Spiriferina kentuckiensis, **L**, b
*372. Spirifer cameratus, **L**, b
*380. Reticularia (Squamularia) perplexa, **L**, b
*388. Ambocœlia planoconvexa, **L**, b
*392. Hustedia mormoni, **L**, b
*419. Seminula argentea, **L**, b

PELECYPODA.

*39. Chænomya leavenworthensis, **L**, b
*40. C. minnehaha, **L**, b
*44. Edmondia aspinwallensis, **L**, b
*74. Nucula ventricosa, **L**, b
*96. Leda bellistriata, **L**, b
*198. Aviculopinna peracuta, **L**, b
*203. Bakewellia parva, **L**, b
204. B. gouldi, b, c
*221. Pteria sulcata, **L**, b
*222. P. longa, b, c
*239. Pseudomonotis hawni, b
*240. P. kansasensis, **L**, b
*241. P. equistriata, **L**, b
*249. Myalina swallovi, **L**, b
*251. M. subquadrata, **L**, b
*252. M. perattenuata, b, c
253. M. aviculoides, b, c
254. M. permiana, b, c
*324. Schizodus curtus, b
*325. S. wheeleri, b
*349. Aviculopecten occidentalis, b
*350. A. germanus, b

*351. A. maccoyi, b
352. A. vanvleeti, b, c
353. A. oklahomensis, b, c
*445. Allorisma costatum, **L**, b
*446. A. granosum, b
*447. A. terminale, b
*476. Pleurophorus subcostatus, **L**, b
*477. P. occidentalis, b, c
478. P. albequus, b, c

GASTROPODA.

*59. Bellerophon crassus, c
*61. Euphemus carbonarius, **L**, b
*70. Bucanopsis montfortianus, **L**, b
*183. Euomphalus catilloides, **L**, b
*318. Sphærodoma intercalare, **L**, b
*319. S. mediale, **L**, b

CEPHALOPODA.

*36. Orthoceras rushense, b, c
*37. O. cribrosum, **L**, b, c
*116. Temnocheilus winslovi, c
*122. Metacoceras sangamonense, b, c,
*125. Tainoceras occidentale, b, c
228. Waagenoceras cumminsi, c
229. W. hilli, c
236. Medlicottia copii, c

TRILOBITA.

*131. Griffithides scitulus, **L**, b

OSTRACODA.

*20. Paraparchites humerosus, c
*91. Jonesina bolliaformis var. tumida, **L**, b
*98. Kirkbya centronota, **L**, b
*110. Bairdia beedii and var. abrupta, **L**, b

INSECTA.

Lepium elongatum, b
Pursa ovata, b
Sindon speciosa, b
Phyloblatta dichotoma, a
P. arcuata, a
Bradyblatta sagittaria, a
Spiloblattina gardineri, d
Tupus permianus, b
Opter brongniarti, b
Protereisma permianum, b
Prodromus rectus, b
Scopus gracilis, b

CRINOIDEA.

*51. Ceriocrinus hemisphericus, **L**, b

ECHINOIDEA.

*7. Archæocidaris aculeata, b

TRIASSIC FAUNAS.

The following provinces are recognized.

(*a*) Eastern or Newark (continental).
(*b*) Rocky Mountain (continental).
(*c*) Western (marine;—California, Nevada, Idaho, and Oregon with Canadian extension).

BRACHIOPODA.

285. Rhynchonella æquiplicata, c
300. Terebratula humboldtensis, c

PELECYPODA.

242. Pseudomonotis subcircularis, c
244. Halobia lommeli, c

CEPHALOPODA.

141. Proclydonautilus triadicus, **U**, c
226. Popanoceras haugi, **M**, c
237. Nannites dieneri, **L**, c
238. Paranannites aspenensis, **L**, c
239. Aspenites acutus, **L**, c
240. Sageceras gabbi, **M**, c
241. Pseudosageceras intermontanum, **L**, c
242. Paralecanites arnoldi, **L**, c
243. Meekoceras gracilistriatum, **L**, c
244. M. jacksoni, **L**, c

245. M. rotelliforme, **M**, c
246. M. mushbachanum, **L**, c
247. M. aplanatum, **L**, c
248. Eutomoceras laubii, **M**, c
249. Longobardites nevadanus, **M**, c
250. Celtites halli, **M**, c
251. Tirolites foliaceus, **U**, c
252. Ceratites humboldtensis, **M**, c
253. C. blakii, **M**, c
254. Acrochordiceras hyatti, **M**, c
255. Clionites fairbanksi, **U**, c
256. C. robustus, **U**, c
257. Trachyceras lecontii, **U**, c
258. T. meeki, **M**, c
259. Columbites parisianus, **L**, c
260. Sagenites herbrichi, **U**, c
261. Tropites subbullatus, **U**, c
262. Discotropites sandlingerensis, **U**, c
263. Paratropites sellai, **U**, c
264. Arcestes andersoni, **U**, c
265. A. pacificus, **U**, c
266. Joannites nevadanus, **M**, c
267. Ussuria waageni, **L**, c
404. Atractites phillippi, c

PHYLLOPODA.

4. Estheria ovata, a, b

INSECTA.

Mormolucoides articulatus, a
Acanthichnus, 10 species, a
Bifurculapes, 5 species, a
Conopsoides, 2 species, a
Copeza, 4 species, a
Hexapodichnus, 2 species, a

JURASSIC FAUNAS.

The following provinces are recognized:

(*a*) Gulf Region (Mexico to Texas).
(*b*) Rocky Mountain (Wyoming, Dakota, etc.).
(*c*) Northern Pacific (California, Idaho, Utah, Nevada, to Alaska).

BRACHIOPODA.

284. Rhynchonella myrina, b, c
286. R. gnathophora, c

PELECYPODA.

243. Pseudomonotis curta, **U**, b
259. Ostrea strigilecula, b
285. Gryphæa mexicana, **U**, a
326. Trigonia quadrangularis, **U**, b
388. Pecten bellistriatus, **U**, b
389. P. extenuatus, **U**, b
390. P. pertenuistriatus, b
442. Pleuromya subcompressa, b, c
443. P. inconstans, **U**, a
490. Arctica coteroi, **U**, a
528. Tancredia bulbosa, **U**, b

GASTROPODA.

334. Nerita nodilirata, **U**, a
335. N. nebrascensis, b
372. Natica williamsi, **U**, a
399. Valvata scabrida, **U**, b
402. Viviparus gilli, **U**, b
472. Nerinea goodelli, **U**, a
475. Nerinella stantoni, **U**, a
676. Limnæa altivuncula, **U**, a
677. L. consortis, **U**, a
684. Planorbis veternus, **U**, b

CEPHALOPODA.

268. Phylloceras apenninicum, **U**, a
269. P. mazapilense, **U**, a
277. Haploceras fialar, **U**, a
278. H. transatlanticum, **U**, a
279. H. zacatecanum, **U**, a
280. H. ordonezi, **U**, a
281. H. costatum, **U**, a
282. Eurynoticeras zitteli, **U**, a
306. Coroniceras claytoni, **L**, c
307. Arnioceras nevadanum, **L**, c
308. A. humboldti, **L**, c
309. Oppelia fallax, **U**, a

310. Œcotraustes denticulata, c
311. Macrocephalites epigonus, **U**, a
312. Cardioceras cordiformis, **U**, b
313. Perisphinctes machlachlani, **U**, a
314. P. nikitini, **U**, a
315. P. mazapilensis, **U**, a
316. P. felixi, **U**, a
317. P. virgulatiformis, c
318. P. colfaxi, c
320. Idoceras laxevolutum, **U**, a
321. I. baldarum, **U**, a
322. Aspidoceras cf. acanthicum, **U**, a
323. A. bispinosum, **U**, a
324. A. avellanoides, **U**, a
325. A. alamitocensis, **U**, a
329. Virgatites mexicanus, **U**, a
330. Aulacostephanus zakatecanus, **U**, a
405. Belemnites densus, **U**, b

OSTRACODA.

*116. Cypris purbeckensis, **U**, b

CRINOIDEA.

202. Pentacrinus asteriscus, **U**, b c
203. P. (Isocrinus) knighti, **U**, b

COMANCHIC FAUNAS.

The following provinces are recognized:

(*a*) Northern Gulf (including Alabama, Kansas, Oklahoma, etc.).

(*b*) Mexico-Texas.

(*c*) Northern Rocky Mountains and Canadian extensions.

(*d*) Pacific.

(*e*) Greenland and other arctic regions.

ANTHOZOA.

130. Parasmylia austinensis, **M**, b
131. P. texana, **U**, b
132. Pleurocora coalescens, **M**, b
133. Cladophyllia furcifera, **M**, b

BRACHIOPODA.

287. Peregrinella whitneyi, d
304. Kingena wacoensis, **U**, b, d

PELECYPODA.

2. Solemya occidentalis, d
*107. Nemodon vancouverensis, d
206. Gervilliopsis invaginata, **U**, b
257. Aucella crassicollis, d
258. A. piochii, d
258a. A. piochii var. ovata, d
260. Ostrea crenulimargo, b
261. O. subovata, **M**, **U**, a, b
262. O. quadriplicata, **U**, a, b
286. Gryphæa marcoui, **M**, b
287. G. corrugata, **U**, a, b
287a. —— var. hilli, **U**, a
287b. —— var. tucumcarii, **U**, a, b
287c. —— var. belviderensis, **U**, a, b
288. G. navia, **U**, a, b
289. G. washitaensis, **U**, b
290. G. mucronatus, **U**, b
*291. G. vesicularis, **U**, b
295. Exogyra texana, b
295a. —— var. weatherfordensis, **L**, b
296. E. plexa, **M**, **U**, b
297. E. arietina, **U**, b
327. Trigonia taffi, **L**, b
328. T. emoryi, **M**, **U**, a, b
*329. T. equistriata, **U**, d
365. Pecten texanus, **M**, **U**, b
366. P. roemeri, **U**, b
*367. P. quinquecostatus, **U**, b
374. P. complexicosta, **L**, d
*393. P. operculiformis, **U**, d
397. Plicatula dentonensis, **U**, b
399. Lima wacoensis, **M**, **U**, b
435. Modiola major, d
462. Pholadomya sancti-sabæ, **M**, **U**, a, b
491. Arctica occidentalis, d
497. Astarte carlottensis, d

498. A. trapezoidalis, **L**, d
499. Opis californica, **L**, d
506. Ptychomya ragsdalii, b
515. Requienia patagiata, **M**, b
516. R. texana, **M**, b
517. Monopleura texana, **M**, b
518. M. pinguiscula, **M**, b
519. M. marcida, **M**, b
520. Caprina crassifibra, **M**, **U**, b
521. C. occidentalis, **M**, b
522. Ichthyosarcolites anguis, **M**, b
524. Radiolites texanus, **M**, b
525. R. davidsoni, **M**, b
550. Protocardia texana, **U**, b
551. Cyprimeria texana, **M**, b
*556. C. crassa, **M**, **U**, b
*571. Tapes hilgardi, **M**, **U**, b
582. Leptosolen conradi, **U**, b

GASTROPODA.

355. Solarium planorbis, **M**, b
373. Natica pedernalis, **L**, **M**, b
375. N. avellana, **U**, d
391. Amauropsis avellana, **M**, b
418. Turritella seriatim-granulata, **M**, b, d
419. T. belviderii, **U**, a
420. T. kansasensis, **U**, a
445. Glauconia branneri, **L**, b
447. Hypsipleura occidentalis, **L**, d
448. H. gregaria, **L**, d
473. Nerinea austinensis, **M**, b
474. N. cultrispira, **M**, b
476. Nerinella subula, b
481. Cerithium bosquense, b
482. C. obliterato-granosum, **M**, b
483. C. austinense, **M**, b
490. Anchura kiowana, **U**, a
644. Actæonia californica, **U**, d
645. Cinulia mathewsoni, **U**, d
646. C. polita, **U**, d
*658. Anisomyon meeki, **U**, d

CEPHALOPODA.

138. Cymatoceras carlottense, d
270. Phylloceras knoxvillense, **L**, d
271. P. onoense, **U**, d
*273. Tetragonites timotheanus, d
275. Gaudryceras sacya, d
283. Puzozia latidorsata, d
285. P. breweri, d
286. Desmoceras haydeni, d
288. Gabbioceras batesi, **U**, d
*289. Pleuropachydiscus hoffmani, **U**, d
290. Pachydiscus brazoensis, **U**, a, b
305. Lytoceras batesi, **L**, d
319. Perisphinctes skidegatensis, d
326. Olcostephanus mutabilis, **L**, d
327. O. loganianus, d
328. O. traski, **U**, d
332. Stoliczkaia texana, **U**, b
333. S. dispar, b, d
334. S. remondii, **U**, d
335. Sonneratia acuto-carinata, **M**, b
336. S. stantoni, **U**, d
337. Lyticoceras hyatti, **L**, d
338. L. angulatum, **L**, d
339. Acanthoceras justinæ, **L**, b
340. Douvilleiceras spiniferum, d
341. D. stolitzkanum, d
344. Crioceras latum, d
345. C. percostatum, d
346. Ancyloceras remondii, **U**, d
347. A. percostatum, **U**, d
348. Hamites fremonti, **U**, a, b
352. Ptychoceras glaber, d
365. Turrilites brazoensis, **U**, b
366. T. carlottensis, d
368. Protengonoceras gabbi, **M**, b
369. Engonoceras gibbosum, **M**, b
370. E. stolleyi, **M**, b
371. E. pierdernale, **M**, b
372. E. belviderense, **U**, a
373. E. serpentinum, **U**, b
*380. Placenticeras syrtale, **M**, a, b
.391. Schlœnbachia leonensis, **U**, b
392. S. inflata, **U**, d
393. S. belknappi, **U**, b
394. S. propinqua, d
406. Belemnites impressus, d
407. B. tehamaensis, **L**, d
408. B. skidegatensis, d

INSECTA.

Archiorhynchus angusticollis, e
Curculiopsis cretacea, e
Elytrulum multipunctum, e

ECHINOIDEA.

18. Cidaris texana, **U**, b

19. Leiocidaris hemigranosum, **U**, b
20. Diadema texanum, **M**, b
21. Diplopodia texana, **M**, b
23. Cyphosoma volanum, **U**, b
24. Holectypus planatus, **M**, **U**, b
25. H. charltoni, **U**, b
41. Holaster completus, **U**, b
43. Epiaster elegans, **U**, b
44. E. whitii, **U**, b
45. Enallaster texanus, **M**, b

Cretacic Faunas.

The following provinces are recognized:

(*a*) Atlantic (including Greenland).
(*b*) Eastern Gulf.
(*c*) Western Gulf (including Mexico).
(*d*) Central and Northern interior.
(*e*) Pacific.

Foraminifera.

*2. Cristellaria cultrata, **M**, **U**, a
3. C. cretacea, **U**, a
*4. Textularia globulosa, **M**, a
*5. T. triquetra, **U**, a
*6. Nodosaria communis, **M**, **U**, a
8. N. zippii, **M**, **U**, a
*9. Orbulina universa, **M**, d
*10. Globigerina bulloides, **M**, **U**, a, d
*11. Anomalina ammonoides, **M**, **U**, a
*12. Truncatulina lobatula, **M**, **U**, a

Bryozoa.

164. Filifascigera megaera, **U**, a
*165. Discosparsa varians, **U**, a
168. Heteropora parvicella, **U**, a
*170. Biflustra torta, **U**, a
*171. Onychocella digitata, **U**, a
172. Membranipora plebeia, **U**, a
173. M. arbortiva, **U**, a

Brachiopoda.

32. Lingula subspatulata, **M**, **U**, d
*301. Terebratula harlani, **U**, a
302. Terebratulina atlantica, **U**, a
305. Terebratella plicata, **U**, a
306. T. vanuxemi, **M**, a

Pelecypoda.

76. Nucula cancellata, **M**, c, d
77. N. percrassa, **M**, a, b, c
78. N. whitfieldi, **M**, a
99. Yoldia septariana, **L**, c
100. Y. evansi, **M**, d
101. Y. longifrons, **M**, a, c
102. Y. scitula, **M**, d
*107. Nemodon vancouverensis, **L**, e
108. N. brevifrons, **M**, a, c
109. N. eufaulensis, **M**, a, b, c
110. N. sulcatinus, **L**, **M**, d
111. Cucullæa vulgaris, **U**, a
112. C. tippana, **M**, a, c
113. C. neglecta, **M**, a, b
114. C. antrosa, **M**, a, c
115. C. truncata, **L**, e
117. Trigonarca obliqua, **L**, d
118. Breviarca siouxensis, **L**, c, d
119. B. saffordi, **M**, a, c
120. B. exigua, **U**, d
146. Arca quindecemradiata, **U**, a
147. Barbatia micronema, **L**, c, d
149. Glycimeris subaustralis, **M**, a, b
150. G. congesta, **M**, a
199. Pinna petrina, **L**, d
200. P. laqueata, **M**, a, b
205. Gervillia propleura, **L**, **M**, a, d
207. Gervilliopsis ensiformis, **M**, a, b
208. Inoceramus dimidius, **L**, d
209. I. simpsoni, **L**, c, d
210. I. fragilis, **L**, c, d
211. I. undabundus, **L**, d
212. I. gilberti, **L**, d
213. I. umbonatus, **L**, c, d
214. I. labiatus, **L**, d
215. I. deformis, **L**, d

216. I. altus, **L**, **M**, d
217. I. nebrascensis, **M**, d
218. I. proximus, **M**, a, b, d
219. I. vanuxemi, **M**, d
220. I. barabini, **M**, d
223. Pteria petrosa, **M**, a, d
224. P. gastrodes, **L**, d
225. P. nebrascana, **M**, d
263. Ostrea soleniscus, **X**, c, d
264. O. haydeni, **L**, d
265. O. panda, **L**, a, c
266. O. congesta, **L**, c, d
267. O. lugubris, **L**, **M**, c, d
268. O. cretacea, **M**, a, b
269. O. denticulifera, **M**, a, b
270. O. subspatulata, **U**, a, c
271. O. falcata, **M**, a, b
272. O. mesenterica, **M**, a
273. O. nasuta, **M**, a, c
274. O. plumosa, **M**, a, b, d
275. O. bryani, **U**, a
276. O. glabra, **M**, **U**, c, d
277. O. subtrigonalis, **M**, **U**, d
278. O. inornata, **M**, d
279. O. pellucida, **M**, d
*280. O. vomer, **M**, **U**, a, c
*291. Gryphæa vesicularis, **L**, **M**, a, b, c, d
292. G. mutabilis, **M**, a
293. G. convexa, **U**, a, b
294. G. newberryi, **L**, c, d
298. Exogyra suborbiculata, **L**, d
299. E. columbella, **L**, c
300. E. læviuscula, **L**, c, d
301. E. ponderosa, **L**, **M**, a, b, c, d
302. E. costata, **M**, a, b, c
308. Unio vetustus, **L**, d
309. U. belliplicatus, **L**, d
311. U. subspatulatus, **M**, d
311a. U. danæ, **M**, **U**, d
312. U. senectus, **M**, **U**, d
313. U. holmesianus, **U**, d
314. Anodonta propatoris, **M**, **U**, d
*329. Trigonia equistriata, **L**, e
330. T. evansana, **L**, e
331. T. thoracica, **M**, a, b
332. T. eufaulensis, **M**, a, b
*367. Pecten quinquecostatus, **M**, a
368. P. conradi, **M**, a
369. P. simplicius, **M**, a, b, c
370. P. quinquenarius, **M**, a, b
371. P. burlingtonensis, **M**, a
372. P. argillensis, **M**, a, b, c
375. P. nebrascensis, **M**, d
391. P. platessa, **L**, d
*393. P. operculiformis, **L**, e
394. P. rigidus, **M**, d
400. Lima utahensis, **L**, d
401. Anomia argentaria, **M**, a, b, c
402. A. propatoris, **L**, M, d
403. A. gryphorhynchus, **M**, **U**, d
405. Paranomia scabra, **M**, a, b
436. Modiola multilinigera, **L**, d
437. M. julia, **M**, a, c
440. Crenella serica, **M**, a, b
441. C. elegantula, **M**, **U**, a, d
463. Pholadomya papyracea, **L**, d
464. P. occidentalis, **M**, a, b
467. Anatimya anteradiata, **M**, a, b
468. Liopistha meeki, **L**, c, d
469. L. bella, **M**, a, b
470. L. protexta, **M**, a, b
471. L. undata, **M**, a, d
472. Cuspidaria ventricosa, **M**, a, d
473. C. moreauensis, **M**, d
492. Arctica ovata, **M**, d
493. Veniella conradi, **M**, a, b
494. V. trigona, **M**, a, b
495. V. mortoni, **L**, d
496. V. humilis, **M**, d
504. Etea carolinensis, **M**, a
505. E. trapezoidea, **M**, a, b, c
507. Corbicula durkii, **L**, d
508. C. occidentalis, **M**, **U**, d
509. Sphærium planum, **M**, **U**, d
*510. S. formosum, **M**, d
523. Coralliochama orcutti, **L**, e
526. Radiolites austinensis, **L**, c
527. R. maximus, **L**, d
529. Tancredia americana, **M**, d
534. Lucina subundata, **L**, **M**, d
535. L. cretacea, **M**, a
536. L. occidentalis, **M**, d
542. Tenea parilis, **U**, a
543. Cardium pauperculum, **L**, d
544. C. speciosum, **M**, d
545. C. tenuistriatum, **M**, a
546. C. eufaulensis, **M**, a, b
547. C. spillmani, **M**, a, b, c
548. C. kümmeli, **M**, a, b

551. Protocardia subquadrata, **M**, d
553. Isocardia cliffwoodensis, **M**, a, c
*556. Cyprimeria crassa, **L**, c
557. C. excavata, **M**, a, b
560. Meretrix tippana, **M**, a, b, c
561. M. eufaulensis, **M**, a, b
562. M. veta, **U**, a
*563. M. ripleyana, **M**, a
567. Dosiniopsis deweyi, **M**, d
568. D. owenana, **M**, d
569. D. nebrascensis, **M**, d
*571. Tapes hilgardi, **L**, c
572. Tellina equilateralis, **M**, d
576. Linearia metastriata, **M**, a, b
577. Ænona eufaulensis, **M**, a, b, c
581. Siliqua huerfanensis, **L**, d
583. Leptosolen biplicatus, **M**, a, b
584. Solyma lineolata, **M**, a, b
585. Legumen planulatum, **M**, a, b, d
587. Cymbophora ashburneri, **L**, e
588. C. utahensis, **L**, d
589. C. alta, **M**, d
590. C. lintea, **M**, a, b
591. C. emmonsi, **L**, d
592. C. warrenana, **M**, d
593. Schizodesma appressum, **M**, a, b, c
594. Corbula pyriformis, **L**, d
595. C. engelmanni, **L**, d
596. C. subtrigonalis, **X**, d
597. C. bisulcata, **M**, a, b
598. C. crassiplica, **M**, a, b, c
604. Panopea decisa, **M**, a, b
605. Turnus kümmeli, **M**, a, c
606. Teredo irregularis, **M**, a, b
607. Polorthus tibialis, **U**, a

SCAPHOPODA.

2. Dentalium pauperculum, **M**, d
3. D. gracile, **M**, d
4. D. stramineum, e
5. D. cooperi, e
6. D. subarcuatum, **M**, a, b
7 D. nanaimoense, **L**, e

GASTROPODA.

327. Margarita ornatissima, **L**, e
328. M. abyssina, **M**, a
333. Neritopsis biangulata, **L**, c
336. Nerita naticiformis, **L**, d
337. N. crebrilineata, **U**, d
338. N. pisum, **L**, d
339. Velatella patelliformis, **L**, d
340. V. carditoides, **L**, d
341. V. baptista, **U**, d
352. Scalaria sillmani, **M**, a, b
370. Vanikoropsis suciensis, **L**, e
371. V. tuomeyana, **M**, d
374. Natica halli, **M**, a, b
*376. N. shumardiana, **L**, e
384. Gyrodes depressa, **L**, d
385. G. conradi, **L**, d
386. G. crenata, **M**, a, b
387. G. abyssina, **M**, a, b, c
388. G. petrosa, **M**, a, b, c
389. G. conradiana, **L**, e
390. G. expansa, **L**, e
392. Amauropsis bulbiformis, **L**, d
396. Xenophora leprosa, **M**, a, b
397. X. umbilicata, **M**, a, b
400. Valvata nana, **L**, d
401. V. subumbilicata, **U**, d
403. Viviparus couesii, **L**, d
404. V. conradi, **M**, d
405. V. leai, **U**, d
406. V. leidyi, **U**, d
407. V. plicapressus, **U**, d
408. V. prudentia, **U**, d
413. Campeloma macrospira, **L**, d
414. C. vetulum, **M**, d
415. C. multilineatum, **U**, d
416. C. multistriatum, **U**, d
417. C. productum, **U**, d
421. Turritella whitii, **L**, d
422. T. vertebroides, **M**, a, b
423. T. encrinoides, **M**, a, b
424. T. trilira, **M**, a, b, c
425. T. tippana, **M**, a, b
443. Laxispira lumbricalis, **M**, a, b
444. Siliquaria pauperata, **M**, a
446. Glauconia coalvillensis, **L**, d
449. Melania insculpata, **U**, d
450. M. wyomingensis, **U**, d
453. Melanopsis americana, **U**, d
454. Pyrgulifera humerosa, **L**, d
455. Goniobasis chrysallis, **L**, d
456. G. chrysalloidea, **L**, d
457. G. cleburni, **L**, d
458. G. convexa, **U**, d
459. G. endlichi, **L**, d
460. G. gracilenta, **U**, d

461. G. invenusta, **U**, d
462. G. macilenta, **L**, d
463. G. nebrascensis, **U**, d
464. G. sublævis, **U**, d
465. G. subtortuosa, **U**, d
466. G. tenuicarinata, **U**, d
491. Anchura exilis, **L**, e
492. A. rostrata, **M**, a, b, c
493. A. pennata, **M**, a, b
494. A. abrupta, **M**, a, b
495. A. sublævis, **M**, d
499. Aporrhais prolabiata, **L**, d
500. A. nuptialis, **L**, d
501. A. distorta, **L**, e
502. A. tippana, **M**, a, b, c
503. A. falciformis, e
504. Pugnellus fusiformis, **L**, d
510. Cypræa mortoni, **M**, a, b
530. Pyropsis coloradoensis, **L**, d
531. P. richardsoni, **M**, a, b
532. P. trochiformis, **M**, a, b
533. P. whitfieldi, **M**, a, b
534. P. octolirata, **M**, a, b
*535. Perissolax brevirostris, **L**, e
549. Fasciolaria utahensis, **L**, d
550. F. culbertsoni, **M**, d
568. Odontofusus medians, **M**, a, b
598. Volutilithes conradi, **M**, a
599. V. biconicus, **M**, a
600. V. texturatus, **M**, a, b
601. V. dalli, **L**, d
602. V. ambigulus, **L**, d
641. Actæon attenuatus, **M**, d
647. Cinulia obliqua, e
649. Haminea subcylindrica, **M**, d
650. H. occidentalis, **M**, d
651. Bulla macrostoma, **M**, a, b
653. Cylichna costata, **L**, e
654. C. scitula, **M**, d
*658. Anisomyon meeki, **L**, e
659. A. centralis, **L**, d
660. A. alveolus, **M**, d
661. A. patelliformis, **M**, d
662. A. subovatus, **M**, d
663. A. sexsulcatus, **M**, d
664. A. borealis, **M**, d
665. A. shumardi, **M**, d
667. Rhytophorus meeki, **L**, d
668. R. priscus, **L**, d
669. Alexia antiqua, **L**, d
670. Physa carltoni, **M**, d
671. P. copei, **M**, d
672. P. felix, **U**, d
678. Limnæa nitidula, **L**, d
685. Planorbis convolutus, **M**, d
686. P. amplexus, **M**, d

CEPHALOPODA.

136. Eutrephoceras dekayi, **M**, a, b, c, d
137. E. bryani, **U**, a
139. Cymatoceras suciense, **L**, e
140. C. elegans, **L**, c, d
142. Hercoglossa paucifex, **U**, a
272. Phylloceras ramosum, **L**, e
*273. Tetragonites timotheanus, **L**, e
275. Gaudryceras denmanense, **L**, e
276. Pseudophyllites indra, **L**, e
285. Puzozia selwyniana, **L**, e
287. Hauericeras gardeni, **L**, e
*289. Pleuropachydiscus hoffmani, **L**, e
291. Pachydiscus otacodensis, **L**, e
292. P. suciaensis, **L**, e
293. P. newberryanus, **L**, e
294. P. complexus, **M**, a, c, d
295. Scaphites warreni, **L**, d
296. S. vermiformis, **L**, d
297. S. nodosus, **M**, a, d
297a. —— var. brevis, **M**, a, d
298. S. quadrangularis, **M**, d
299. S. hippocrepis, **M**, a
300. Baculites gracilis, **L**, c, d
301. B. chicoensis, **L**, e
302. B. anceps, **L**, c
303. B. compressus, **M**, a, d
304. B. ovatus, **M**, a, b, d
331. Hoplites vancouverensis, **L**, e
342. Metoicoceras swallovi, **L**, d
343. M. whitei, **L**, c, d
349. Hamites obstrictus, **L**, e
350. Ptychoceras crassum, **M**, d
351. P. meekanum, **M**, d
353. P. mortoni, **M**, d
354. Helicancyclus æquicostatus, **L**, e
355. Helioceras stevensoni, **M**, d
356. H. simplicostatum, **L**, d
357. H. elongatum, **L**, e
358. Exiteloceras jenneyi, **M**, d
359. E. pariense, **L**, d
360. Heteroceras newtoni, **M**, d

361. H. tortum, **M**, d
362. H. conradi, **M**, a
363. Anisoceras subcompressum, **L**, e
364. A. cooperi, **L**, e
367. Turrilites pauper, **M**, a
374. Engonoceras hilli, **L**, c
375. Metengonoceras dumbli, **L**, c
376. Sphenodiscus pleurisepta, **L**, c
377. S. lobatus, **M**, a, b
378. S. lenticularis, **M**, d
379. Placenticeras planum, **U**, c
*380. P. syrtale, **M**, c
381. P. placenta, **M**, a, b
382. P. whitfieldi, **M**, d
383. P. intercalare, **M**, d
384. P. stantoni, **L**, d
385. P. pseudoplacenta, **L**, d
385a. —— var. occidentale, **M**, c, d
386. P. spillmani, **M**, a, b
387. Stantonoceras newberryi, **U**, c
388. S. guadaloupæ, **M**, **U**, c, d
389. S. pseudocostatum, **M**, d
390. Barroisiceras dentatocarinatum, **X**, a, c, e
395. Schloenbachia oregonensis, **L**, e
396. S. chicoensis, **L**(?), e
397. S. gabbi, **L**(?), e
398. Mortoniceras texanum, **L**
399. M. delawarense, **M**, a
400. Prionotropis woolgari, **L**, c d
401. P. hyatti, **L**, d
402. Prionocyclus wyomingensis, **L**, d
403. P. macombi, **L**, d
409. Belemnitella americana, **M**, a, b, c

Annelida.

1. Serpula whitfieldi, **M**, a
10. Spirorbis rotula, **U**, a

Ostracoda.

115. Cypridea tuberculata var. wyomingensis, **L**, d
*116. Cypris purbeckensis, **L**, d
120. Metacypris consobrina, **L**, d
121. M. subcordata, **L**, d
122. Cytherideis equalis, **L**, d
123. C. impressa, **L**, d
124. Cythere monticula, **L**, d

Cirripedia.

7. Scalpellum conradi, **U**, a
8. Squama spissa, **L**, d
9. S. lata, **L**, d
10. Stramentum haworthi, **L**, d

Malacostraca.

31. Linuparus vancouverensis, **L**, e
32. L. canadensis, **L**, d, e
33. Callianassa whiteavesi, **L**, **M**, d, e
34. C. conradi, **M**, d
35. C. mortoni, **M**, d
36. C. stimpsoni, e
41. Palæocorystes harveyi, **L**, e
45. Plagiolophus vancouverensis, **L**, e
46. Archæopus antennatum, **L**, e

Insecta.

Stantoniella cretacea, **M**, d
Hylobiites cretaceus, **M**, d
Corydalites fecundus, **U**, d

Crinoidea.

201. Uintacrinus socialis, **L**, d

Echinoidea.

22. Pedinopsis pondi, **L**, c
37. Echinobrissus texanus, **L**, c
38. Cassidulus florealis, **M**, a
39. C. æquoreus, **M**, a, b
40. Echinocorys ovalis, **U**, a
42. Cardiaster cinctus, **M**, a
46. Hemiaster texanus, **L**, c
47. H. lacunosus, **M**, b
48. H. parastatus, **M**, **U**, a, b
49. Linthia variabilis, **M**, b
50. L. tumidula, **U**, a

Eocenic Faunas.

The following provinces are recognized:

(*a*) Atlantic.
(*b*) Gulf region.

(*c*) Interior continental.
(*d*) Pacific (California to Alaska).
(*e*) Greenland.

FORAMINIFERA.

*6. Nodosaria communis, a, b
7. N. bacillum, a, b
*10. Globigerina bulloides, a
*11. Anomalina ammonoides, a
*12. Truncatulina lobatula, a

ANTHOZOA.

*135. Flabellum cuneiforme, **U**, a, b
136. Platytrochus stokesi, **M**, a, b
137. Discotrochus orbignianus, **M**, b
138. Turbinolia pharetra, **U**, b
142. Balanophyllum desmophyllum, **M**, a, b
143. B. irroratum, **U**, b
144. B. haleanum, **L**, b
145. Eupsammia elaborata, **L**, a, b
146. Endopachus maclurii, **U**, b

BRYOZOA.

*165. Discosparsa varians, **L**, a
166. Cavaria dumosa, **L**, a
167. Ceriopora micropora, **L**, a
*170. Biflustra torta, **L**, a
*171. Onychocella digitata, **L**, a
175. Membranipora rimulata, **L**, a

BRACHIOPODA.

*301. Terebratula harlani, **L**, a

PELECYPODA.

79. Nucula ovula, **L**, a, b
97. Leda parva, a, b
98. L. eborea, **L**, b
116. Cucullæa gigantea, **L**, a, b
*148. Barbatia cuculloides, b
151. Glycimeris idonea, **L**, a, b
226. Pteria limula, **L**, a
*280. Ostrea vomer, **L**, a
281. O. sellæformis, **L**, a, b
*282. O. compressirostra, **L**, a, b
*283. O. trigonalis, **U**, b
376. Pecten choctavensis, **L**, a, b
377. P. greggi, **L**, b
378. P. johnsoni, b
379. P. wahtubbeanus, **M**, **U**, b
*380. P. perplanus, b
395. P. alabamensis, **L**, b
438. Modiola saffordi, **L**, b
439. M. alabamensis, **L**, a
465. Pholadomya marylandica, **L**, a
466. Phenacomya petrosa, **L**, a
500. Crassatellites alæformis, **L**, a
501. C. aquianus, **L**, a
502. C. gabbi, **L**, b
503. C. halei, **L**, b
*510. Sphærium formosum, **L**, c
511. Venericardia smithi, **L**, b
512. V. alticosta, **M**, **U**, b
513. V. planicosta, **L**, a, d
537. Lucina aquiana, **L**, a
538. L. smithi, a, b
*539. L. curta, **M**, **U**, a, b
540. Diplodonta hopkinsensis, **L**, a, b
552. Protocardia lenis, **L**, a, b
*563. Meretrix ripleyana, **L**, b
564. M. subimpressa, **L**, a, b
565. M. uvasana, **U**, d
566a. M. ovata var. pyga, **L**, a
566b. M. ovata var. ovata, **L**, a
570. Dosiniopsis lenticularis, **L**, a
573. Tellina virginiana, a
574. T. williamsi, a
599. Corbula subcompressa, **L**, b
600. C. aldrichi, a
601. C. oniscus, a, b
603. Panopea elongata, **L**, a

SCAPHOPODA.

8. Dentalium mediaviense, **L**, b
9. D. minutistriatum, **M**, a, b
10. D. thalloides, **M**, b
13. Cadulus turgidus, **L**, b
14. C. abruptus, **L**, a, b

GASTROPODA.

323. Gibbula glandula, **L**, a
342. Emarginula arata, **M**, b
356. Solarium alveatum, **M**, b

358. Capulus expansus, **L**, b
361. Crepidula lirata, **M**, b
368. Sigaretus bilix, b
*376. Natica shumardiana, **U**, d
377. N. marylandica, **L**, a
377a. N. eminula, **L**, **M**, b
378. N. semilunata, **L**, b
379. N. mediavia, **L**, b
380. N. mississippiensis, **M**, **U**, b
393. Amauropsis alveata, **U**, d
409. Viviparus raynoldsianus, **L**, c
410. V. trochiformis, **L**, c
411. V. formosus, **L**, c
426. Turritella mortoni, **L**, a, b
427. T. vetusta, **M**, b
428. T. humerosa, **L**, a, b
467. Goniobasis simpsoni, **M**, c
468. G. tenera, c
469. G. nodulifera, c
470. G. carteri, c
471. G. columinis, c
484. Cerithium conicum, **M**, b
485. C. fluviatile, **L**, b
496. Calyptraphorus velatus, **M**, **U**, b
496a. var. compressus, **L**, b
497. C. trinodiferus, **L**, a, b
498. C. jacksoni, **L**, a
506. Rimella laqueata, **M**, b
*511. Cypræa pinguis, b
513. Cassidaria brevidentata, **L**, b
514. Pyrula penita, **L**, **M**, a, b
522. Neptunea bella, **L**, b
529. Tudicla marylandica, **L**, a
*535. Perissolax brevirostris, **L**, d
546. Strepsidura subscalarina, **L**, a
547. Levifusus trabeatus, **L**, **M**, a, b
548. L. pagodiformis, **L**, b
553. Falsifusus meyeri, **L**, b
554. Fulgurofusus quercollis, **L**, b
555. F. rugatus, **L**, b
561. Exilia pergracilis, **L**, b
*562. Lathyrus floridanus, **U**, b
563. Streptolathyrus interstriatus, **L**, a, b
564. Pseudolathyrus tortilis, **L**, b
565. Lirofusus subtenuis, **L**, a, b
566. Fulguroficus argutus, **L**, a, b
567. Fusoficula juvenis, **L**, a, b
569. Clavilithes kennedyanus, **L**, **M**, b
570. Lacinia alveata, **M**, b
575. Mazzalina inaurata, **X**, b
593. Volutilithes petrosus, **L**, **M**, a, b
594. V. sayanus, **M**, b
595. V. rugatus, **L**, b
596. V. limopsis, **L**, **M**, b
603. Caricella pyruloides, **M**, b
607. Oliva alabamensis, **M**, b
609. Olivula staminea, **M**, b
610. Ancillopsis subglobosa, **M**, b
611. Cancellaria gracilioides, **L**, a, b,
620. Pleurotoma persa, **L**, b
621. P. ostrarupis, **L**, b
622. P. childrani, **L**, a, b
623. P. moorii, **L**, b
624. P. terebralis, **L**, b
635. Mangilia infans, **L**, **M**, b
639. Tornatellæa lata, **L**, a, b
640. T. bella, **L**, a, b
648. Ringicula dalli, **L**, a
655. Cylichna galba, **M**, b
673. P. bridgerensis, **M**, c
674. Physa pteromatis, **L**, c
679. Limnæa tenuicostata, **L**, c
687. Planorbis planoconvexus, **L**, c
688. P. utahensis, **M**, c
689. P. cirratus, **M**, c
696. Pupa arenula, **M**, c

Cephalopoda.

143. Hercoglossa tuomei, **L**, a
144. H. ulrichi, **L**, b
145. Aturia vanuxemi, **L**, a
410. Belosepia ungula, **M**, b

Ostracoda.

114. Bythocypris subæquata, **L**, a
119. Cytherella marlboroensis, **L**, a
125. Cythere marylandica, **L**, a
126. C. bassleri, **L**, a
133. Cytheridea perarcuata, **L**, a

Malacostraca.

36. Callianassa stimpsoni, d
37. C. ulrichi, **L**, b
39. Astacus primævus, **M**, c

Myriopoda.

Julus telluster, **M**, c

INSECTA.

Pronemobius tertiarius, **M**, c
Tyrbula multispinosa, **M**, c
Paralatindia saussurei, **M**, c
Brachytarsus pristinus, **M**, c
Dryocœtes carbonarius, **M**, c
Trypodendron impressum, **M**, c
Helops wetteravica, e
Cryptocephalus vetustus, **M**, c
Chrysomelites fabricii, e
Ægialia rupta, **M**, c
Corymbites velatus, **M**, c
Buprestites heeri, e
Antherophagus priscus, **M**, c
Lathrobium abscessum, **M**, c
Hydrochus relictus, **M**, c
Decatoma antiqua, **M**, c
Podagrion abortivum, **M**, c
Indusia calculosa, **M**, c
Milesia quadrata, **M**, c
Chiromus septus, **M**, c
Sciara scopuli, **M**, c
Diadocidia? terricola, **M**, c
Procydnus mamillanus, **M**, c
Oliarites terrentulus, **M**. c
Lithopsis fimbriata, **M**, c

ECHINOIDEA.

*27. Periarchus lyelli, **M**, b

OLIGOCENIC FAUNAS.

The following provinces are recognized:

(*a*) Gulf coast (including Florida and West Indies).
(*b*) Interior continental.
(*c*) Pacific (including Alaska).

FORAMINIFERA.

16. Orbitoides mantelli, **L**, a

ANTHOZOA.

*135. Flabellum cuneiforme, **L**, a
139. Oculina vicksburgensis, **L**, a
140. O. mississippiensis, **L**, a

PELECYPODA.

*148. Barbatia cuculloides, **L**, a
*282. Ostrea compressirostra, a
*283. O. trigonalis, **L**, a
*380. Pecten perplanus, **L**, a
*539. Lucina curta, **L**, a
*578. Semele carinata, **U**, a

SCAPHOPODA.

*15. Cadulus thallus, **U**, a

GASTROPODA.

*331. Adeorbis supranitidus, a
*359. Calyptræa centralis, **M**, a
*362. Crepidula plana, **M**, a
364. Crucibulum chipolanum, **M**, a
381. Natica floridana, a
*394. Rissoina lævigata, **M**, a
*395. R. decussata, **M**, a
*398. Xenophora conchyliophora, **M**, a
429. Turritella tampæ, **M**, a
430. T. gatunensis, a
*431. T. indenta, **M**, a
*437. T. subannulata, **M**, a
*440. Vermetus varians, a
477. Bittium permutabile, **M**, a
478. B. cossmanni, **M**, a
479. B. boiplex, **M**, a
*480. B. cerithidioides, a
*486. Cerithium adamsi, **M**, a
487. C. hillsboroënsis, **L**, a
*505. Orthaulax gabbi, **M**, a
507. Strombus aldrichi, **M**, a
508. S. chipolanus, **M**, a
*511. Cypræa pinguis, a
514. Pyrula mississippiensis, **L**, a
518. Buccinum mississippiense, **L**, a
551. Fusus henekeni, **M**, a
552. F. haitensis, **M**, a
*571. Turbinella wilsoni, **L**, a
*572. T. chipolana, **M**, a
*573. Vasum haitense, **M**, a
*580. Murex mississippiensis, a

581. Typhis curvirostratus, **L**, a
*583. T. obesus, **M**, a
*592. Mitra staminea, a
612. Cancellaria conradiana, **M**, a
*625. Pleurotoma albida, **M**, a
*630. Drillia ostrearum, **M**, a
*631. D. abundans, **L**, a
637. Conus planiceps, a
680. Limnæa meeki, b
681. L. shumardi, b
690. Planorbis vetustus, b
691. P. leidyi, b

Malacostraca.

38. Callianassa oregonensis, c

Arachnida.

Parattus evocatus, b
P. latitatus, b
P. resurrectus, b
Titanœca hesterna, b
T. ingenua, b
Linyphia retensa, b
Tethnæus hentzii, b
Epeira abscondita, b

Insecta.

Lepisma platymera, b
Tyrbula russelli, b
Nanthacia torpida, b
Agathemera reclusa, b
Labiduromma exsulatum, b
Palæothrips fossilis, b
Homœogamia ventriosa, b
Zetobora brunneri, b
Cremastorhynchus stabilis, b
Acalyptus obtusus, b
Cryptorhynchus profusum, b
Anthonomus reventus, b
Entimnus primordialis, b
Spermophagus vivificatus, b
Bruchus anilis, b
Oryctoscirtetes protogæum, b
Chrysomelites alaskanus, c
Parolamia ridus, b
Chauliognathus pristinus, b
Epiphanis deletus, b
Oxygonus mortuus, b
Prometopia depilis, c
Nomaretus serus, b
Myas rigefactus, b
Amara powelli, b
Bembidium exoletum, b
Atocus defessus, b
Protostephanus ashmeadi, b
Ichneumon petrinum, b
Aphænogaster longæva, c
Dolichoderus obliteratus, c
Formica arcana, c
Stenogomphus carletoni, b
Trichocnemis aliena, b
Ephemera howarthi, b
Inocellia veterana, b
Rhaphidia ? tranquilla, b
Osmylus requietus, b
Bothromicromus lachlani, c
Palæochrysa stricta, b
Setodes abbreviata, b
Hydropsyche marcens, b
Neuronia evanescens, b
Phryganea labefacta, b
Limnophilus soporatus, b
Jupiteria charon, b
Lithopsyche styx, b
Nymphalites obscurus, b
Prodryas persephone, b
Prolibythea vagabunda, b
Psecadia mortuella, b
Stolopsyche libytheoides, b
Barbarothea florissanti, b
Lithortalis picta, c
Sciomyza revelata, c
Heteromyza senilis, c
H. detecta, b
Palombolus florigerus, b
Mycetophætus intermedius, b
Pronophlebia rediviva, b
Mycetophila occultata, b
Sackenia arcuata, b
Gnoriste dentoni, b
Lasioptera recessa, b
Lithomyza condita, b
Sciara deperdita, c
Boletina sepulta, c
Trichonta dawsoni, c
Carmelus gravatus, b
Closterocoris elegans, b
Capsus obsolefactus, b
Eothes elegans, b

Stenovelia nigra, b
Lygæus obsolescens, b
Trapezonotus exterminatus, b
Linnæa evoluta, b
Lithocromus gardneri, b
Heeria gulosa, b
H. lapidosa, b
Eotingis antennata, b
Procydnus divexus, b
Corixa immersa, b
Planocephalus aselloides, b
Schizoneuroides scudderi, b
Florissantia elegans, b
Fulgora obticescens, b
Aphana atava, b
Delphax senilis, b
Cicada grandiosa, b
Petrolystra gigantea, b

ECHINOIDEA.

*26. Diplothecanthus reticulatus, a
*27. Periarchus lyelli, **L**, a
33. Mortonia quinquefaria, **L**, a
34. M. rogersi, **L**, a
51. Maretia ruspatangus, a

MIOCENIC FAUNAS.

The following provinces are recognized:

(*a*) Atlantic.
(*b*) Gulf coast.
(*c*) Interior continental.
(*d*) Pacific.
(*e*) Greenland.

FORAMINIFERA.

*2. Cristellaria cultrata, a
*6. Nodosaria communis, a, d
*9. Orbulina universa, d
*10. Globigerina bulloides, a, d
*11. Anomalina ammonoides, d
*12. Truncatulina lobatula, a, d

ANTHOZOA.

134. Septastræa marylandica, **M**, a
141. Astrohelia palmata, **M**, a

BRYOZOA.

169. Heteropora tortilis, a
174. Membranipora oblongula, a
176. Adeonellopsis umbilicata, a
177. Schizoporella informata, a

BRACHIOPODA.

*52. Discinisca lugubris, a

PELECYPODA.

*282. Ostrea compressirostra, **M**, a, b
*283. O. trigonalis, **M**, a
284. O. percrassa, **M**, a, b
381. Pecten madisonius, **M**, a
382. P. jeffersonius, **M**, a
383. P. magnolia, **L**, d
384. P. marylandicus, **M**, a
385. P. estrellanus, d
386. P. fucanus, d
*396. P. mortoni, **M**, a
434. Mytilus conradinus, **M**, a, b
*514. Chama congregata, **M**, a
*541. Diplodonta acclinis, **M**, a
554. Isocardia fraterna, **M**, a
558. Clementia inoceriformis, **M**, a
*559. Venus mercenaria, **M**, a
*575. Tellina declivis, **M**, a
*578. Semele carinata, **M**, a
579. S. subovata, **M**, a
580. Cumingia medialis, **M**, a
586. Mactra clathrodon, **M**, a
*602. Saxicava arctica, **M**, a

SCAPHOPODA.

11. Dentalium attenuatum, **M**, a
12. D. caduloide, **M**, a
15. Cadulus thallus, **M**, a

GASTROPODA.

324. Calliostoma philanthropus, **M**, a
325. C. eboreum, **M**, a
326. C. humile, **M**, a
329. Tinostoma nanum, **M**, a
*330. T. milium, **M**, a
*331. Adeorbis supranitidus, **M**, a
*332. A. concavus, **M**, a
343. Emarginula marylandica, **M**, a
344. Fissuridea griscombi, **M**, a
345. F. marylandica, **M**, a
346. Eulima eborea, **M**, a
347. Niso lineata, **M**, a
*348. Turbonilla nivea, **M**, a
*349. T. interrupta, **M**, a
350. Chrysallida melanoides, **M**, a
351. Odostomia conoidea, **M**, a
353. Scalaria sayana, **M**, a
354. S. pachypleura, **M**, a
357. Solarium trilineatum, **M**, a
*359. Calyptræa centralis, **M**, a
360. C. aperta, a
*362. Crepidula plana, a
*363. C. fornicata, a, b
365. Crucibulum costatum, a
366. C. pileolum, **M**, a
369. Sigaretus fragilis, a
*382. Natica heros, **M**, a
*383. N. duplicata, **M**, a
*398. Xenophora conchyliophora, **M**, a
*431. Turritella indenta, **M**, a
432. T. æquistriata, a
433. T. plebeia, **M**, a
434. T. variabilis, **M**, a
435. T. cumberlandia, **M**, a
436. T. exalta, **M**, a
441. Vermetus graniferus, **M**, a
442. V. virginicus, **M**, a
451. Melania sculptilis, c
452. M. taylori, c
*486. Cerithium adamsi, a
*505. Orthaulax gabbi, **L**, b
*509. Strombus pugilis, b
*511. Cypræa pinguis, a, b
512. Erato perexigua, a
515. Pyrula harrisi, **M**, a
517. Columbella communis, **M**, a
519. Buccinofusus parilis, **M**, a
520. Siphonalia devexa, **M**, a
521. S. migrans, **M**, a
523. Nassa trivittatoides, a
524. N. peralta, **M**, a
*526. N. bidentata, a
527. N. harpuloides, **M**, a
528. N. scalarispira, **M**, a
536. Fulgur fusiforme, a
537. F. tuberculatum, **M**, a
538. F. maximum, **M**, a
539. F. tritonis, **M**, a
*541. F. contrarium, a
542. Sycotypus rugosus, **M**, a
544. S. pyriformis, a
*545. S. excavatus, **U**, a
557. Heilprinia equalis, a
558. H. exilis, b
*562. Lathyrus floridanus, b
*571. Turbinella wilsoni, **L**, b
*572. T. chipolana, **L**, b
*573. Vasum haitense, **L**, b
577. Urosalpinx rustica, **M**, a
*578. U. cinerea, **M**, a
579. U. strumosa, a
*580. Murex mississippiensis, b
*581. M. rufus, a
583. Typhis acuticosta, **M**, a
*584. T. obesus, b
585. Trophon tetricus, **M**, a
586. Ecphora quadricostata, **M**, a
587. E. tampaënsis, **M**, a, b
*588. Marginella minuta, **M**, a
*589. M. virginiana, **M**, a
*590. M. limatula, a
*591. M. denticulata, **M**, a
*593. Mitra staminea, b
604. Aurinia mutabilis, **M**, a
605. A. typus, **M**, a
*606. Oliva litterata, a, b
*608. O. mutica, a, b
613. Cancellaria alternata, **M**, a
614. C. lunata, **M**, a
615. C. biplicifera, **M**, a
616. Terebra unilineata, **M**, a
617. T. curvilineata, **M**, a
618. T. curvilirata, **M**, a
619. T. simplex, **M**, a
*625. Pleurotoma albida, **M**, a
626. P. communis, **M**, a
627. P. marylandica, **M**, a
628. P. biscatenaria, **M**, a
629. P. engonata, **M**, a

632. Drillia incilifera, **M**, a
*633. D. ebenina, b
634. D. limatula, **M**, a
636. Mangilia parva, **M**, a
638. Conus diluvianus, **M**, a
642. Actæon shilohensis, a
643. A. ovoides, **M**, a
652. Volvula iota, **M**, a
656. Cylichna calvertensis, **M**, a
682. Vorticifex binneyi, c
683. V. tryoni, c
692. Planorbis lunatus, d
700. Helix leidyi, c

ANNELIDA.

11. Spirorbis calvertensis, **M**, a

OSTRACODA.

127. Cythere clarkana, **M**, a
128. C. exanthemata, **M**, a
129. C. evax, **M**, a
130. C. cornuta var. americana, **M**, a
131. C. alaris, **M**, a
132. C. vaughani, **M**, a
134. Cytheridea subovata, **M**, a
135. Cytheropteron nodosum, **M**, a

CIRRIPEDIA.

*11. Balanus concavus, **M**, a, b, d

MALACOSTRACA.

42. Loxorhynchus grande, **U**, d
43. Cancer fissus, **U**, d
47. Archæoplax signifera, a

INSECTA.

Cistelites minor, e
C. punctulatus, e
Tenebrio primigenius, d
Galerucella picea, d
Trox oustaleti, d
Buprestis, 3 species, d
Cercyon ? terrigena, d
Hydrophilites naujatensis, e
Nebria paleomelas, d
Carabites feildenianus, e

ECHINOIDEA.

28. Scutella alberti, **M**, a
29. S. fairbanksi, **L**, d
52. Echinocardium orthonotum, **M**, a

PLIOCENIC FAUNAS.

The following provinces are recognized:

(*a*) Atlantic.
(*b*) Gulf coast.
(*c*) Interior continental.
(*d*) Pacific.

BRACHIOPODA.

*52. Discinisca lugubris, a

PELECYPODA.

*283. Ostrea trigonalis, b
373. Pecten stearnsii, d
387. P. healeyi, d
*541. Diplodonta acclinis, a, b
549. Cardium meekianum, d
*559. Venus mercenaria, a
*575. Tellina declivis, b
*578. Semele carinata, a
*602. Saxicava arctica, b, d

GASTROPODA.

*330. Tinostoma milium, b
*331. Adeorbis supranitidus, **L**, a
*332. A. concavus, a, b
*348. Turbonilla nivea, a
*362. Crepidula plana, a
*363. C. fornicata, a, b
*367. Crucibulum auricula, a
*382. Lunatia heros, a
*383. Neverita duplicata, a
*394. Rissoina lævigata, **L**, b
*395. R. decussata, **L**, b
*398. Xenophora conchyliophora, a

*437. Turritella subannulata, **L**, a, b
438. T. perattenuata, **L**, b
439. T. apicalis, **L**, b
*440. Vermetus varians, **L**, a, b
*480. Bittium cerithidioides, **L**, b
*486. Cerithium adamsi, **L**, a, b
488. C. caloosaënsis, **L**, b
489. C. scalatus, **L**, b
*509. Strombus pugilis, b
*525. Nassa vibex, **L**, b
*526. N. bidentata, b
538a. Fulgur rapum var., **L**, b
539a. F. rapum, a, b
*540. F. caricum, a
*541. F. contrarium, **L**, b
*541a. F. obrapum, a
*541b. F. perversum, a
*543. Sycotypus canaliculatus, a
*545. S. excavatus, **L**, a
556. Heilprinia caloosaënsis, a, b
*559. H. (Barbarofusus) barbarensis, d
*560. H. (B.) robusta, d
574. Vasum horridum, **L**, b
*577. Urosalpinx cinerea, a
*581. Murex rufus, b
*584. Typhis obesus, b
*588. Marginella minuta, a
*589. M. virginiana, **L**, b
*590. M. limatula, a, b
*591. M. denticulata, **L**, b
592. Mitra holmesi, **L**, b
*603. Voluta musica, b
*606. Oliva litterata, **L**, a, b
*608. O. mutica, b
*630. Drillia ostrearum, **L**, b
*631. D. abundans, **L**, b
*633. D. ebenina, **L**, b
*666. Melampus olivaceus, d
675. Physa meigsii, **L**, b
693. Planorbis conanti, **L**, b
694. P. disstoni, **L**, b
701. Helix diespiter, b
702. H. crusta, b

CIRRIPEDIA.

*11. Balanus concavus, a, d

MALACOSTRACA.

40. Astacus subgrundialis, c

ECHINOIDEA.

30. Echinarachnius ashleyi, **L**, d
31. E. interlineatus, **U**, d
*32. E. excentricus, d
35. Mellita caroliniana, a
36. Encope macrophora, a

PLEISTOCENIC FAUNAS.

The Pleistocenic marine fauna is largely identical with the recent fauna, though often having a different distribution. Only a few species are here given. (See the paper by J. H. Wilson for the Atlantic, and Ralph Arnold for the Pacific coast. For the Fauna at Scarboro see Scudder, and for the Loess fauna Shimek.)

The following localities are referred to:

(*a*) Atlantic coast (Sankaty head, etc., and the clays of New England).
(*b*) Port Kennedy, Pa., cave fauna.
(*c*) Scarboro heights and vicinity of Toronto.
(*d*) Mississippi valley Loess.
(*e*) Pacific coast region.

PELECYPODA.

*559. Venus mercenaria, a
*602. Saxicava arctica, a

GASTROPODA.

*349. Turbonilla interrupta, a
*363. Crepidula fornicata, a

*382. Lunatia heros, a
*383. Neverita duplicata, a
*559. Barbarofusus barbarensis, e
*560. B. robusta, e
*577. Urosalpinx cinerea, a
703. Helix albolabris, d
704. H. alternata, d

Annelida.

2. Serpula dianthus, a

Cirripedia.

*11. Balanus concavus, a, e

Malacostraca.

44. Callinectes sapidus, a

Insecta.

Aphodius præcursor, b
Chœridium ? ebeninum, b
Phanæus antiquus, b
Hydrochus amictus, c
Cymbiodyta extincta, c
Bembidium fragmentum, c
B. glaciatum, c
Loricera ? lutosa, c
L. glacialis, c
L. exita, c
Loxandrus gelidus, c
Chlænius punctulatus, b
Cymindis aurora, b

Echinoidea.

*31. Echinarachnius excentricus, e

APPENDIX C.

GENERAL BIBLIOGRAPHY OF NORTH AMERICAN INVERTEBRATE INDEX FOSSILS AND FOSSIL FAUNAS (1832–1909).

The following lists[1] include most of the works describing North American invertebrate index fossils or noting their distribution. No pretensions however are made at completeness. They also include a few of the more important purely stratigraphic papers. The publications are arranged in order of age in the following divisions: PRE-CAMBRIC, CAMBRIC, ORDOVICIC, SILURIC, DEVONIC, MISSISSIPPIC, CARBONIC, PERMIC, PALÆOZOIC GENERAL (*i. e.,* papers dealing with two or more Palæozoic periods), TRIASSIC, JURASSIC, COMANCHIC, CRETACIC, MESOZOIC GENERAL (*i. e.,* papers dealing with two or more Mesozoic periods), TERTIARY, PLEISTOCENIC, ALL AGES (*i. e.,* papers dealing with periods in two or three eras). Under each period the publications are further subdivided for quicker reference into provinces, which for each division are usually the following—*Eastern Canada and Maine; Western Canada* (Great Lakes—Central British Columbia—Mackenzie), *Hudson Bay and Arctic region; Northern Appalachians and western New England; Southern Appalachians and Atlantic; Northern Mississippi Valley; Gulf region; Rocky Mountains and Great Basin; Pacific region* (California-Alaska); *Mexico and Central America; West Indies; North America General.* Hence, in looking up the publications of a single province or period, the more general list should likewise be consulted, as there are six possible lists for each province. The geographic division of this bibliography is necessarily more along political than natural lines, and hence the divisions given here do not, as a rule, correspond to those adopted in the tables of Appendix B. When the author's name appears in heavy type, the paper contains descriptions or figures of species or is otherwise considered of special importance. In some cases works dealing with special groups only and fully listed under that

[1] In their preparation free use has been made of the U. S. G. S. bibliographic bulletins, nos. 127, 188, 189, 301, 372, 409.

group (*i. e.,* insects, etc.), are not repeated in the present bibliography. The student should therefore consult both this general and the special lists under each class. It should be further noted, that in the older literature, the Ordovicic is called Lower Silurian, and the Comanchic Lower Cretaceous.

PRE-CAMBRIC.

1888 **Dawson, J. W.** Eozoon canadense. Can. Rec. Sci. 3 : 201–226.

1890 **Matthew, G. F.** Eozoon and other low organisms in Laurentian rocks at St. John. New Brunswick Nat. Hist. Soc. Bull. 9 : 36–41.

1890 —— On the occurrence of sponges in Laurentian rocks at St. John, New Brunswick. Ibid. 9 : 42–45.

1896 Dawson, J. W. Review of the evidence for the animal nature of Eozoon canadense. Can. Rec. Sci. 6 : 470–479.

1897 —— Note on Cryptozoon and other ancient fossils. Ibid. 7 : 203–219.

1899 **Walcott, C. D.** Pre-Cambrian fossiliferous formations. G. S. A. Bull. 10 : 199–244, plates.

1901 —— Sur les formations pre-Cambriennes fossiliferes. Int. Cong. Geol., Compte Rendu VIII., pp. 299–312.

1906 —— Algonkian formations in northwestern Montana. Fossils noted. G. S. A. Bull. 17 : 1–28.

1907 Matthew, G. F. Note on Archæozoon. New Brunswick Nat. Hist. Soc. Bull. 25 : 547–552, plate.

1909 Daly, R. A. First calcareous fossils and the evolution of the limestones. G. S. A. Bull. 20 : 153–170.

1909 Van Hise, C, R. Principles of classification and correlation of the pre-Cambrian rocks [Correlation paper 1]. Jour. Geol. 17 : 97–104.

1909 Adams, F. D. [Correlation paper 2.] Ibid. 17 : 105–123.

1909 Van Hise, C. R., and Leith, C. K. Pre-Cambrian geology of North America. U. S. G. S. Bull. 360.

CAMBRIC.

Eastern Canada.

1861 Hall, J. Letter on the primordial faunæ and Point Levis fossils. A. J. S. (2) 31 : 220–226 ; Can. Nat. 6 : 113–120 ; Rept. Geol. of Vermont 1 : 382–386.

1865 Hartt, C. F. Preliminary notice of primordial fauna in vicinity of St. John, N. B. Can. Nat., n. s. 2 : 318–320.

1874 **Billings, E.** Description of new species from the primordial rocks of Newfoundland. Can. Geol. Surv., Paleozoic fossils 2, pt. 2, plates.

1878 **Whiteaves, J. F.** On some primordial fossils from southeastern Newfoundland. A. J. S. (3) 16 : 224–226.

1882–1893 **Matthew, G. F.** Illustrations of the fauna of the St. John group. Trans. Roy. Soc. Canada, vol. 1, sect. 4, pp. 87–108, 271–280 ; vol. 2, sect. 4, pp. 99–124 ; vol. 3, sect. 4, pp. 29–84 ; vol. 5, sect. 4, pp. 115–166 ; vol. 8, sect. 4, pp. 123–166 ; vol. 9, sect. 4, pp. 33–65 ; vol. 10, sect. 4, pp. 85–109 ; vol. 11, sect. 4, pp. 85–129.

1885 Billings, E. Outline of recent discoveries in the St. John group. New Brunswick Nat. Hist. Soc. Bull. 4 : 97–102.

1886 —— Note on occurrence of Olenellus(?) kjerulfi in America. A. J. S. (3) 31 : 472–473.

1887 —— On the Cambrian faunas of Cape Breton and Newfoundland Can. Roy. Soc. Trans. 4, sect. 4, pp 147–157.

1888 —— On Psammichnites and the early trilobites of the Cambrian rocks in eastern Canada. Am. Geol. 2 : 1–9.

1889 —— On Cambrian organisms in Acadia. Can. Roy. Soc. Trans. 7, sect. 4, pp. 135–162.

1891 —— Notes on Cambrian faunas. Am. Geol. 8: 287–291.

1892 —— List of the fossils found in the Cambrian rocks in and near St. John. New Brunswick Nat. Hist. Soc. Bull. 10: 11–23.

1892 —— Protolenus, a new genus of Cambrian trilobites. Ibid. 10: 34–37.

1893 —— Notes on Cambrian faunas. Can. Rec. Sci. 5: 247–258.

1895 —— The Protolenus fauna [in New Brunswick and Newfoundland]. N. Y. Acad. Sci. Trans. 14: 101–153, plates.

1895 —— Two new Cambrian graptolites with notes on other species of Graptolitidæ of that age. [New Brunswick.] Ibid. 14: 262–273.

1895 —— Report on geology [Brachiopoda of the St. John group]. New Brunswick Nat. Hist. Soc. Bull. 13: 94–95.

1896 —— Notes on Cambrian faunas—the genus Microdiscus. Am. Geol. 18: 28–31.

1896 —— Faunas of the Paradoxides beds in eastern North America. N. Y. Acad. Sci. Trans. 15: 192–247, plates.

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1898 —— Recent discoveries in the St. John group. New Brunswick Nat. Hist. Soc. Bull. 16: 32–43.

1899 —— Studies of Cambrian faunas [New Brunswick]. Can. Roy. Soc. Proc. and Trans. (2), vol. 4, sect. 4, pp. 123–149, plates.

1899 —— Fragments of the Cambrian faunas of Newfoundland. Ibid. (2), vol. 5, sect. 4, pp. 67–95, plates.

1899 —— The Etcheminian fauna of Smith Sound, Newfoundland. Ibid. (2), vol. 5, sect. 4, pp. 97–119, plates.

1899 —— A new Canadian trilobite. New Brunswick Nat. Hist. Soc. Bull. 17: 137–142, plate.

1899 —— Preliminary notice of the Etcheminian fauna of Newfoundland. Ibid. 4: 189–196, plates.

1899 —— Preliminary notice of the Etcheminian fauna of Cape Breton. Ibid. 4: 198–208, plates.

1901 —— New species of Cambrian fossils from Cape Breton. Ibid. 4: 269–286, plate.

1901 —— Acrothyra, a new genus of Etcheminian brachiopods. Ibid. 4: 303–304, figs.

1901 —— Hyolithes gracilis and related forms from the lower Cambrian of the St. John group. Can. Roy. Soc. Proc. and Trans. (2), vol. 7, sect. 4, pp. 109–111, figs.

1901 —— Acrothyra and Hyolithes—a comparison. Ibid., vol. 7, sect. 4, pp. 93–107, figs.

1902 —— Oboloid shells of the Cambrian system in Canada and their relationship. Ibid., vol. 8, sect. 4, pp. 93–98, plate.

1902 —— Development in size of the inarticulate brachiopods of the basal Cambrian. Ibid., vol. 8, sect. 4, pp. 99–105.

1902 —— Did the upper Etcheminian fauna invade Canada from the southeast? Ibid., vol. 8, sect. 4, pp. 105–107.

1902 —— Additional notes on the Cambrian of Cape Breton, with descriptions of new species. New Brunswick Nat. Hist. Soc. Bull. 4: 377–426, plates.

1902 —— Ostracoda of the basal Cambrian rocks in Cape Breton. Can. Rec. Sci. 8: 437–466, plates.

1902 —— Cambrian rocks and fossils of Cape Breton. Can. Geol. Surv. Summ. Rept. for 1901, pp. 221–230.

1902 **Jones, T. R.** Notes on Dr. G. F. Matthew's Cambrian Ostracoda from northeastern America. Geol. Mag., new ser., dec. 4, vol. 9, pp. 401–403, figs.

1902 Ami, H. M. Preliminary lists of the organic remains occurring in the various geologic formations comprised in the map of the Ottawa district [Cambric, Ordovicic and Pleistocenic]. Can. Geol. Surv. Ann. Rept., new ser., 12: 49–77G.

1902 —— Lists of fossils obtained from the several formations along the Ottawa River (Grenville sheet) [Cambric and Ordovicic]. Ibid., 12: 139J–143J.

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1904 —— Note on the genus Hylopus of Dawson. Ibid. 5: 247–252, fig.

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1906 **Matthew, G. F.** Notes on Cambrian faunas—Ostracoda, Trilobita. New Bruns. Nat. Hist. Bull. 24: 406, 475–480 (Fossils from Cape Breton and Labrador).

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(Great Lakes—Central British Columbia—Mackenzie.)

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1888 **Walcott, C. D.** Cambrian fossils from Mount Stevens, northwest territory of Canada. A. J. S. (3), 36: 161–166.

1892 **Whiteaves, J. F.** Description of a new genus and species of Phyllocarid crustacea from the middle Cambrian of Mount Stephens, B. C. Can. Rec. Sci. 5: 207–208.

1899 **Matthew, G. F.** Upper Cambrian fauna of Mount Stephen, B. C. The trilobites and worms. Can. Roy. Soc. Proc. and Trans. (2), 5, sect. 4, pp. 39–66, plates.

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1903 —— Note on some fragmentary remains of fossils from the upper part of Mount Noyes (Canadian Rockies). Ibid., vol. 10, pp. 297–298, figs.

1908 **Walcott, C. D.** Mount Stephen rocks and fossils. Canadian Alpine Journ., vol. 1, no. 2, pp. 232–248, 8 plates.

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1903 Low, A. P. Report on an exploration of the east coast of Hudson Bay from Cape Wolstenholme to the southern end of James Bay. Can. Geol. Surv., Ann. Rept., n. s., 13, 84 pp., plates.

Eastern Massachusetts.

1889 Foerste, A. F. The paleontological horizon of the limestone at Nahant, Mass. Bost. Soc. Nat. Hist. Proc. 24: 261–263.

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1892 Woodworth, J. B. Note on the occurrence of erratic Cambrian fossils in the Neocene gravels of the island of Martha's Vineyard. Am. Geol. 9: 243–247.

1898 **Walcott, C. D.** Note on the [Cambrian] brachiopod fauna of the quartzitic pebbles of the Carboniferous conglomerates of the Narragansett Basin, R. I. A. J. S. (4), 6: 327–328.

1898 Grabau, A. W. Paleontology: eastern Mass. A. A. A. S. 50th Anniv. meeting.

1899 **Hobbs, W. E.** Some new fossils from eastern Mass. Am. Geol. 23: 109–115.

1900 **Burr, H. T.** A new Lower Cambrian Fauna from eastern Mass. Ibid. 25: 41–50.

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1907 **Shimer, H. W.** An almost complete specimen of Strenuella strenua [from Lower Cambrian of eastern Mass.]. A. J. S. (4), 23: 199–201, figs.

1907 —— A Lower-Middle Cambrian transition fauna from Braintree, Mass. A. J. S. (4), 24: 176–178, fig.

Northern Appalachians and Western New England.

1847 **Hall, J.** Paleontology of New York. I. [Cambric and Ordovicic]. Plates. N. Y. Geol. Surv.

1863, 1867 **Hall, J.** Preliminary notice of the fauna of the Potsdam sandstone . . . and some new species from the upper Mississippi Valley. 1863, N. Y. Mus. Nat. Hist. Rept. 16, Appendix D; 1867, Albany Inst. Trans. 5: 93–195.

1873 Ford, S. W. Remarks on the distribution of the fossils in the lower Potsdam rocks at Troy, N. Y. A. J. S. (3), 6: 134–140.

1879–1889 **Dwight, W. B.** Explorations in the Wappinger Valley limestone of Dutchess Co., etc., N. Y. A. J. S. (3), 17: 389–392; 19: 50–54; 21: 78–79; 27: 249–259; 31: 125–133; 34: 27–32; 38: 139–153.

1875 **Ford, S. W.** Note on the discovery of a new locality of primordial fossils in Rensselaer Co., N. Y. A. J. S. (3), 9: 204–206; 11: 369–371.

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1884 Walcott, C. D. Potsdam fauna at Saratoga, N. Y. Science 3: 136–137.

1885 —— New genus of Cambrian trilobites, Mesonacis. A. J. S. (3), 29: 328–330.

1886 **Whitfield, R. P.** Notice of some new species of primordial fossils [in N. Y. and Vermont]. Am. Mus. Nat. Hist. Bull. 1: 139–154, plates.

1887 **Walcott, C. D.** Fauna of the "upper Taconic" of Emmons, in Washington Co., N. Y. A. J. S. (3), 34: 187–199, plate.

1888 —— The Taconic system of Emmons and the use of the name Taconic in geologic nomenclature. Ibid. 35: 229–242; 307–327; 394–401 [Cambric and Ordovicic].

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1891 Wolff, J. E. On the Lower Cambrian age of the Stockbridge limestone. Ibid. 2: 331–338.

1892 Dale, T. N. On the structure and age of the Stockbridge limestone in the Vermont Valley. Abs. G. S. A. Bull. 3: 514–519.

1903 **Woodworth, J. B.** On the sedentary impression of the animal whose trail is known as Climachtichnites [eastern N. Y.]. N. Y. State Mus. Bull. 69: 959–966, plates.

1903 **Ruedemann, R.** The Cambric Dictyonema fauna in the slate belt of eastern New York. Ibid. 69: 934–958, plates.

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1892 —— Notes on the Cambrian rocks of Pennsylvania and Maryland from the Susquehanna to the Potomac. Ibid. 44: 469–482.

1894 —— Notes on the Cambrian rocks of Pennsylvania from the Susquehanna to the Delaware. Ibid. 47: 37–41.

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1896 —— The Cambrian rocks of Pennsylvania. U. S. G. S. Bull. 134, 43 pp., plates.

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1899 Diller, J. S. Origin of Paleotrochis [Taconic of N. C.]. A. J. S. (4), 7: 337–342, and G. S. A. Bull. 10: 228.

1900 **Weller S.** Descriptions of Cambrian trilobites from New Jersey, with notes on the age of the magnesian limestone series. N. J. Geol. Surv., Rept. for 1899, pp. 47–52, plate.

1900 **Walcott, C. D.** Lower Cambrian terrane in the Atlantic province. Wash. Acad. Sci. Proc. 1: 301–399, plates.

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1904 Keith, A. Greeneville; Tennessee–North Carolina, U. S. G. S. Folio 118.

1908 Stose, G. W. The Cambro-Ordovician limestones of the Appalachian Valley in southern Pennsylvania. [Cambric and Ordovicic fossils.] Jour. Geol. 16: 698–714.

Mississippi Valley.

1861 **Shumard, B. F.** The primordial zone [Cambrian] of Texas, with description of new fossils. A. J. S. (2), 32: 213–221.

1863, 1867 **Hall, J.** Preliminary notice of fauna of the Potsdam sandstone . . . and some new species from the upper Mississippi Valley. 1863, N. Y. Mus. Nat. Hist., Rept. 16, Appendix D; 1867, Albany Inst. Trans. 5: 93–195.

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1901 **Beecher, C. E.** Note on the Cambrian fossils of St. Francois Co., Missouri. A. J. S. (4), 12: 362–366.

Rocky Mountains and Great Basin.

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1897 —— Note on the genus Lingulepis [describes L. meeki, n. sp., from the middle Cambrian of the Yellowstone Nat. Park]. Ibid. (4), 3: 404–405.

1899 —— Cambrian fossils [Yellowstone Nat. Park]. U. S. G. S. Mon. 32, pt. 2, pp. 440–478, plates.

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1906 **Pack, F. J.** Cambrian fossils from the Pioche Mountains, Nevada. Jour. Geol. 14: 290–302, plates.

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North America, General.

1885–1886 **Walcott, C. D.** On the Cambrian faunas of North America. U. S. G. S. Bull. 10, 74 pp., plates; Bull. 30, 369 pp., plates.

1889 —— Stratigraphic position of the Olenellus fauna of North America and Europe. A. J. S. (3), 37: 374–392.

1889 —— Description of new genera and species of fossils from the middle Cambrian. U. S. Nat. Mus. Proc. 11: 441–446.

1890 —— Descriptive notes of new genera and species from the lower Cambrian of North America. Ibid. 13: 33–46.

1890 —— The fauna of the lower Cambrian or Olenellus zone. U. S. G. S. Ann. Rept. 10: 509–760, plates.

1891 —— Correlation papers—Cambrian of North America. U. S. G. S. Bull. 81, 447 pp.

1891 —— Description of new forms of upper Cambrian fossils. U. S. Nat. Mus. Proc. 13: 267–279, plates.

1892 **Vogdes, A. W.** On the North American species of the genus Agnostus. Am. Geol. 9: 377–396, plates.

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1859 **Salter, J. W.** Ordovician fossils from eastern Canada. Ibid., dec. 1, 47 pp., plates.

1860–1861 Logan, W. E. Remarks on the fauna of the Quebec group of rocks. Can. Nat. 5: 472–477; Can. Jour. 6: 40–46; A. J. S. (2), 31: 216–220.

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1888 —— On Utica fossils from Rideau, Ottawa, Ontario. Ottawa Nat. 1: 165–169.

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APPENDIX D.

HINTS FOR COLLECTING AND PREPARING FOSSIL INVERTEBRATES.

A. Outfit for Collecting.

The outfit needed for collecting invertebrate fossils need not be very elaborate. The following articles are recommended:

(*a*) *Collecting Bag*.—A leather or canvas collecting bag, with shoulder strap and flap and buckle. A convenient size is 13 x 13 inches. The larger canvas hunting bags with leather binding are very satisfactory. Discarded army knapsacks, obtainable at little cost, are very serviceable.

(*b*) *Hammers*.—Various hammers of moderate weight will be found useful according to the nature of the rock. A brick-layer's hammer with the peen edge at right angles to the handle is most useful in shales, being especially serviceable in prying up layers which are subsequently split. For splitting layers of shaly rock, a hammer with the peen edge parallel to the length of the handle is most serviceable. This is the most desirable when one is taking but one hammer into the field. A miner's pick is the least desirable hammer for palæontological work, except where the rock is strongly weathered. All hammers should have square faces, with the corners intact. It is a mistake to have the weight of the hammer exceed a pound or a pound and a half for most work. Of course a sledge hammer will be found useful for breaking large masses of sandstone or limestone. It is well to have the entire length of the hammer and handle just one foot; this will be useful in measuring thicknesses of beds rapidly.

(*c*) *Chisels, etc*.—Cold chisels of several sizes, some tempered for limestone cutting and some for sandstones are useful, and sometimes necessary. The larger ones are often useful as wedges for prying off fragments or layers; steel wedges are useful for this purpose. Short and well-tempered drills of different sizes will be found of use in removing specimens from hard rocks or splitting them. *Never use a hammer as a chisel,* for flying chips of steel are a source of grave danger.

(*d*) *Lens.*—A pocket lens of large field, preferably double or triple, is almost indispensable; the single lens should be of low power.

(*e*) *Note Book and Pencil.*—No field worker or scientific collector ever goes into the field without a note book. A hard cover is desirable, on the inside of one of which a paper protractor may be fixed for a clinometer, with a string and button for indicator. It will be found useful, if much ground is to be covered, to tie the note book to the belt or button-hole and the pencil to the note book, allowing in each case a sufficient length of loose string for ready use. Note books and pencils are easily lost and cannot be replaced in the field. Always have your name and address in the front of the book.

(*f*) *Colored Pencils.*—A set of colored pencils will be found most useful in making sections of the regions studied. It is best to carry these in a small canvas or leather pocket divided after the manner of a cartridge belt, each pencil being in a separate tight-fitting compartment. On the back of the pocket may be several loops for attaching it to the belt. The pencils then are always at hand, and the proper color is quickly selected.

(*g*) *Labels.*—A small pad (2 x 3 inches) of paper, preferably colored, for labels is necessary, and should never be omitted.

(*h*) *Wrapping Paper and Twine.*—Never go into the field without a sufficient supply of old newspapers. Manila wrapping paper for packages, or a supply of paper bags of various sizes obtainable at any grocery store, are necessary for proper packing of collections.

(*i*) *Boxes, Cotton Batting, etc.*—A number of assorted boxes, from pill boxes to cigar boxes are needed in collecting large quantities of delicate weathered-out material. Cotton batting is likewise indispensable for this purpose.

B. Field Work.

(*a*) *Collecting.*—The natural exposures of fossiliferous rocks on hill sides, in river gorges and ravines, and the artificial exposures in railroad cuts, quarries, etc., are the hunting grounds of palæontologists. Weathered surfaces where rocks are close to the surface also make excellent collecting grounds. Stone walls and fences may be a prolific source of weathered fossils. Very little can be accomplished by attacking vertical cliff faces either natural or artificial. It is better to attack the loose fragments quarried off or fallen through the process of weathering. In cliffs long exposed, the talus at the base is the best hunting ground, great care being necessary, that the fragments collected from are correlated with the beds in place. When no such fragments are available, quarrying will have to be resorted to. Weathered limestone surfaces are very satisfactory hunting grounds, but weathered sandstones are generally less satisfactory since the shells weather away and only external and internal molds remain. In such cases, if the cavities showing the former presence of the fossils are numerous, it is best to take large masses of the rock and ship them to the laboratory, where the further breaking up should be done. Never try to extract the fossil from the sandstone or limestone in the field. Take as much of the matrix as cannot be safely removed, leaving the further cleaning for the laboratory. Many a good specimen has been spoiled in the attempt to clean it in the field.

Shales should be broken or pried off from the river bank or cliff in large masses and then split. It is useless as a rule to attack a vertical shale bank and attempt to extract delicate fossils. The weathered talus at the base of all but actively undercut shale banks generally furnish a rich supply of the more delicate fossils of the shales. These should be placed between layers of cotton batting in small boxes, the size of the box selected depending upon the abundance of these specimens. Always have the box filled before it is packed away, and with a *label on the inside*. When filled add sufficient cotton batting or paper to prevent movement of the fossils when the box is shaken, tie down the cover and write the locality and bed on the *outside as well.*

The beginner should be cautioned to be on his guard against rockfalls as a result of prying off masses of rock near the base of the cliff. This is especially the case in much jointed cliffs, where the prying off of a mass near the base of the cliff may loosen the masses higher up.

Shales as a rule split better when wet; after drying they are more brittle and break cross-wise.

Concretions often yield good fossils, but are hard to break. Building a fire around a concretion or other resistant rock and heating it, often makes it quite brittle. Water may be poured over the mass, when highly heated, or the smaller nodules may, after heating, be dropped into water. Pyrite concretions from fossiliferous shales are best treated in the laboratory.

Unconsolidated clays and marls seldom yield their fossils unbroken. It is best to cut them out with enough clay adhering to keep the mass intact, leaving the final preparation for the laboratory. Stanton suggests covering the pieces before packing with a coat of common hot furniture glue to prevent cracking and crumbling in drying. Such marls should always be packed in small boxes. Sands and clays rich in small fossils are best shipped in bulk to the laboratory where the sorting is more practicable. Of course, if necessary, the laboratory method may be employed in the field so far as apparatus is available. Clays resulting from weathering of fossiliferous shales should be collected in bulk, as they contain many good small specimens.

In general the collector should bear in mind that good collections can be made only with care. On weathered surfaces it is well to get down on hands and knees and carefully pick over the ground, taking everything in sight. Do not stop to examine your material too closely, and do not throw away a specimen because you think it is a duplicate. Extensive collecting alone will save the rarer species, and a large series of even the common forms is desirable, for it shows the variation of the species. Discarding of specimens is best done in the laboratory, where they can be carefully studied. Hasty collecting, unless absolutely necessary, should be avoided—it takes time to get the material of a good collection together. Furthermore, it is a great mistake to pass by a good locality, or even a moderately good one, because it is inconveniently situated and in the hope of finding a more convenient one elsewhere. Such hope is often doomed to disappointment.

The collector should always take the greatest care to determine and record the exact position of his fossil in the section studied. The field notes should always be accompanied by a sketch (preferably in colors) of the section, the beds numbered or lettered, and the collections labeled accordingly.

(*b*) *Packing.*—All specimens should be wrapped in newspaper or tissue paper, care being taken that if more than one specimen is rolled into the same piece of paper, they do not touch each other. It is imperative that this rule should be followed, otherwise good specimens will be ruined. Avoid the common habit of putting unwrapped specimens in the pockets. If paper becomes scarce, grass or leaves or other substitutes may serve for temporary packing, but such specimens should be repacked before shipment. Broken specimens should have each fragment wrapped separately. As before noted, delicate specimens should be packed in small boxes between layers of cotton batting, the box being filled with the latter. All the specimens from one bed and locality may *after wrapping* be made into a package, wrapped in manila paper, or put into one of the paper bags. A single label with date, locality, bed, name of collector, and any other desirable information should be put inside of the package—being first folded once or twice, with the writing inside. If the labels are of colored paper, they will be easily detected on unpacking. Never write the locality, etc., on the margin of the wrapping paper. It is generally obliterated in transit or lost in unpacking.

Always tie the bundle or bag with twine, and write the essentials of the label on the outside, preferably with a blue pencil. This aids in sorting large collections afterwards and finding the material wanted first. Single specimens should of course have separate labels, wrapped with the specimen. When the packages are ready for shipping, pack them tightly into moderate sized, strong wooden boxes (soap boxes are best), or into barrels, placing the packages on their ends, not on the flat side. The box should be solidly packed, and all empty spaces filled in with paper, excelsior or other packing. Never pack so loosely that the packages can move in the box during shipment. It is well to number the boxes and keep a record of the contents of each. Never be content to write the locality only on the outside of the package or box, for this is subject to erasure during shipping.

C. Laboratory Work.

1. *Numbering and Labeling of Fossils.*

The first thing on unpacking fossils is the proper numbering or labeling of the specimens according to locality. A label to this effect may be put in every tray of specimens, or better, each specimen may be numbered by writing on it with india ink (color selected according to color of rock), or a small disc of white or colored paper may be glued to each specimen and the number written on this. These discs may be purchased of any size, or can be punched with a large punch from sheets of paper. The number should correspond to one opposite the entry of locality and bed in the " accession book." When extensive collections are brought in, especially from different localities, this labeling or numbering should never be omitted. It is never safe to trust the memory, or to trust to the keeping together of a large collection, where only one tray is labeled. A small rectangle may be painted on the specimen with white enamel paint, which dries rapidly, and upon the hard surface of which a number can easily be written with india ink and a fine pen.

2. *Cleaning Fossils.*

The removal of the matrix adhering to the fossil is a matter of importance, for often significant parts of a fossil may be hidden. Both mechanical and chemical methods are employed.

(*a*) *Mechanical Methods.*—A number of coarse wire chisels, well sharpened, a small hammer or mallet, and a sand-bag are the first requisites. The sand-bag is a stout canvas bag about 8 x 15 inches, filled about three fourths full of clean, moderately coarse, angular sand, after which the mouth of the bag is closed tightly, so that the sand cannot escape. This bag placed on the table, over the leg, or better on an upright log or block standing on the floor, serves as a support and buffer. The specimen may be placed upon it in any position without fear of injuring the under side, or breaking it. The matrix can then be chiseled away carefully, heed being taken that the matrix immediately adjoining the specimen does not carry off fragments of the fossil. It is well to frequently moisten the specimen with a wet sponge unless that should lead to separation of parts of the fossil. A number of engraver's tools will be found useful for scraping away small masses of matrix. A pointed steel pen in a holder, with one half side broken away makes a very good tool for fine work. In working on limestone with this tool, always keep the specimen wet, or even under water. In this case a white enameled dish should be used, and the specimen laid on a piece of rubber on the bottom. A pair of wire nippers, with the cutting edge at right angles to the longer axis of the tool will be found most serviceable. With a little dexterity gained through practice, specimens may often be cleaned by use of this tool alone.

Good stiff brushes—tooth brushes, nail brushes and wire brushes are very serviceable tools in cleaning fossils.

Various mechanical devices may be employed to advantage in some cases. Such is the dental engine in which brushes are fixed and rapidly revolved in contact with the dry matrix. When the fossil is harder than the matrix this works well. The sand blast has also been used for this purpose. Freeing specimens from the matrix by an artificial freezing mixture has also been employed. A porous matrix saturated with a hot solution of sulphate of magnesia, or other rapidly crystallizing salt will, on cooling, be loosened by this crystallization, and may be removed by brushing. Care should be taken that only the matrix is saturated and this can be accomplished by applying the hot solution with a brush.

Separation of fossils from a shale matrix is often accomplished by the use of caustic potash. Small discs cut from a stick of potash, are placed on the shale particles to be removed, and are left there over night. The action may be started by adding a drop of water. In the morning the shale will be found in a disintegrated state,—and may be washed away. It is however important that the specimen should be thoroughly washed in pure water to which a drop of hydrochloric acid may be added. Otherwise a white efflorescence will appear and the fossil may become disintegrated.[1] Pyrite nodules carrying fossils, may be broken by heating them and then plunging in cold water.[2]

[1] For an explanation of this process, see E. Böse and Victor V. Vigier, *Centralblatt für Mineralogie*, 1907, pp. 305–313.

[2] For the application of this process and the results, see F. B. Loomis, Bull. N. Y. State Museum, LXXIX., pp. 892–920, 1240–1248, 1903.

When fossils are broken, the pieces should first be thoroughly cleaned, and then cemented with liquid glue. To dry, place the specimen on a " sand bath " or box of fine sand so that the parts are supported in the position in which they are to be cemented. Supports of clay or plastolin may also be used. Fossil shells preserved in clay, often adhere to the matrix exposing only the inner surface. In such a case dental wax may be melted into the fossil, and this burned in thoroughly by the use of a blowpipe. After cooling, the shell, now filled with the hard wax, will readily separate from the clay or the clay may be dug and washed away. Excellent results have been obtained from this method by the Maryland survey in the study of the Tertiary fauna of the coastal plain.

Loose sands or weathered shales are best treated by the use of sieves of various sizes of mesh. The sieve with the largest mesh is placed at the top of the series and the finest at the bottom. The material may be sifted dry, but it is often better to play a stream of water on the topmost sieve on which the material is placed. The finest material which passes through the bottom sieve, and the water is caught in a dish placed below the sieves. The sieves are kept in constant motion as one mass (the sieves obtainable fit into one another sufficiently for rigidity) and as a result the material will be found sorted according to sizes. The fossils may then be picked out by means of a pair of pointed pincers or a moistened camel hair brush. The material caught in the dish below may be examined after gently pouring off the water. Clean water should be used, otherwise foreign particles may be included. Schuchert suggests that the mud to be washed for fine organisms should first be thoroughly dried in an oven or the sun, and then well soaked in water for a day or more before washing. He advocates sieves of 6, 18 and 38 meshes to the inch for the separation.

Fossils may be removed from shales by alternately soaking the mass in water and heating in an oven until it is entirely disintegrated. Running water applied to this material will wash away the mud, and the remaining material with its enclosed fossils may be subjected to boiling over a brisk fire " for about half an hour, the boiling being continued with occasional changes of water till little or no mud appears."

Washing the Clay for Microscopic Organisms.—The following method is recommended for obtaining microscopic organisms from the clays resulting from the disintegration of the shales:

"In preparing most of the samples of clay, we would put about one ounce of the material and the same amount of common washing soda into a druggist's two-quart, clear-glass packing bottle, not over one fourth filled with water, and let it remain twelve to twenty-four hours, frequently shaking the bottle, so as to thoroughly break up the clay. Now fill the bottle with water, and after twenty-five minutes carefully pour off the upper three fourths of it. Again fill with water, and in twenty five minutes decant as before; repeating this at twenty-five minute intervals until the upper three fourths of the water in the bottle, after a twenty-five minute rest, will be nearly clear. A large amount of the fine sand, clay, and soda has by this process been washed, and the action of the soda has broken up the clay and removed most of the adhering material from the fossils. Now mount a few microscopic slides from the residuary sands, etc., at the bottom of the bottle, by taking up with a pipette (a piece of small glass tubing makes the best pipette) a small amount of the material; scatter very thinly over the middle of the slides; dry them thoroughly over an alcohol lamp, or in some better way, and, while hot, cover the dry material with a few drops of Canada balsam, keeping the slides quite warm until the balsam will be hard when cold. As these "trial slides" are seldom of any value, it is not necessary to use cover glasses if the balsam is hardened as above directed. A careful examination of these slides under the microscope, with a good quarter- or half-inch objective, will decide as to the value of the material under observation; and if it proves to be only sand, pour it all out, wash the bottle, and again try the same process with another sample of clay. But if the slides show a few good fossils, the next step is to separate them as much as possible from the mass of sand, etc., with which they are associated. In this, as in the first washing, specific gravity will do most of the work. Pour off most of the water and put the shells, sand, etc., into a four-ounce beaker (or glass tumbler), wash out the bottle, fill the beaker about three fourths full of water, and, after it has rested ten minutes, pour three fourths off the top, through a glass funnel into the bottle, repeating this five or six times. As in the first washing, mount and examine a few slides from the material at the bottom of the bottle, mounting and preserving slides, if found to be of value. If nothing of value is found, pour out the contents of the bottle and fill up again as before from the beaker, after five minutes' rest, repeating these washings, and examinations at shorter resting intervals, of, say, three, two, and one minute, or less, until nothing but the coarsest sand remains in the beaker. . . . Each layer of clay, as deposited by its specific gravity, has now been examined, and most of the fossils are contained in some one, or possibly two, of them. Nineteen twentieths of the original sample of clay have been washed away and in the selected one twentieth that remains there may be one fair fossil to 100 grains of sand."[3]

In the above process, all glassware, etc., must be perfectly clean, and the water used must be first filtered, otherwise organisms foreign to the rock under investigation may appear. In the final disintegration of the shale for this purpose, it is well to boil it for a few minutes in a rather strong solution of washing soda.

(*b*) *Chemical Methods.*—Fossils in a calcareous matrix may be developed by dripping rain water or water charged with carbon dioxide. The matrix of lime-mud or lime-sand generally dissolves more readily than the organism. Boiling of the specimen in a strong solution of sugar has also been advocated (Bather). This attacks the amorphous limestone, but not the crystalline fossil. The specimen should be removed from time to time, washed, dried, and brushed. The fossil, if partly exposed, may be painted over with a protective solution such as an alcoholic solution of "Brillac," or of pure shellac, and the specimen then suspended in weak hydrochloric, or in acetic acid.[4]

"After a period varying from half an hour to twenty-four hours, according to the nature of the matrix, the specimen is taken out, washed in pure water, and allowed to dry. The softened matrix is then removed with a brush of bristle or horse-hair. Any freshly exposed portions of the fossil are then coated with the

[3] Woodward and Thomas, Geol. of Minnesota, Final Report, Vol. III., Pt. I., pp. 25 and 26.

[4] Bather recommends hypo-acetine, a preparation sold by Tyror & Co., Ltd., Sterling Chemical Works, Stratford, London, because it will partly dissolve and partly soften the matrix.

protective solution and the whole again suspended in the acid. The process is repeated indefinitely until the whole of the matrix is dissolved and brushed away and the complete fossil exposed. The protecting collodion may then be removed by acetine or ether-alcohol."[5]

Delicate pyritized fossils with hard shale or slate matrix adhering, may be cleaned according to Bather by the use of hydrofluoric acid. This will attack the slate but not the pyrites. The specimen may be exposed to the fumes or better since these are obnoxious, the specimen may be washed in either a strong or dilute solution, according to the character of the matrix. Any exposed portion may be covered with a protective solution[6] or with melted wax and the process repeated until the whole fossil is exposed. There is danger of carrying the process too far and loosening the entire specimen.

When the fossils are silicified and enclosed in a calcareous matrix they may be placed in hydrochloric acid of moderate strength and dissolved out. It should be noted, however, that the fossil may not always be entirely silicified. If the acid appears to attack the fossil, it should be washed, dried and the exposed part covered with a protective solution. It is well in that case to weaken the acid. Acetic acid or pure vinegar may be used for purposes of delicate etching.

3. *Preservation of Fossils.*

Many fossils are so soft and fragile that they must be hardened sometimes even before cleaning away the matrix. Bather recommends a thin alcoholic solution of "brillac" or white shellac. A good formula is 6 dessert-spoonsful of dry white shellac, dissolved in one quart of 95 per cent. alcohol. This has also been used to advantage in hardening tests of recent echinoids. In the case of fossils, the solution should be repeatedly applied, until the mass is sufficiently hardened. Carbon-tetrachloride[7] has also been recommended as a solvent for finely powdered shellac, copal or other hardening substance. Its non-inflammability especially recommends it. Silicate of potash or water glass has also been used as

[5] Bather, p. 83.
[6] Shellac dissolved in alcohol or other solvent, or hot beeswax.
[7] Carbona of the market will serve.

a hardening fluid. The commercial product requires thinning by water before it can be used. For the preservation of graptolites, delicate arthropods and similar fossils, Bather recommends "a thin solution of cellulose, apparently in amyl acetate" which is sold under the name of "Zapon" for the preservation of antiquities.[8] It "forms an almost imperceptible lacquer which prevents the action of the atmosphere. It has also the effect of intensifying the colors and outlines of dark fossils such as graptolites. The vapor is inflammable and if used in a closed room produces headaches."

Fossils which have been changed to pyrite or marcasite are very prone to disintegrate, especially the latter. These fossils may be kept in petroleum or benzine or in a solution of carbon tetrachloride. The stopper of the bottle should be glass.

For dry preservation the following method has been proposed: After careful cleaning, the fossil "should be placed for some hours in a hot solution of caustic alkali; this neutralizes all the free acid without attacking either the pyrites or any carbonate of lime that may be present. Should a white coating be produced, it may be removed by dilute hydrochloric acid, but after this the specimens should be very carefully washed with distilled water. They must then be dried, preferably by passing through alcohol or petrol, according to the treatment eventually selected.

"If passed through the alcohol, when all the water has been driven off, the fossil may be placed in a thin solution of shellac and left in it for some time, so as to allow the shellac to penetrate as far as possible. A stronger solution of shellac may be applied as a final coating. If passed through the petrol, the fossil may be placed directly in melted paraffin wax and left therein a sufficient time for the wax to be absorbed."[9] Bichromate of potash has been recommended according to L. Abbott in place of caustic alkali. Zapon has also been used by Bather as a protective varnish.

4. *Making of Artificial Casts from Natural Molds.*

In many cases the fossil has been removed in one way or another, and nothing but the mold remains. In such cases a cast made with gutta-percha will often give the surface features of the

[8] Supplied by the British Xylonite Co. as "F. 10432"—9s. 8d. per gallon.
[9] Bather, F. A., *loc. cit.*, pp. 88–89.

fossil with even greater detail than could be seen on the original specimen. A small piece of gutta-percha is to be softened in hot water and pressed into the moistened mold with the thumb, which must be wet, to prevent sticking. Considerable pressure is required, and the squeezed-out borders should be folded in again in order to insure a perfect cast. "Pink gutta-percha (superior quality) for base plates,"[10] gives the sharpest and best results. It is however difficult to manipulate on account of its rapid hardening. It comes in thin sheets of a pink color, but is rather expensive. Another very good dental wax is the "yellow wax" manufactured by the S. S. White Dental Manufacturing Co., 120 Boylston St., Boston, Mass. It is pure bees wax prepared in thin sheets and sells for 50 cents a half pound. It is softened by heating in hot water. "Modeling composition for dental purposes, No. 2, medium," is often more serviceable than gutta-percha, because it stays softer longer and is more easily manipulated; it is also cheaper. Its deep red color makes it rather objectionable for squeezes, and it does not take detail as readily as the gutta-percha. It is likewise made soft by heating in hot water. It is obtainable in half pound boxes from dental supply stores.

To obtain the best results with the fossils of impure argillaceous limestones, the following process, devised by J. M. Clarke, is recommended: "Let small fragments exposing fossils in section be placed in dilute muriatic acid, until the calcareous matter is removed to a sufficient depth from the surface to leave all impressions of fossils at the surface perfectly clear. The argillaceous or other impurity of the matrix left after the reaction will be exceedingly soft, but retain the impressions, whether external or internal, with exceeding delicacy of detail. The fragments may then be carefully removed from the acid and washed, by placing them for a moment in pure water. They should then be thoroughly dried, and afterwards hardened by cautiously soaking in a very weak solution of glue, care being taken that this solution be sufficiently thin to enter all the ornamental or structural cavities and interstices of the impressions. After again drying, soft, clean, and clear squeezes are to be taken with soft gutta-percha. To preserve the hardened matrix, such squeezes must be taken rapidly,

[10] Manufactured by Eugene Doherty, 110 and 112 Kent Ave., Brooklyn, N. Y.

lest the heat of the gutta-percha soften the glue and cause adhesion. If, however, the destruction of the matrix is not of moment, the gutta-percha may be withdrawn at will, and the adhering dirt soaked and washed off at leisure."[11]

Temporary casts or squeezes are quickly made in artist's modeling clay or "plastolin" obtainable at any artist's supply store. The squeezes obtained in this material are not so clean and sharp as in the best dental wax, and they are soft and easily destroyed. But the material needs no softening, is always ready for use, and can be used again an indefinite number of times. Besides it is cheap, and so saves cost of making squeezes from large molds. The mold should always be thoroughly moistened, otherwise the plastolin will adhere. Small holes or fissures are also apt to be filled by this material and should be stopped up first. Gutta-percha casts and casts in dental wax become brittle with age. Permanent casts are best made in plaster of paris.

5. *Preparation of Thin Sections.*

Thin sections are necessary in the study of certain fossils, such as the Bryozoa and the Stromatoporoidea. For purposes of developmental study sections are also important. A revolving plate is useful but not necessary, except for grinding down silicified specimens. These, however, seldom preserve the finer structure. Calcareous fossils may be rubbed down on a hone-stone, or on a glass plate with emery powder and water. The emery should be fine especially for the later rubbing. At first emery of grade 80 to 100 may be used, but when the section approaches the point desired, grade 120 to 150 should be substituted, all traces of the coarser grade being first washed off. The final rubbing should be done with pumice powder (obtainable at any druggist's), and water, on a separate glass plate; "jeweller's rouge" or the finest emery dust may likewise be used. Use sufficient water to prevent caking, but not too much. In all cases the specimen must be held very steady and pressed close to the plate, so that the surface produced is a perfectly flat one. Small specimens which cannot be held between the finger and thumb without touching the plate, should be cemented to a square of heavy glass. Specimens ground down

[11] Fourteenth Ann. Rept. N. Y. State Geol., 1894, p. 100, footnote.

on one side are also to be cemented to the glass for grinding the other side. The glass should be about an inch square and perhaps a quarter of an inch in thickness. For cementing the specimens the following mixture has been found most satisfactory: Slowly melt together in an evaporating dish or casserole 16 parts by weight of viscous Canada balsam and 50 parts of common (orange) shellac. Keep the mixture heated for some time, and allow to cool slowly. Before it is quite cool, draw the viscous mass out into strings, and roll between the hands into rods half an inch in diameter and of convenient length. This will keep indefinitely.

Before cementing the specimen to the glass slide heat it on an iron or brass stand over a bunsen burner or an alcohol lamp, in order to drive off all the moisture. Heat the glass plate at the same time, and melt a small amount of the cement by holding the stick upon the hot glass; or better melt a small piece of the cement in a separate dish, and spread a thin coat of the molten cement over the gently heated glass plate. Then lay the specimen with the polished side on the cement, and heat gently, taking care that no bubbles are forming. Allow to cool under pressure. When thoroughly cool and hard, grind down the other side, on a grindstone or emery wheel first, and later on a glass plate with fine emery and finally pumice powder. Care must be exercised that the section becomes of uniform thickness, and that the rubbing is stopped when the section shows signs of breaking.

When the section is complete, gently warm an ordinary object glass, preferably of the shorter type used by petrographers. This should first be thoroughly cleaned. Put a drop of Canada balsam on the warm glass and allow it to spread, but not to boil. At the same time heat the old glass until the cement is thoroughly softened, and the thin section floats in it; then slide, or transfer the section with a mounted needle, to the new slide put another drop of balsam on the section, heat gently and press a clean warm cover glass upon it. Allow to cool under slight pressure. When cool remove the superfluous balsam with a warm knife and alcohol, or with benzine. Label the slide at once.

In making sections of stromatoporoids, care must be taken that the longitudinal sections are parallel to the vertical or radial elements (see Vol. I, p. 35), and the transverse sections parallel as nearly as possible to the horizontal elements. Similar care must be exercised in making sections of Bryozoa. Here the longitudinal sections should expose the whole length of the zooids if possible. Frequent examination during the first grinding will therefore be necessary.

Sections of cup corals require the use of a saw. An ordinary band saw with steel holder will serve for calcareous specimens, when used with water, or water and emery. In this case a guide should be arranged so that the cutting produces a smooth surface. A rapidly revolving tin disc with water dripping over it and fine emery gives better result—while the best are obtained when the disk is trimmed with diamond bort. After the first sawing of the coral, the two surfaces resulting should be ground smooth and finished with pumice powder, and then cemented to a glass plate, before the second sawing. Do not saw the sections too thin—leave much to subsequent grinding. Often the polishing of the sawed surfaces is sufficient to show the internal structure.

The same method is employed in making sections of cephalopods. When it is necessary to get at the younger stages of ammonoids, the older whorls must generally be broken off; this should always be done under water.

6. *Coating of Fossils to Bring out Detail and for Photographing.*

Impressions of fossils often show the detail in much greater clearness if they are covered with a coating of impalpable white powder. Ammonium chloride powder has been found very satisfactory. Various kinds of apparatus have been used for this purpose.[12] A simple method devised by Mr. J. E. Hyde of the palæontological staff at Columbia University, is as follows: Two 8-ounce wide mouth wash bottles, each about half full, the one of ammonia, the other of hydrochloric acid are connected with a third, which is about half full of water, by bent glass tubes through rubber corks. These tubes extend to near the bottom of the acid and ammonia bottles, their ends being submerged in the liquid, but in the water bottle they end just below the cork. The mouth piece from the last wash bottle extends to near the bottom of the bottle, being submerged in the water. The water also serves to absorb the gases

[12] See Van Ingen, New York Academy of Science, Annals, Vol. 14, p. 115–116, 1902.

passing over from the ammonia and acid bottles. The outgoing tubes from the ammonia and acid bottles, begin at a distance above the level of the liquid, or just below the bottom of the cork. Their outer ends—preferably of two pieces each, joined by means of thin pieces of india rubber tubing—end in drawn-out points of small orifice. They should be so arranged that the orifices lie side by side. This may be effected by passing the last joint of each tube through two slightly converging holes in a cork. Long rubber tubings instead of the pointed glass tubes, are often more easily manipulated. Blowing into the mouth piece of the first wash bottle will force the vapors of ammonia and hydrochloric acid through their respective tubes, and as they issue from the contiguous orifices they will combine into a fine white powder of ammonium chloride which by proper adjustment may be made to coat the specimen uniformly. It is desirable that the vapors should be free from moisture. Therefore a U-tube filled with calcium hydroxide should be inserted in the outgoing tube of the acid and of the ammonia bottles. When not in use the apparatus should be disconnected and the acid and ammonia bottles corked.

Coating with ammonium chloride powder will be found very serviceable in photographing fossils, as it gives them a uniform tint and structures are not obscured by color.

The powder is easily brushed off and will not injure the most delicate specimens.

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APPENDIX E.

GLOSSARY AND GENERAL INDEX.

Abactinal—in echinoids referring to the dorsal (upper) side of the test.

Abdomen—in crustacea, the posterior of the two or three divisions of the body (see Fig. 1542) ; the pygidium.

Aberrant—differing from the type.

Abyssal—referring to the great depths of seas or lakes where light is absent. Those animals are abyssal which live at the bottom of abyssal bodies of water.

Acadian—term for the middle Cambric.

Acanthopore — in Paleozoic bryozoa, one of the small tubular spines often found at the junction of the zoëcia. Function probably similar to that of avicularia.

Acetabula — in Dibranchiate cephalopods, the suckers on the inner side of the arms.

Acme—the top or highest point.

Actinal—in echinoids referring to the under or mouth side of the test.

Actiniform—having a radiate form.

Adductor—one of the muscles in bivalve shells used in closing the shell. (In brachiopods, see I., 174, also Fig. 392*a*. In pelecypods, see I., 362, and Fig. 476.)

Adolescent—youthful (see also *ontogeny*).

Adventitious—additional.

Agglutinate—to unite firmly, as though with glue.

Agoniatite limestone—in Marcellus division of the middle Devonic of New York, etc.

Air-chambers—chambers below the living-chamber in the shells of cephalopods.

Akron dolomite—upper Siluric, western New York.

Ala (plural *alæ*)—a wing-like process.

Alar—pertaining to wings.

Alar septa—the lateral primary septa of the Tetracoralla (see I., 48, and Fig. 75).

Alate—having wing-like expansions.

Alimentary canal—the digestive tract or canal of an animal.

Alivincular—in pelecypods, referring to the ligament when consisting of a single elastic strand stretched from beak to beak, as in *Lima*.

Alleghany—middle Coal Measures of Pennsylvania, Ohio, etc.

Altamaha grit—middle Oligocenic of Georgia.

Alum Bluff—upper Oligocenic, Gulf coast.

Alveolus—a cavity. In Belemnoidea the alveolus or alveolar cavity at the broad or anterior end of the guard lodges the phragmocone.

Ambitus—the greatest circumference.

Ambulacral—pertaining to the ambulacra (see *ambulacrum*).

Ambulacral areas—perforated areas in the test of an echinoderm, through which distensible tube-feet or tentacles project (see Figs. 1921, 1928).

Ambulacral plates—the plates within the ambulacra.

Ambulacrum—in echinoderms, the area bounded on each side by one or more rows of holes (for tube-feet or tentacles), passing from the ocular plate to the edge of the mouth opening. There are five ambulacra in the test of an echinoderm.

Ambulatory—walking.

Ames limestone—Conemaugh formation, upper Coal Measures of Pennsylvania, Ohio, etc.

Amherstburg dolomite — upper Monroan of Michigan, Ohio, etc.

Ammoniticone—a closely-coiled Ammonoid shell (see II., 19).

Amphidetic—in pelecypods, referring to the ligament when extended on both sides of the beak, as in *Glycimeris*.

Anal—pertaining to the anus. For use in crinoids, see II., 491, and Fig. 1858.

Anal opening—see anus.

Anal tube—in Fistulate crinoids, the special tube for carrying off the waste (see Figs. 1865, 1871).

Anal vein—in insects one of the wing veins (see Fig. 1724).

Anaptychus—in many Ammonoid cephalopods the single calcareous operculum.

Anastomose—to intercommunicate by branching, usually producing a net-like appearance.

Anchylose—to unite solidly; to grow together into one.

Anderdon limestone—upper Monroan of Michigan, Ohio, etc.

Angulated—with angles or corners.

Anisic—middle Triassic.

Annular—ring-shaped.

Annulations—rings or ring-like segments.

Annulus—a ring; in trilobites, a segment of the thorax.

Anodont dentition—in pelecypods, with no teeth, as in *Anodonta*.

Antenna—a movable, jointed organ of sensation attached to the heads of insects and crustaceans (see Fig. 1692).

Antennules—in crustacea, the anterior of the two pairs of antennæ when two are present (see Fig. 1692).

Antepenult—the third from the last, the one before the penult.

Anterior—front. In brachiopods, the side opposite the beak. In pelecypods, the end opposite the pallial sinus. In gastropods, the end with the aperture.

Anticosti group—lower and middle(?) Siluric of Atlantic coast.

Antietam sandstone—lower Cambric, Pennsylvania-Maryland.

Antisiphonal lobe—in cephalopod shells the lobe on the dorsum, opposite the siphuncle.

Antrim shale—upper Devonic, Michigan.

Anus—the posterior opening of the alimentary canal, through which the waste matter is thrown out of the body.

Aperture—the opening of shells, cells, etc.

Apex—the tip or top of anything. In gastropod shells, the terminal or first formed portion.

Apical—pertaining to the apex or summit.

Apical angle—the angle included by the two sides of the spire of a shell.

Apical system—in echinoids, the set of ten plates at the summit of the test (see II., 574, Fig. 1935*a*).

Apison shale—lower Cambric, southern Appalachians.

Apophysis—a marked prominence in animals or plants due to natural growth; a calcareous process in the interior of shells, etc.

Appressed—pressed closely against.

Aptychus—in many Ammonoid cephalopods, the double calcareous operculum closing the opening of the shell when the soft parts of the animal are withdrawn.

Aquia—lower Eocenic of the Atlantic coast.

Aragonite—calcium carbonate ($CaCO_3$) crystallizing in the orthorhombic system. In shells it is chalky and opaque.

Arborescent—branching like a tree.

Arbuckle limestone—middle Cambric to lower Ordovicic, Oklahoma.

Arcuate—arched; bent like a bow.

Arenaceous—of the texture or character of sand.

Areole (*areola*) — in echinoids, the smooth sunken area surrounding the base of the tubercle (see II., 575, and Fig. 1918, *b, c*).

Argillaceous—of clay or slate.

Arikarie—lower Miocenic of Nebraska.

Aristotle's lantern — the complicated dental apparatus of echinoids.

Arkansan—lower Coal Measures of central United States.

Articulated — joined by interlocking processes or by teeth and sockets.

Ashley River marls—lower Miocenic of South Carolina.

Asperate—rough.

Astoria shales—Oligocenic of western Oregon.

Astrorhizæ—branching grooves, often present on the surface of hydrocorallines (see I., 35).

Atoka shales—subdivision of the Arkansan of Oklahoma.

Attenuate—to taper, to become thin or slender.

Aubrey group—Coal Measures of Grand Canyon.

Auricle—ear, or anterior projection of the hinge of many pelecypods.

Auriculate—having ears.

Austin chalk—lower Cretacic (Coloradoan) of Texas.

Avicularia—in many broyozoa, prehensile projections, shaped like a bird's head; incapable of preservation in the fossil state, but their former presence may usually be noted in the slight, pore-like hollows in which they were lodged.

Aviculoid—resembling *Avicula;* winged.

Axial—pertaining to the axis.

Axial canal—central canal of a crinoid stem.

Axial furrows—furrows or depressions bordering the axis in trilobites.

Axillaries—for use in crinoids, see II., 490.

Axis—the central longitudinal division of the body of a trilobite.

Azygous—unpaired. In crinoids, that side of the calyx which has plates differing from those of the regular sides. In cephalopods, referring to the unpaired lobes—the siphonal and antisiphonal.

Bactriticone — a straight Ammonoid shell (see II., 19).

Bajocian—division of middle Jurassic.

Bangor limestone—upper Mississippic, southern Appalachians.

Barker series—middle Cambric, Montana.

Basals—the lowest cycle of plates in crinoids with monocyclic base; in crinoids with dicyclic base, the row of plates next above the infrabasals (see Figs. 1876, 1907*B*). For use in echinoids, see *genital plates.*

Basipodite—see II., 388.

Batesville sandstone—see *Cypress sandstone.*

Bays sandstone — upper Ordovicic, southern Appalachians.

Beak—in bivalve shells, the projecting part of each valve near the hinge; it is where the growth of the valves began (see I., 172).

Bear River—non-marine Coloradoan.

Beaver limestone — lower Cambric, southern Appalachians.

Becraft limestone—division of the Helderbergian.

Bedford oolite—see *Salem limestone.*

Bedford shale—division of the Waverly.

Beekmantownian—a general term for the lower Ordovicic.

Beekmantown limestone—lower Ordovicic, eastern North America.

Belly River—non-marine Montanan of Canada.

Bend formation—lower Carbonic of Texas.

Benthonic—referring to the benthos.

Benthos—an organism which inhabits the bottom of the sea.

Benton—lower division of Colorado formation; Great Plains region.

Berea grit—division of the Waverly group.

Bertie waterline—upper Siluric of western New York.

Bethany Falls formation—upper Carbonic of Kansas.

Bethany limestone—base of the Missourian or upper Coal Measures of Iowa.

Bi—a prefix meaning twice or doubly.

Biconvex—with both valves convex, as in most brachiopods and pelecypods.

Bidentate—having two teeth.

Bifid—split into two.

Bifoliate—two-leaved. Those Bryozoa are said to be bifoliate in which there is a union of the basal epithecæ of two parts of a colony, producing a mesotheca.

Bifurcating—dividing into two, forking.

Bighorn limestone—middle-upper Ordovicic, Montana.

Bilateral—pertaining to the two sides of a body.

Bingham quartzite—upper Carbonic of Utah.

Biramous—with two branches.

Biserial—with double series or rows; for use in crinoids, see II., 490, and Fig. 1806.

Biserial pores—in echinoids, see *pores*.

Bivium—see *trivium*.

Black Hand formation—division of the Waverly group of Ohio.

Black River limestone—middle Ordovicic, New York, etc.

Blanco—middle(?) Pliocenic of Texas.

Bliss sandstone—Cambric, Rio Grande.

Body chamber—the latest formed chamber of a cephalopod shell, enclosing the soft parts of the animal (see Fig. 1230, and II., 20).

Bonnterre limestone—middle Cambric, Ozark region.

Boone chert—lower Mississippic of Arkansas.

Boss—in echinoids, the base of a tubercle.

Boston group—upper Mississippic of Arkansas.

Bosworth formation—upper Cambric, Canadian Rockies.

Bourrelet—in some echinoids the inflated interambulacral plates dividing the floscelle (see Fig. 1930, *a*, *e*).

Bowden beds—Oligocenic of Jamaica.

Bow River group—lower Cambric of Canadian Rockies.

Brachia—plural of *brachium*, an arm. In brachiopods, those portions of the lophophore which diverge arm-like from the two sides of the mouth.

Brachial—pertaining to the brachia or the arms of vertebrates, brachiopods and crinoids; one of the arm plates of crinoids, usually distinguished as costals, distichals, palmars, etc.

Brachial valve—in brachiopods, the valve to which the brachia were attached. This is the dorsal valve and usually the smaller (see I., 170).

Brachidia—plural of *brachidium*. In brachiopods, the calcareous ribbons or internal skeleton for the support of the fleshy brachia (see I., 173, Fig. 220).

Brahmanic—lower division of Triassic.

Braintree beds—middle Cambric, eastern Massachusetts.

Branchiæ—gills.

Branchial—pertaining to the gills.

Branchlet—a little branch or twig.

Bretonian—a term for the upper Cambric (Grabau), as used by Matthew includes some Ordovicic.

Bridger beds—middle Eocenic of Wyoming.

Bryozoüm—the entire compound colony of bryozoa.

Buda limestone—upper Comanchic of Texas.

Burlingame limestone—upper Carbonic of Kansas.

Burlington limestone—lowest division

of Osage group, lower Mississippic of Mississippi Valley.

Burrow—a hole in the ground, rock or wood, etc., made by certain animals for shelter (see Fig. 1539).

Byssal—pertaining to the byssus.

Byssal notch—in pelecypods, the notch or opening for the emission of the byssus.

Byssus—tough threads formed by the foot of certain pelecypods by which they attach themselves to rocks or other support.

Calcarenite—a limestone composed of small, sand-like calcareous fragments.

Calcareous—formed of or containing lime.

Calciferous formation—old name for Chazy limestone.

Calcilutite—a very fine-grained limestone formed of a lime-mud.

Calcirudite—a limestone breccia or conglomerate composed of calcareous fragments.

Calcite—calcium carbonate ($CaCO_3$), crystallizing in the hexagonal system. In shells it is translucent.

Calices—plural of *calyx*.

Calicinal—pertaining to the calyx or cup.

Calicle—a small, cup-like cavity.

Calicular—resembling a cup.

Callosity—a hardened spot or area.

Callovian—division of the middle Jurassic.

Callus—in gastropods, the thickened part of the inner lip, which usually covers portions of the preceding volutions, thus more or less completely concealing the umbilicus.

Caloosahatchie — lower Pliocenic of Florida.

Calvert formation—middle Miocenic of Maryland.

Calyx—a cup. In corals, the cup limited below by the upper edges of the septa. In crinoids, cystoids and blastoids, the body exclusive of the arms and stem.

Cambric—the lowest of the Paleozoic systems.

Cambridge limestone—Conemaugh formation, upper Carbonic.

Cameræ—air-chambers of a cephalopod shell, separated from one another by septa.

Camerate—chambered.

Camillus shale—subdivision of the Salina of New York.

Canal—in some gastropods, the anterior edge of the aperture is drawn out into a canal, the *anterior canal,* as in *Fusus;* in some there is likewise present an *anal canal* at the posterior margin of the aperture, as in *Aporrhais.*

Axial canal—the tubular passage through the center of the stem of crinoids (see II., 488).

Canaliculate — channeled; having a canal.

Cancellated—marked by lines crossing one another forming a lattice-like pattern.

Caney shale—upper Mississippic of Oklahoma, etc.

Canyon—upper Carbonic of Texas.

Capitan limestone—upper Permic of Oklahoma, etc.

Carapace—the hard shell or shield covering the back of crustacea, etc. In trilobites its three transverse divisions are named cephalon, thorax and pygidium (see Fig. 1542).

Cardiac—pertaining to the heart or to the region of the heart.

Cardiff shale—middle Devonic, New York.

Cardinal—pertaining to the hinge.

Cardinal angle—in bivalve shells, the angle formed at each of the extremities of the hinge between the hinge and the forward extension of the shell.

Cardinal area—in many brachiopods, the flattened area on each valve between the beak and the hinge line, and extending to the cardinal angles (see Fig. 218).

Cardinal process—in brachiopods, the process extending from under the beak of the brachial valve to which the diductor (opening) muscles are attached (see Fig. 261).

Cardinal quadrants—two quadrants of a Tetracorallum which bound the main or cardinal septum.

Cardinal septum—the first or main of the four primary septa of a Tetracorallum; the cardinal septum has the pinnate arrangement of the secondary septa on both sides (see Fig. 75).

Cardinal teeth—in pelecypods, the teeth directly beneath the beak; lateral teeth may be present anterior or posterior to these.

Carina—a raised ridge or keel. In some fenestelloid and other Bryozoa, a projecting ridge running down the center of the branches. In *Heliophyllum* and some other corals, one of the vertical strengthening plates extending a short distance from the septa; these appear in cross-section as straightened septal spines (see Figs. 102, 105). In *Balanus*, that one of the two unpaired plates of the fixed tubular portion of the shell which adjoins the terga; the other unpaired plate is the rostrum and the paired plates the lateralia.

Carinated—having a ridge or keel; in corals referring to the presence of carinæ.

Carlisle—division of the Benton group, lower Cretacic of Great Plains region.

Carpopodite—see II., 388.

Cartilage—compressible, elastic substance between the hinge margins of the valves of pelecypods. The cartilage (resilium) is the internal as the ligament is the external medium for opening the valves.

Cashaqua shale—upper Devonic of New York.

Cassin limestone—lower Ordovicic of Champlain Valley.

Cassville plant shale—basal bed of Dunkard series—Permic.

Cast—the impression taken from a mold (see I., 3).

Castle Mountain group—lower Cambric to lower Ordovicic, Canadian Rockies.

Cathedral formation—middle Cambric, Canadian Rockies.

Catskill beds—upper Devonic, New York and Pennsylvania.

Cattaraugus group—Devono-Mississippic of southwestern New York and Pennsylvania.

Caudagalli grits—see *Esopus shale*.

Caudal—pertaining to the tail.

Caudal fin—see II., 388.

Cedar Valley limestones—middle Devonic, Iowa.

Cells—for arrangement and naming of these in insects' wings, see II., 423, and Fig. 1725.

Celluliferous—cell- or cup-bearing. In Bryozoa, referring to the zoœcia; Bryozoa commonly have a celluliferous and a non-celluliferous side.

Centren—see Fig. 1231.

Centrodorsal plate—in crinoids, see Fig. 1907.

Centrodorsan—see Fig. 1231.

Centroventran—see Fig. 1231.

Cephalic—referring to the cephalon or head.

Cephalic border—the anterior border of the cephalon of a trilobite.

Cephalic limb—in trilobites, the lateral area of the cephalon on either side of the glabella; this includes the free and the fixed cheeks (see Fig. 1586).

Cephalon—the head. The anterior of the three divisions of the dorsal test of trilobites.

Cephalothorax—the combined head and thorax of Crustacea (see Figs. 1692, 1694).

Ceratite limestone—middle Triassic of California.

Cercopods—lateral tail spines, present in some of the Phyllocarida, as in *Ceratiocaris* (Fig. 1676).

Cespitose—matted, tangled or growing in low tufts.

Cnagrin formation—upper Devonic of Ohio.

Chamber—an enclosed space or cell. In cephalopods, the space between two septa.

Chambersburg limestone—middle Ordovicic of Pennsylvania.

Charlestown sandstone—middle Carbonic of Appalachians.

Chase formation—Permic of Kansas.

Chattahoochee formation—middle Oligocenic of the Gulf coast.

Chattanooga black shale—lower Mississippic of the Appalachians.

Chautauquan series—part of upper Devonic of eastern U. S.

Chazyan—general term for middle Ordovicic.

Chazy limestone—middle Ordovicic of eastern North America.

Cheeks—in trilobites, lateral portions of the cephalon, divided into fixed and free cheeks (cf. *fixed, free*).

Chela (plural *chelæ*)—pincer-like claw terminating some of the legs of crustaceans (see Figs. 1692, 1694).

Chelate—bearing chelæ.

Chelopod—see II., 388.

Chemung—upper Devonic of North America.

Cherokee shale—base of Coal Measures of Kansas.

Chert—a compact siliceous rock of organic or chemically precipitated origin, *e. g.*, flint.

Chesapeake group—middle Miocenic of Atlantic coast.

Chester group—upper Mississippic of central U. S.

Chickamauga limestone—middle Ordovicic of southern Appalachians.

Chickasawan formation—lower Eocenic of Gulf coast.

Chickies quartzite—lower Cambric of Pennsylvania.

Chico series—Cretacic (chiefly Coloradoan) of Pacific coast.

Chilhowee series—lower Cambric of southern Appalachians.

Chilidium—a convex plate covering the chilyrium; probably secreted by the posterior edge of the dorsal mantle lobe.

Chilyrium—a triangular opening under the beak of the brachial valve in those brachiopods in which that valve is furnished with a high hinge area, as in the Protremata (*e. g., Syntrophia*).

Chipola marls—middle Oligocenic of Gulf states.

Chiques quartzite—see *Chickies*.

Chitin—a horn-like substance, found in the hard parts of all the articulated animals, such as beetles and crustaceans, and when pure consisting of $C_{15}H_{26}N_2O_{10}$.

Chitinous—composed of chitin.

Chondrophore—see *resilifer*.

Chonopectus sandstone—division of Kinderhook of upper Mississippi Valley.

Choptank formation—middle Miocenic of eastern U. S. (division of Chesapeakean).

Chouteauan—general name for the Kinderhook division of the lower Mississippic.

Chouteau limestone—upper division of the Kinderhook of Mississippi Valley.

Cicatrix—a scar.

Cimarron formation—upper Permic of Kansas.

Cincinnati group (*Cincinnatian*)—general term for the upper part of the upper Ordovicic.

Cirri—lateral appendages to the stem of crinoids.

Cisco formation—upper Carbonic of Texas.

Claggett formation—middle Cretacic of Canada.

Claiborne—middle Eocenic of the Gulf region.

Clastic—consisting of fragments, *e. g.*, rocks composed of fragments of older rocks.

Clavate—club-shaped.

Clavicle—in some pelecypods, a heavy internal ridge running downward from the beak; its posterior end supports the resilium.

Claytonian — lower Eocenic of Gulf coast (Midwayan).

Clear Creek limestones—Helderbergian and Oriskanian of Illinois, etc.

Cleveland shale — upper Devonic of Ohio.

Cliffwood formation—basal marine Cretacic of New Jersey.

Clinton group—lower Niagaran of eastern North America.

Clypeus—see II., 419.

Cobleskill limestone—upper Siluric of eastern North America.

Cochran formation—lower Cambric of southern Appalachians.

Cœlome—the general body cavity of an animal as distinguished from all special cavities, as the intestinal cavity, etc.

Cœnenchyma—in composite corals, the calcareous tissue connecting the different individuals, as in *Oculina*.

Cœnosteum—the coral-like calcareous structure of some of the hydrocorallines, as *Millepora*.

Coeymans limestone—division of Helderbergian, lowest Devonic of North America.

Coldbrookian—the basal lower Cambric of the Atlantic coast.

Coldwater shale—lower Mississippic of Michigan — equivalent to Cuyahoga shale of Ohio.

Colorado formation—lower Cretacic of the interior of North America.

Columbites beds — lower Triassic of Idaho.

Columbus limestone—middle Devonic of Ohio.

Columella—a small column. In corals, a small rod at the center of the cup (see Fig. 119, upper); in gastropods, the axis of union of the successive coils (see Fig. 856, *d*).

Columellar—referring to the columella.

Columellar lip—in gastropods, the inner lip.

Columellar folds or *columellar plicæ* —ridges or plications upon the inner lip of some gastropod shells (see Fig. 1153).

Columnar—formed in columns.

Comanche Peak limestone—a division of the Fredericksburg or middle Comanchic.

Commensalism—the state of living with another organism, either as a tenant or as a co-inhabitant, but not as a parasite (see I., 36).

Como beds—upper Jurassic of Wyoming.

Compound eye—in many arthropods, such as the common house fly, the cray fish and the trilobite *Phacops* (Fig. 1636, *b*), very many single eyes each complete in itself are crowded together into two aggregations, the compound eyes.

Concavo-convex—with one side concave and the other convex. Shells of brachiopods are normally concavo-convex, with the brachial valve concave and the pedicle valve convex; shells are reversed or resupinate when the opposite condition is true.

Conchiolin—the organic part of the substance of a shell left after the removal of the lime carbonate by acids.

Conemaugh formation—a division of the upper Carbonic of eastern North America.

Confluent—blended so that the line of separation is not visible.

Coniform—cone-shaped.

Connoquenessing sandstone — upper Kanawha of Ohio and western Pennsylvania.

Conococheague limestone—upper Cambric of Pennsylvania-Maryland.

Conoidal—nearly but not quite conical.

Conotheca—in Belemnoidea, see II., 24.

Convolute—Said of the spires of those gastropods and cephalopods in which the later whorls entirely conceal the earlier whorls (see Fig. 1105).

Coprolite—the fossil excrement of animals.

Corallian—division of upper Jurassic (Sequanian).

Corallite—an individual from a compound corallum.

Corallum—the hard structure secreted by the coral polyp.

Compound corallum—made up of corallites, either separate or closely joined by their walls (as in *Favosites*).

Composite corallum—compound corallum with cœnenchyma or extrathecal calcareous tissue connecting the corallites as in *Galaxia* and many other recent forms.

Corneous—horny.

Corona—crown. In echinoids, all of the test except the plates at or near the center of the dorsal surface (see II., 572).

Coronal—crown-like.

Coronate—somewhat crown-shaped; applied to those gastropods which bear a crown-like row of spines upon the upper angle of their whorls.

Costa (plural *costæ*)—rib or ridge. In corals, extrathecal extension of a septum (see I., 47). In insects, one of the wing veins (see Fig. 1724).

Costals—in crinoids, the first brachial or arm plates, lying between the radials and the first bifurcation of the arms (see Figs. 1804, 1907).

Axillary costals—in crinoids, see Fig. 1907, C_2.

Cotype—see *type*.

Council Grove formation—lower Permic of Kansas.

Counter—opposite.

Counter quadrant—the quadrant bounding the counter septum of a tetracorallum.

Counter septum—the front, primary septum of a tetracorallum, opposite the cardinal septum; the secondary septa are parallel with it (see Fig. 75).

Coxa—in insects, the basal segment of the leg (see II., 420).

Coxopodite—see II., 388.

Cranidium—in trilobites, all of the cephalon except the free cheeks (see Fig. 1559, *a*).

Crenulate—with margin cut into rounded notches.

Crescentic—shaped like a new moon.

Crest—for use in ammonoids, see II., 23.

Crinoidal limestone—see *Ames limestone*.

Croatan beds—middle Pliocenic of North Carolina.

Cross-veins—for arrangement in insects' wings and their nomenclature, see II., 422, 423.

Crown—all of a crinoid except the stem.

Cruciform—cross-shaped.

Crura—in brachiopods, the two short curved processes attached to the hinge plate of the brachial valve. To these are united the brachidia when these are present (in Figs. 220_4 and 383, the crura extend from the hinge plate to the sharp, inward tooth-like projection).

Cruralium—the name applied to the two crura when united.

Ctenidia—the plume-like gills of mollusks.

Cubitus—in insects, one of the wing veins (see Fig. 1724).

Cumberland limestone—lower Cambric to lower Ordovicic of Pennsylvania.

Cuneate—wedge-shaped.

Cuneiform—wedge-shaped.

Cuyahoga limestone—division of Waverly group.

Cyathophylloid—in form like *Cyathophyllum*, one of the Tetracoralla.

Cyclodont dentition—in pelecypods, see I., 361.

Cypress sandstone—upper Mississippic and Mississippi Valley.

Cyrtoceracones—Nautiloid cephalopod shells which are merely bent without making a complete revolution.

Cyst—a closed sac or bladder.

Cystiphragm—a strongly curved plate extending only partly across a zoëcium. These are usually confined to the margins, with diaphragms in the center of the zoëcial tube (see Fig. 186, *c'*, *d*).

Cystose—containing or resembling a cyst or bladder.

Dactylopodite—see II., 388.

Dakota sandstone—basal Cretacic sandstone of central North America.

Daonella beds—middle Jurassic of Nevada.

Dayton limestone—Niagaran of southern Ohio.

Deadwood formation—upper Cambric of Black Hills, etc.

Decewville beds—upper Oriskany of western Ontario.

Decker Ferry formation—upper Siluric of New Jersey, Pennsylvania, etc.

Deepkill shale—lower Ordovicic of Hudson Valley.

Deep River formation—middle Miocenic of Montana.

Delaware limestone—Niagaran of Iowa, also middle Devonic of Ohio.

Del Rio formation—upper Comanchic (Washitan) of Texas.

Delthyrium—in brachiopods, the triangular opening under the beak of the pedicle valve, through which in some species the anchoring fleshy pedicle passes (see Fig. 218).

Deltidial plates—in the higher brachiopods (Telotremata), the two plates which grow inward from the sides of the delthyrium and at times completely close the opening. They are secreted by a dorsal extension of the ventral mantle lobe and are never present in the earliest growth stages of the shell (see Fig. 219.)

Deltidium—a single triangular plate present in some brachiopods (Protremata and some Neotremata), covering the delthyrium. This is secreted by the dorsal surface of the pedicle and since its growth is in an anterior direction the growth lines are horizontal. It begins to be formed as the prodeltidium, while the animal is still in its embryonic, free-swimming condition.

Deltoid—shaped like the Greek letter delta Δ; wedge-shaped. In crinoids, the interradial plates.

Dendroid—branching after the manner of a tree.

Dental—pertaining to teeth.

Dental lamellæ—same as dental plates.

Dental plates—in brachiopods, internal plates below the teeth in the pedicle valve (see I., 173).

Dental sockets—in brachiopods, the pair of shallow depressions bounding the beak of the brachial valve internally for the reception of the teeth of the opposite valve (see Fig. 261).

Denticles—small teeth or tooth-like ridges.

Denticulate—toothed.

Depressed—on a level with, or below the general surface.

Des Moinian—lower Coal Measure (middle Carbonic) of central U. S.

De Soto beds—upper Pliocenic of Florida.

Dextral—right-handed. The normal direction of coiling in gastropods; see also *sinistral*.

Di—a prefix meaning twice.

Diaphragm—a more or less straight partition extending horizontally or diagonally from one side of a tube to the other (see Fig. 182, *d*).

Dichotomous—regularly dividing by pairs.

Dicyclic—with two cycles. Applied to crinoids which have infrabasals as well as basals.

Diductor—in brachiopods, one of the muscles used in opening the shell (see I., 173; also Fig. 392, *a*).

Digitate—branching like the fingers of a hand from a central point.

Digonal—two-angled.

Dimyarian — referring to pelecypods with both anterior and posterior adductor muscles, as *Venus*.

Dinaric—middle Triassic, general term.

Diogenodont dentition—in pelecypods, see I., 361.

Dis—a prefix meaning separation or signifying not.

Disciform—disk-shaped.

Discinoid—resembling *Discina*.

Discoid—shaped like a disk; coiled in one plane (see Fig. 1206).

Dissepiments—in graptolites and bryozoans, the cross bars uniting the branches. In corals, the horizontal or oblique plates uniting the adjoining septa; as seen in transverse section, they are usually curved or irregular between the septa (see Figs. 32, 101).

Distal—remote from the point of attachment or center.

Distichals—in crinoids, the second series of arm plates or brachials, situated above the axillary costals (see Fig. 1907, *D*).

Divaricate—to branch.

Divaricators—the opening muscles of brachiopods. Also called diductors.

Dolomite—a mineral consisting of carbonate of lime and magnesia.

Dorsad—toward the dorsum or back; backward.

Dorsal—pertaining to the back.

Dorsal cup—in crinoids, the crown exclusive of the arms and tegmen.

Dorsal furrows—in trilobites, the two grooves limiting the glabella and axis laterally.

Dorsal shield—in trilobites, the entire dorsal test, inclusive of cephalon, thorax and pygidium (see Fig. 1542).

Dorsal valve — in brachiopods, the brachial valve.

Dorsocentren—see Fig. 1231.

Dorsum—the back. In most cephalopod shells, the interior of the coil; in insects, see II., 420.

Doublure—the infolded margin of a trilobite test; this produces the hollow spines from the ends of the genal angles, the segments and the pygidium (see Figs. 1556, *e*, 1559).

Douglas formation—upper Carbonic of Kansas.

Dresbach shale—a subdivision of the St. Croix formation.

Dudley formation—middle Carbonic of Kansas.

Dundee limestone—middle Devonic of Michigan.

Dunkard formation—Permic of eastern United States.

Duplin beds—upper Miocenic of North Carolina.

Dysodont dentition—in pelecypods, see I., p. 361.

Eagle Ford formation—lower Cretacic (Coloradoan) of Texas.

Eagle Pass formation—see *Navarro formation*.

Ear—in pelecypods, the anterior cardinal expansion of the shell, usually smaller and more distinctly defined than the posterior expansion or wing.

Eccentric—not centrally placed.

Ectoderm—the outer cellular body layer.

Eden formation — lower Cincinnatian (upper Ordovicic) of eastern U. S.

Edwards limestone—middle Comanchic (Fredericksburgian) of Texas.

Elbrook formation—middle Cambric of Pennsylvania, Maryland, etc.

Eldon formation—middle Cambric of the Canadian Rockies.

Ellis formation—Jurassic of Yellowstone region.

Elmdale formation—base of Permic in Kansas.

Elvins formation—upper Cambric of Ozark Mountains.

Elytra—in beetles, the horny sheaths concealing and protecting the softer posterior wings (see II., 424).

Emarginate—with a notched margin.

Embryonic — referring to the earliest, undeveloped stage of an animal, after the egg stage (see also *Ontogeny*).

Endocyclic—see *regular.*
Endoderm — the inner cellular body layer.
Endopodite—see II., 387.
Endosiphocone—see Fig. 1239.
Endosipholining—see II., 20
Endosiphosheaths—see II., 20; also Fig. 1239.
Endosiphotube—see Fig. 1239.
Endosiphuncle—in some cephalopods, the small hollow axis at the center of the siphuncle. It is surrounded by thin calcareous cones filling the space to the siphonal funnels (see II., 20).
Endothecal—within the theca; intrathecal. Used of corals.
Englishtown sands (*Columbus sands*)—Matawan (middle Cretacic) of Atlantic coast.
Ephebic—mature (see *Ontogeny*).
Epicranium—see II., 419.
Epidermal—pertaining to the skin.
Epidermis—for use in shells, see periostracum.
Epimerum—see II., 420.
Episternum—see II., 420.
Epitheca—the concentrically wrinkled calcareous crust often surrounding the base of an individual coral (I., 47); in hydrocorallines and bryozoans (I., 107), surrounding the base of a colony.
Epizygal—for use in crinoids, see II., 490.
Equilateral—with equal sides. In bivalve shells, referring to the equality of the two halves of a valve on each side of a line passing from beak to center of base.
Equivalve—with the two valves of equal size.
Erian series—middle Devonic, general term.
Escutcheon—in pelecypods, the depression behind the beak.
Esopus shale—lower Devonic of New York, Pennsylvania, etc.
Etchegoin formation—upper Miocenic of California.
Etcheminian—a term for the lower Cambric of the Atlantic province.
Eureka shale (black)—Kinderhook of Arkansas.
Evolute—applied to loosely coiled shells where the later whorls do not hide the earlier.
Excentric—not centrally placed; eccentric.
Exfoliate — to remove small portions from the surface.
Exhalent—in sponges, applied to canals with an outflowing current, either directly to the upper surface or indirectly through a large general cavity, the paragaster (see Fig. 21).
Exocyclic—see *irregular.*
Exopodite—see II., 387.
Exothecal—outside of the theca.
Explanate—spread out in a flat surface.
Extra—a prefix meaning beyond, outside, in addition to.
Extrathecal—in corals, referring to the portion outside of the theca.
Extraverted — turned outward. In brachiopods, applied to the spiral brachidia when turned base to base (see Fig. 467, *c*).
Eye—in trilobites, see *compound eye, holochroal, schizochroal, ocellus, facet.*

Fabiform—bean-shaped.
Facet—a little face; a small, usually plane, circumscribed surface. In the compound eyes of most crustacea and insects, the external surface of a single ocellus.
Facetted—having facets or numerous faces, as the eye of an insect, etc.
Facial sutures—sutures in the cephalon of trilobites which separate the free cheeks from the fixed (see Fig. 1569, 1573).
Facies—the general habit of a species or group of species with reference to its adaptation to its environment, as littoral facies.

Fairview formation—lower Cambric of Canadian Rockies.

Falcate—curved like a scythe or sickle.

Falciform—sickle-shaped.

Fascicle—a small cluster.

Fasciculate—clustered, grouped in bundles.

Fasciole—in echinoids, a narrow band of close granular ornamentation (see II., 575, and Fig. 1911).

Anal fasciole—the fasciole surrounding the anus.

Lateral fasciole—see Fig. 1911.

Peripetalous fasciole—see Fig. 1911.

Subanal fasciole—the fasciole enclosing a space beneath the anus.

Fathom—a measure of length equalling six feet, used chiefly for depths of the sea.

Fauna—all the animals living in an area or epoch.

Fayetteville shale—lower division of Boston group, Arkansas.

Femur—in insects the middle segment of the leg (see II., 420).

Fenestrules—the openings between the branches of a bryozoan colony.

Fernando beds—lower Pliocenic of California.

Fern Glen limestone—Kinderhook of Missouri.

Fiber—any fine, slender, thread-like substance.

Fibrous—consisting of fibers.

Filament—a fine thread or fiber.

Filiform—thread-shaped, very slender.

Fimbriæ—fringes.

Fission—the act of splitting or dividing into parts.

Fixed cheek—that part of the cephalon of a trilobite which lies between the glabella and the facial suture (see Figs. 1542, 1557).

Flabellate—fan-shaped.

Flagellum (plural *flagella*)—a long, lash-like appendage (see II., 387, and Fig. 1692).

Flange—a projecting rim.

Flathead quartzite—middle Cambric of Yellowstone region.

Flat Rock dolomite—upper Monroan of Michigan, Ohio, etc.

Flexuous—bent in a winding or zigzag manner.

Flora—the vegetation of an area or epoch.

Florissant beds—continental Oligocenic of Colorado.

Floscelle—in some echinoids, the petal-like expansion of the ambulacral plates near the mouth opening, accompanied by an enlargement and crowding of the pores (see Fig. 1930).

Floyd shale—upper Mississippic of the southern Appalachians.

Fold—an elongate elevation.

Medial fold—see *median fold.*

Median fold—in some brachiopods, the central and usually the largest elevation extending from the beak to the front of the shell; it is usually upon the brachial valve.

Mesial fold—see *median fold.*

Foliate—leaf-like; in the form of a thin, leaf-like expansion.

Food grooves—in crinoids, etc., the grooves in the ambulacra through which the food is urged into the mouth.

Foramen—an opening or pore; specifically, in brachiopods, the opening for the pedicle in the pedicle valve.

Foramina—plural of foramen (see I., 8).

Fort Payne formation—lower-middle Mississippic of southern Appalachians.

Fort Scott limestone—lower Coal Measure limestone (middle Carbonic) of Kansas.

Fort Union formation—lower Eocenic of Montana (continental).

Fort Worth limestone—upper Comanchic (Washitan) of Texas.

Fossil—the remains of an organism or anything indicating the presence of an organism, buried by natural causes and preserved in the rocks of the earth's crust.

Classification of—see I., 6.

Distortion of—see I., 5.
Index fossil—a fossil which, because of its limited vertical but wide horizontal distribution is of value as an index to the age of the stratum where found. For correlation by means of index fossils, see I., 2.
Mode of preservation—see I., 4.
Naming of—see I., 5.
Types of—see I., 3.

Fossula—in corals (some Tetracoralla), the groove in the calyx due to the reduction or abortion of the cardinal septum (see Figs. 84, 83 upper).

Fox Hills group—upper part of middle Cretacic (Montanan) of Great Plains.

Franconia sandstone—subdivision of St. Croix formation.

Frankfort shales—upper Ordovicic of New York, etc.

Fredericksburg division (*Fredericksburgian*)—middle Comanchic.

Free cheeks—in trilobites, lateral portions of the cephalon separated off by the facial sutures (see Figs. 1542, 1557).

Freemont limestone—upper Ordovicic of Colorado.

Freeport formation—upper division of the Alleghenian (middle Coal Measures) of Ohio, Pennsylvania, etc.

Frond—the body formed by the union of stem and leaf among ferns, lichens and palms. Also the leaf-like expansion of an entire graptolite or bryozoan colony.

Fucoid—a seaweed, particularly of the type similar to the modern *Fucus* or rockweed.

Functional—pertaining to the appropriate action of any special organ or part of an animal or vegetable organism.

Funiculus—a small cord (see II., 387).

Furcate—branching like a fork.

Furrow—for use in trilobites, see II., 251, and Fig. 1542; in insects, see II., 424.
Dorsal furrow—see *dorsal.*
Lateral furrows—in trilobites, see Fig. 1542.
Occipital furrows—see *occipital.*

Fusiform—spindle-shaped (see Fig. 18).

Fusoid—spindle-shaped.

Galeate—with a helmet-like covering.

Galena limestone—upper Ordovicic (Trenton) of central North America.

Gallatin limestone—middle Cambric of Yellowstone region.

Garnett limestone—Carbonic of Kansas.

Garrison formation—lower Permic of Kansas.

Gasconade limestone—upper Cambric of the Ozarks.

Gaspe limestone—Helderbergian (lower Devonic) of eastern Canada.

Gaspe sandstone—middle and upper Devonic of eastern Canada.

Gastric—pertaining to the stomach.

Gatun formation—middle Eocenic of the Isthmus of Panama.

Gay Head beds—Miocenic of Atlantic coast.

Gemmation—the formation of young by budding, as in some corals.

Genal—pertaining to the cheeks.
Genal angles—posterior lateral angles of the free cheeks of trilobites.
Genal spines—posterior prolongations or spines of the free cheeks of trilobites.

Generic name—see *genus.*

Genesee shale—upper Devonic of New York, etc.

Genetic—pertaining to origin.
Genetic affinity—relationship by direct descent.

Geniculate—bent abruptly at an angle. In brachiopods, referring to those shells with the front portion bent abruptly, almost at a right angle (see Fig. 273, *b*).

Genital plates—in echinoids, the upper of the two circles of plates in the apical system; they are situated interradially. Called also basal plates (see Fig. 1935, *g*).

Genotype—see *type.*

Genundewah limestone—upper Devonic of New York.

Genus—the first of the two or three names applied to a single fossil (see I., 5).

Georgetown limestone — Washitan or upper Comanchic of Texas.

Georgia shales — lower Cambric of northern Appalachian region.

Georgian—a term for the lower Cambric of the Pacific and Appalachian provinces.

Gerontic—old (see *ontogeny*).

Gibbous—swollen, very convex.

Gills—the respiratory organs of mollusks and higher marine animals. In pelecypods, see I., 362.

Girardeau limestone—basal Siluric of the Ozark region.

Glabella—in trilobites, the central and most prominent portion of the cephalon, bounded by the fixed cheeks (see Fig. 1542).

Glabellar—referring to the glabella.

Glen Rose limestone — subdivision of Trinitan or lower Comanchic of Texas.

Globe limestone—upper Devonic and upper Carbonic of Arizona.

Glomerate—growing in dense heads or clusters, generally of an irregular character.

Gonopolyp—a reproductive polyp of Hydrozoa.

Gonotheca—the protective covering of a reproductive polyp (see Fig. 31).

Goodland limestone—Fredericksburgian (middle Comanchic) of northern Texas.

Gower limestone—Niagaran of Iowa.

Grainger shale—Devono-Mississippic of southern Appalachians.

Grand Greve limestone—Oriskanian of eastern Canada.

Grand Gulf group—middle Oligocenic of Gulf states.

Grand Rapids group—upper Mississippic of Michigan.

Graneros shale—lower Cretacic (Benton) of Colorado, etc.

Granulated—having small and even elevations resembling grains.

Granulose — bearing or resembling grains or granules.

Greenbrier limestone—upper Mississippic of Appalachians.

Greenfield dolomite—basal bed of lower Monroan of Ohio, etc.

Greenhorn limestone—subdivision of the Benton (Coloradoan).

Green River group — continental Eocenic of Wyoming.

Greer formation—Permic of Oklahoma and Texas.

Gregarious—living in colonies.

Grenville limestone—upper Chazy of Ottawa River region.

Groove—in trilobites, see Fig. 1542.

Growth lines—in shells, lines marking the periodic increase in size (see I., 171).

Guadalupian—Permic of western Texas and New Mexico.

Guard—the calcareous, posterior portion of the internal shell of Belemnoidea. It is cigar-shaped. Called also rostrum (see Fig. 1512).

Guelph—upper division of Niagaran.

Gyroceracones—loosely coiled, Nautiloid cephalopod shells, with no impressed zone (see Figs. 1293, 1298).

Habitat—the area or region in which an animal or plant naturally lives.

Hamburg limestone — middle Cambric of Nevada; has also been used for a bed in the Kinderhook of the Mississippi Valley.

Hamilton beds—middle Devonic of eastern United States.

Hannibal shales—middle division of Kinderhook, Mississippi Valley.

Harding sandstone—upper Ordovicic, Rocky Mountain region.

Hardiston quartzite—lower Cambric of New Jersey.

Harpers formation—lower Cambric of Pennsylvania and Maryland.

Harrodsburg limestone—middle Mississippic of Indiana.

Hartshorn formation—lower Carbonic of Oklahoma.

Hastate—shaped like the head of a spear.

Hatchetigbee formation—lower Eocenic of Gulf coast.

Hawthorn formation—lower Chipolan (middle Oligocenic) of Florida.

Hayti marls—Oligocenic of Hayti.

Helderbergian series—lower Devonic of eastern North America.

Hemi—a prefix, meaning half.

Hemisepta—in some Bryozoa, short plates projecting from the posterior or the anterior wall (see Fig. 208, *e*).

Hepatic—pertaining to the liver.

Hepta—a prefix, meaning *seven*.

Hermosa formation—Carbonic of Colorado.

Hesse sandstone—lower Cambric of the southern Appalachians.

Hexa—a prefix, meaning *six*.

Hickory series—middle Cambric of Texas.

Hinckley sandstone—subdivision of St. Croix.

Hinge—that on which anything turns or swings.

Hinge area—in many brachiopods, the flat area bordering the hinge line; cardinal area.

Hinge line—the line of articulation between two valves (see Fig. 218).

Hinge plate—in brachiopods, the two expansions at the beak, within the brachial valve, bounding the dental sockets and medially uniting in the cardinal process. In the higher forms of pelecypods (Teleodesmacea), the solid internal shelly growth at the beak upon which the teeth are placed.

Hinge teeth—in many bivalve shells, projections form the hinge area of one valve which fit into sockets upon the opposite valve, thus strengthening the union of the two valves. In brachiopods, the teeth are present only on the pedicle valve, with only sockets on the brachial valve. In tooth-bearing pelecypod shells, both teeth and sockets are present in each valve.

Hirsute—rough with hairs.

Hiwasee slate—lower Cambric of the southern Appalachians.

Holo—a prefix, meaning entire.

Holochroal—in trilobites, that type of compound eye in which the visual area is covered by a continuous horny integument, as in *Calymene*.

Holotype—see *type*.

Homewood sandstone—upper Kanawha (lower Carbonic) of Ohio, etc.

Homologous—having the same type of structure.

Horsetown formation—upper division of the Shasta or Comanchic series of California.

Horton formation — Mississippic of Nova Scotia.

Hosselkus limestone—upper Triassic of California.

Hudson River shales—upper Cambric to upper Ordovicic of Hudson Valley, etc.

Hueconian formation—Carbonic limestone of northwest Texas.

Huerfano formation — lower Eocenic of Colorado.

Hunton limestone—a lithologic unit in Oklahoma, partly Niagaran and partly Helderbergian.

Hydaspic division—subdivision of the middle Triassic.

Hydroid—an animal belonging to the class of Hydrozoa (see I., 20).

Hydrophyton—in hydrocorallines, the horny or calcareous basal structure secreted by a colony (see Figs. 56, 57).

Hydrospire—in blastoids, the internal calcareous tubes running parallel to and bounding the sides of the ambulacra.

Hydrotheca—in hydrozoa, the chitinous cup surrounding the base of the expanded polyp and into which it can by muscular contraction withdraw for protection (see Fig. 31).

Hyponome—water tube of squids, cuttle fish and other cephalopods; ambulatory funnel (see Fig. 1230).

Hyponomic sinus—see *sinus*.

Hypostoma—the upper lip of trilobites; it is attached to the under folded anterior margin (doublure) of the cephalon, and is usually found detached. It corresponds to the labrum of other arthropods. Also spelled hypostome (see Figs. 1556, *e*, 1559).

Hypozygal—for use in crinoids, see II., 490.

Im—a form of the prefix *in*.

Imago—the adult stage of an insect.

Imbricate—to overlap in series.

Imperforate—without an opening. In echinoids, referring to the interambulacral areas and also to the absence of a pit in end of a mamelon.

Implantation — planting between, as when a new plication suddenly appears between two older ones.

Impressed zone—in cephalopods, see II., 18, bottom.

In—a prefix, meaning *not* or *in*.

Inarticulate—not united by teeth and socket.

Incised—cut into.

Incrusting—covering as with a crust.

Index fossil—see *fossil*.

Inequilateral—having unequal sides; see *equilateral*.

Inferior—lower in position.

Inferradials—for use in crinoids, see II., 489.

Inflated—swollen.

Inflected—bent or turned inward or downward.

Infra—a prefix, meaning *below, after*.

Infrabasals—in crinoids, with dicyclic base, the lowest cycle of plates (see Figs. 1804, 1876).

Inhalent—in sponges, applied to canals or pores with inflowing current (see Fig. 21).

Ink-bag—the organ present in most dibranchiate cephalopods, as the squid, which secretes a brownish black fluid (sepia).

Inosculate—to connect so as to have intercommunication.

Inter—a prefix, meaning *between*.

Interambulacra—in echinoids, the five broad areas separating the ambulacra (see Fig. 1920). In crinoids, see II., 491.

Interambulacral—referring to the interambulacra.

Interbrachials—plates in the calyx of a crinoid lying between the brachials.

Intercalation — the insertion of anything among others. In the normal enlargement of a shell, the radiating ribs or plications may increase in number by the dividing of the older ones or by the intercalation or implantation of new ones.

Intercellular—between the cells.

Intercostals—in crinoids, the plates lying between the costals (see II., 491).

Interdistichals—plates in the calyx of a crinoid lying between the distichals.

Interlamina—plates between scales or plates.

Internode—for use in crinoids, see II., 488.

Interporiferous area—in echinoids, that portion of the ambulacrum lying between the poriferous zones or areas, from which protrude the tube feet (see Fig. 1920, *d*).

Interradials—plates in the calyx of a crinoid lying between the radials.

Interstitial—pertaining to an intervening space between lines, plications, etc.

Interzoëcial—between the zoëcial tubes in Bryozoa, etc.

Intra—a prefix, meaning *within*.

Intrathecal—within the theca; endothecal.

Introverted—turned inward; in brachiopods, referring to the spiral brachidia when turned apex to apex (see Fig. 385, *e*).

Invaginated—inserted as in a sheath.

Involute—rolled inward; applied to

shells in which, as in *Nautilus,* the later whorls partially or completely hide the preceding.

Iola limestone — middle Carbonic of Kansas.

Irregular—not regular. Applied to echinoids in which the mouth is either central or eccentric and the anus is eccentric; exocyclic (see Fig. 1928, 1933).

Ischiopodite—see II., 388.

Isodont dentition—in pelecypods, see I., 361.

Izard limestone — upper Ordovicic of Arkansas.

ites—a Greek adjective suffix, meaning *like,* or indicating origin or relationship with. Much used in form *ites* for fossils and *ite* for minerals, often with no particular significance.

Ithaca beds—local division of the Portage in New York.

Jacalitos formation—upper Miocenic of California.

Jacksonian, Jackson limestone—upper Eocenic of Gulf coast.

Jakutic division — subdivision of the Scythic or lower marine Triassic.

Jefferson City limestone—Ordovicic of Ozark region.

Jeffersonville limestone — middle Devonic of southern Indiana, etc.

Jerseyan—the upper Cretacic of the Atlantic coast.

Joachim limestone—middle Ordovicic of the Ozark region.

Johannian division—a lithologic division, including part of the middle and part of the upper Cambric of the Atlantic coast.

John Day bed—Oligocenic of Oregon.

Joint—in crinoids, an individual segment of the stem.

Jordan coal—basal Coal Measures (middle Carbonic) of Missouri.

Jordan sandstone—subdivision of the St. Croix formation.

Judith River beds—middle Cretacic of Canada and Northwestern United States.

Jugum—in brachiopods, the yoke-like calcareous ribbon, directly uniting the two branches of the brachidia (see Fig. 385, *e*).

Juniata beds—upper Ordovicic of central Appalachians.

Kanawha series—lower Carbonic of Appalachians.

Karnic division—subdivision of the upper marine Triassic.

Kaskaskia limestone—upper Mississippic of Mississippi Valley.

Katemcy series — upper Cambric of Texas.

Keel—a strong central carina or ridge; in cephalopods, see II., 24.

Keokuk limestone—middle division of Osage group, lower Mississippic of Mississippi Valley.

Kiamitia clay—basal Washita (upper Comanchic) of Oklahoma-Texas.

Kimeridgian—division of the marine upper Jurassic. (*Kimmeridgian.*)

Kimmswick limestone—lower Kinderhook of Missouri.

Kinderhook group—lower division of lower Mississippic of Mississippi Valley.

Kiowa shale—upper Comanchic (basal Washita) of Kansas, etc.

Kittanning sandstones, shales, limestones and coals—middle Carbonic (Alleghenian) of Pennsylvania, Ohio, etc.

Kittatinny limestone—lower Cambric to lower Ordovicic of New Jersey.

Knobstone group—lower Mississippic of Indiana and Kentucky.

Knox dolomite — upper Cambric to lower Ordovicic of southern Appalachians.

Knoxville group — lower Comanchic (Shastan) of California.

Kootenay formation—non-marine Comanchic of Canada.

Labette formation—lower Coal Measures (middle Carbonic) of Kansas.
Labium—in crustacea, the lower lip.
Labrum—in crustacea, the upper lip.
Ladinic—subdivision of marine upper Triassic.
Ladore—middle Carbonic of Kansas.
Lafayette formation—Pliocenic of eastern United States.
Lake Louise formation—lower Cambric of Canadian Rockies.
Lamella—a very thin plate-like layer.
Lamellar—disposed in lamellæ or plates.
Lamelliform—having the form of a leaf or lamella.
Lamellose—having thin plates or scales.
Lamina—a thin plate or scale; also applied to the thinnest distinct layer into which a stratified rock can be separated.
La Motte sandstone—middle Cambric of Ozark region.
Lancaster limestone—lower Cambric to lower Ordovicic of southern Pennsylvania.
Lancet-plate—in blastoids, the narrow plate running the entire length of the middle of each ambulacrum.
Lappet—a pendent.
Lateral lappet—in some ammonoids, one of the lateral, forwardly directed projections of the aperture; called also lateral crest (see Fig. 1452).
Laramie formation—upper Cretacic (Continental) of Great Plains.
Larva—the early form of some animals before they assume the mature shape, as the caterpillar stage.
Larval—referring to the larva.
Lateral gemmation—budding from the sides, as in some corals.
Lateral teeth—ridge-like projections on either side of the beak, in the interior of pelecypod shells.
Latilaminæ—the union of several horizontal laminæ in the hydrocorallines to form a comparatively thick layer (see I., 36).
Laurel limestone—Niagaran of Tennessee.
Lawrence shales—upper Carbonic of Kansas.
Leadville limestone—Mississippic of west central Colorado.
Lebanon limestone—middle Ordovicic of Tennessee.
Leclaire limestone—Niagaran of Iowa.
Leroy shales—upper Carbonic of Kansas.
Lewistown limestone—upper Siluric of Pennsylvania.
Lexington division—basal upper Ordovicic of the Cincinnati region.
Ligament—in pelecypods, the external structure for opening the valves (see I., 362).
Lignitic—lower Eocenic of Gulf region; see *Chickasawan.*
Limb—in trilobites, see *cephalic limb,* and Fig. 1586.
Lime Creek shales—upper Devonic of Iowa.
Linden beds—Helderbergian of western Tennessee.
Lines of growth—see *growth lines.*
Lingual—referring to the tongue.
Lingual ribbon—see *radula.*
Linguiform—tongue-shaped.
Linguloid—tongue-shaped; like *Lingula* (see I., 178, 3).
Lips—in univalve shells, the outer and inner margins of the aperture.
Liræ—ridges or plications on the inside of the outer lip of some gastropod shells, as *Nerinea.*
Listrium—in brachiopods (as *Orbiculoidea* and some others of the Neotremata), the plate closing the progressive track of the pedicle opening, posterior to the apex of the pedicle valve.
Lite—of stone (from Greek lithos, stone; dropping of *h* due to conformity with the unrelated suffix *ite*).
Lithic—pertaining to stone.
Lithodesma—in pelecypods, the accessory calcareous piece strengthening the resilium (as in *Liopistha, Cuspidaria*).
Little Falls dolomite—lower Ordovicic of Mohawk Valley.

Little River group—a continental formation regarded by Canadian geologists as upper Devonic, but by paleobotanists as lower Carbonic (Kanawaha group).

Littoral—referring to the shores of seas or lakes. Littoral animals are those which inhabit the shallower portions of lakes or seas where light is present. The littoral zone extends from high water to the edge of the continental shelf.

Living chamber—the last chamber in the shell of a cephalopod; the chamber occupied by the body of the animal; body chamber.

Livingston formation—uppermost Cretacic of Montana.

Lobes—backward bending portions of the suture of cephalopod shells; they point *away* from the aperture of the shell (see II., 21, 23).

Lobulate—with lobes.

Lockport dolomite — division of the Niagaran of New York.

Loess—continental Pleistocenic of the Mississippi and Missouri Valley.

Logan sandstone — upper division of Waverly group.

Longitudinal—in a direction parallel with the length.

Lophophore—in Bryozoa and Brachiopoda the curved fleshy ridge surrounding the mouth and bearing the hollow tentacles (see I., 174).

Lorraine shales — upper Ordovicic of New York, etc.

Louisiana limestone—lower division of the Kinderhook of the Mississippi Valley.

Louisville limestone—Niagaran of Kentucky and Indiana.

Loup Fork beds—upper Miocenic to Pliocenic of Great Plains region.

Lowville limestone—upper Chazyan of New York.

Lucas dolomite—upper Monroan of Michigan, Ohio, etc.

Ludlowville shale—middle Devonic of New York state.

Lunarium—in Bryozoa, a more or less thickened portion of the posterior wall which is curved to a shorter radius and often projects above the plane of the zoœcium (see Fig. 182, *f*).

Lunule—in pelecypods, the depression in front of the beak; in echinoids, one of the perforations present in the tests of some forms (see Fig. 1926).

McAlester formation—lower Carbonic of Arkansas and Oklahoma.

Macerate—to soften and separate by immersion in a liquid.

Macro—a prefix, meaning great.

Macrocorallites—the larger corallites in a compound corallum.

Macula (plural *maculæ*)—a flattened or depressed area upon the surface of a bryozoan colony.

Madera limestone—lower Carbonic of New Mexico, etc.

Madison limestone — Mississippic of Montana.

Madison sandstone—upper Cambric of Wisconsin.

Madreporic—in echinoderms, referring to the madreporite.

Madreporite—in echinoids, a porous, sieve-like structure located in the apical system; also the plate containing it—the largest of the five genital plates (see Fig. 1935, *m*). Likewise present in cystoids, asteroids, etc.

Magdalena group—lower Carbonic of New Mexico, etc.

Magnesian, lower—basal Ordovicic of the upper Mississippi region.

Magothy formation — middle Cretacic of Atlantic coast.

Malone formation—upper Jurassic of Texas.

Mamelon—a small hemispherical elevation. In echinoids, the rounded knob or ball forming the top of a tubercle upon which rests the spine (see Figs. 1913, 1918).

Manasquan—upper Cretacic of Atlantic coast.

Mandibles—the first upper or outer pair of jaws of crustaceans and insects.

Manitou limestone—lower Ordovicic of the Rocky Mountain front range.

Mansfield sandstone—Carbonic of Indiana.

Mantle—the fleshy membrane infolding the soft parts of mollusks and brachiopods and building the shell. In cephalopods, see Fig. 1230.

Manzano group—upper Carbonic of New Mexico, etc.

Maquoketa formation—upper Ordovicic of upper Mississippi Valley.

Marcellus shale—middle Devonic of eastern North America.

Marion formation—subdivision of the Sumner (Permic) of Kansas.

Mariposa formation—upper Jurassic of California.

Mark's Mill beds—upper Eocenic of Arkansas.

Marmaton formation—middle Carbonic of Kansas.

Marshalltown formation—middle Cretacic of Atlantic coast.

Martinez group—lower Eocenic of Pacific coast.

Marysville limestone—middle Cambric of southern Appalachians.

Matawan formation—middle Cretacic of Atlantic coast.

Matthews landing beds—lower Eocenic of Alabama.

Mauch Chunk red shale—upper Mississippic of the Appalachians.

Maxilla—one of the two pairs of jaws in crustaceans and insects (see II., 387).

Mayville limestone—basal Niagaran of Wisconsin.

Maysville beds—middle division of Cincinnati group, upper Ordovicic (= Lorraine).

Maxilliped—in Crustacea, the jaw-feet (see II., 387, and Fig. 1692).

Maxville limestone—upper Mississippic of Ohio.

Mazon Creek beds—middle Carbonic (Alleghenian) of Illinois.

Meadville shales and limestones—lower Mississippic of western Pennsylvania.

Media—in insects, one of the wing veins (see Fig. 1724).

Medial—middle.

Median—middle.

Median fold—see *fold.*

Median sinus—see *sinus.*

Medina sandstone—basal Niagaran of western New York.

Medusa—a jelly fish.

Meekoceras beds—lower Triassic of the Pacific region.

Membranaceous—pertaining to or consisting of membrane.

Mendota beds—upper Cambric of Wisconsin.

Meramec group—general term for the middle Mississippic.

Merced series—Pliocenic of Pacific coast.

Mercer beds—upper Kanawha of Ohio, etc.

Merchantville beds—middle Cretacic of Atlantic coast.

Mero-plankton—an organism which during its larval stage drifts aimlessly (planktonic), but later settles to the bottom and becomes benthonic.

Meropodite—see II., 388.

Mesenteries—in corals, one of the vertical membranous partitions projecting inward from the body wall and dividing the gastric cavity into a series of radiating compartments, each of which is continuous with the cavity of the tentacle above. In forms secreting radiating septa, the mesenteries are in pairs, each pair enclosing a septum which is secreted by the upward bent portion of the ectoderm beneath.

Mesial—middle.

Meso—a prefix, signifying in the middle; frequently used in contradistinction to *meta,* behind, and *pro,* before. For use in insects, see II., 420.

Mesoderm—the middle body layer.

Mesopore—in Bryozoa, one of the smaller, angular or irregular tubes occupying the space between the normal larger ones (zoëcia).

Mesotheca—the "middle wall" resulting from the growing together of the epitheca of two parts of a bryozoan colony.

Mesothorax—see II., 420.

Meta—a prefix, frequently used in zoology as indicating posterior (see *meso*).

Metamorphosis—a change in the form or function of an organism by a natural process of growth or development. In insects, this change takes place suddenly, as from the larval or caterpillar stage to the butterfly, and is hence very noticeable.

Metastome — underlip of Crustacea, composed of small pieces immediately below and behind the mouth. Very seldom preserved in trilobites; it is just posterior to the hypostome.

Metathorax—see II., 420.

Micro—a prefix, meaning small.

Microcorallites—the smaller corallites of a compound corallum.

Midwayan—lower Eocenic of the Gulf coast.

Millsap limestone — Mississippic of Front Range of Colorado.

Milwaukee dolomite—middle Devonic of Wisconsin.

Mimoceracone—a loosely coiled Ammonoid shell (see II., 19).

Missourian — upper Carbonic (upper Coal Measure) of central U. S.

Mold—any impression of an object, either external or internal (see I., 3).

Molt—to shed the skin, hair, feathers, horns, carapace, or the like; also spelled moult.

Moniliform — jointed; resembling a string of beads

Moniliform siphuncle—see figs. 1263, 1346.

Monmouth beds — middle Cretacic of Atlantic coast.

Mono—prefix, meaning *one*.

Monocyclic—in a single cycle; applied to those crinoids having no infrabasals below the basals.

Monomyarian—applied to those pelecypods in which the anterior adductor muscle is absent or degenerate, as *Ostrea*.

Monongahela formation—upper Carbonic of Pennsylvania, Ohio, etc.

Monroan—general term for the upper Siluric.

Montanan—middle Cretacic of the interior.

Monterey formation — Oriskanian of Maryland.

Monticule—an elevation. In certain Bryozoans and coral colonies these commonly carry the larger apertures.

Monticuliporoids—compound calcareous bryozoa with the walls of the zoëcia thickened in their outer region with numerous cystiphragms (genera 26–34).

Moorefield shales—middle Mississippic of Arkansas.

Morris coal beds—see *Mazon Creek beds*.

Morrison formation—upper Jurassic of Front Range region.

Moscow shale—middle Devonic of New York.

Mt. Auburn beds—upper division of the Maysville or middle Cincinnati group.

Mt. Hope beds—division of the Maysville or middle Cincinnati group.

Mt. Laurel formation—middle Cretacic of Atlantic coast.

Mt. White formation—lower Cambric of Canadian Rockies.

Mucro—a pointed end.

Mucronate—produced into a long pointed extension.

Multi—prefix, meaning *many*.

Multicellular—composed of more than one cell.

Multilocular—of many loculæ or chambers.

Multivinculum—in pelecypods, applied to the ligament when consisting of many elastic strands stretched from beak to beak, as in *Arca* and *Perna*.

Mural—pertaining to a wall.

Mural pores—pores in the walls of the corallites of the Favositidæ (see Fig. 139).

Muscle scar—the scar in a shell marking the former attachment of a muscle. For application in brachiopods and pelecypods, see also *adductor, diductor*. In cephalopods, see II., 18.

Naco limestone—Carbonic of Arizona.

Nacreous—pearly; the nacreous layer in shells is the inner smooth "mother of pearl" layer.

Nahant formation—lower Cambric of eastern Massachusetts.

Nanafalia formation—lower Eocenic of Alabama.

Nanaimo group—lower Cretacic (Coloradoan) of Vancouver Islands.

Nanjemoy formation—subdivision of the Pamunkey (lower Eocenic) of Atlantic coast.

Naples beds—local division of the Portage (upper Devonic) of New York.

Nashville group—upper Ordovicic of western Tennessee.

Nasute—projecting nose-like.

Naticoid—like *Natica* (see I., 588, C., and I., 717, and Fig. 1038).

Nautilicone—closely coiled Nautiloid cephalopod shells, with impressed zone (ex. *Nautilus*); see Fig. 1335.

Nautiliform—coiled like *Nautilus* or like *Bellerophon* (see I., 619, Figs. 830, 1335).

Navarro formation (*Eagle Pass*)—upper Cretacic of Texas.

Navesink marls—middle Cretacic (Monmouth) of Atlantic coast.

Neanic—youthful (see *ontogeny*).

Nebo sandstone—lower Cambric of southern Appalachians.

Neck furrow—see *occipital furrow*.

Neck ring—see *occipital ring*.

Neelytown limestone—uppermost Cambric of eastern New York (Saratogan).

Nekton—an organism which leads an actively swimming life.

Nepionic—infantile (see *ontogeny*).

Nettle-cell—in most Cœlenterata, one of the nematocysts or stinging cells found covering the tentacles and other body parts.

Nevada limestone—Devono-Mississippic of Nevada.

New Albany black shale—upper Devonic of Indiana, etc.

Newark system—continental Triassic of eastern North America.

Newman limestone—middle Mississippic of southern Appalachians.

New Scotland beds—a division of the Helderbergian (lower Devonic).

Niagaran—general term for the lower Siluric.

Nichols shale—lower Cambric of southern Appalachians.

Nidamental glands—those glands in cephalopods which secrete the sticky substance for cementing the eggs together (see Fig. 1230).

Niobrara series—lower Cretacic (Coloradoan) of Great Plains region.

Node—a knob. In gastropods, see I., 583. In crinoids, see II., 488.

Nodose—bearing nodes or tubercles.

Nodulose—knotty or having nodes.

Noel black shale—see *Eureka black shale*.

Nolichucky shale—middle Cambric of southern Appalachians.

Non—a prefix, meaning *not*.

Noric—division of the upper marine Triassic.

Normanskill shale—middle Ordovicic of Hudson Valley, etc.

North Attleborough limestones—lower Cambric of southeastern Massachusetts.

Notch—for anterior and posterior notch in gastropods, see I., 583.

Notum—in insects, the tergum (see II., 420).

Nummuloidal—in cephalopods, applied to the siphonal funnel when swollen out between the septa (see also II., 20).

Nymphæ—in pelecypod shells, the thickened ridges on the cardinal margins to which are fastened the edges of the ligament.

Oak Grove beds—upper Oligocenic of Gulf coast.

Oakville — upper Miocenic of Gulf states.

Obconical — inversely conical; apex downward.

Oblate—flattened at the poles.

Obolelloid—see I., 177, 3.

Obovate — inversely ovate, or egg-shaped.

Ocala limestone—lower Oligocenic of Gulf coast.

Occipital—pertaining to the back part of the head; in trilobites, applied to the posterior part of the cephalon.

Occipital furrow or groove — the transverse groove on the cephalon of trilobites which separates the posterior or occipital or neck ring from the rest of the cephalon (see Fig. 1542).

Occipital lobes—in some trilobites, a pair of ovoid, disconnected lobes at the base of the glabella in the neck furrow, developed at the expense of the neck ring; there is one upon each side of the axis usually just within the dorsal furrow (present in *Proëtus*).

Occipital ring—the posterior division of the glabella of a trilobite; the neck ring.

Occipital spine—in some trilobites, the spine projecting from the axis of the occipital ring; the neck spine (see Fig. 1547, *a*).

Ocelli—plural of ocellus.

Ocellus—a little eye. One of the minute single eyes of many invertebrates, such as crustaceans and insects. Also one of the many simple eyes which form the compound eyes of many of the same animals (see Fig. 1636, *b*).

Octo—a prefix, signifying *eight.*

Ocular—pertaining to the eye.

Ocular plates — in echinoids, the lower of the two circles of plates in the apical system; they are situated radially upon the ends of the ambulacra; called also radial plates (see Fig. 1935, *r*).

Ocular ridge—in trilobites, the ridge passing from the anterior part of the glabella to the anterior end of the palpebral lobe (see Fig. 1584, *a*).

Odontophore—in gastropods, the pulley-like ridge of cartilage over which is moved the radula or lingual ribbon.

Ohio shale—upper Devonic of Ohio, etc.

Oid—a suffix, meaning *in the form of.* (From Greek *eidos,* appearance, preceded by *o* as the stem vowel (original or supplied) of the preceding element of the compound. In contraction, $o + ei = oi$. For example, anthropo-eidos becomes anthropoides or anthropoid in English.)

Olean conglomerate—upper Potsville of southern New York.

Olentangy formation—upper Devonic of Ohio.

Oneonta sandstone — upper Devonic (Portage).

Oneota dolomite—lower Ordovicic of upper Mississippi Valley.

Onondaga limestone—middle Devonic of New York, etc.

Ontogeny—the life history of an individual organism; it is divided into the following five periods: (1) Embryonic, from the fertilized egg to and including the formation of the embryonic shell (protoconch, etc.), in mammals the ovarian stage; (2) Nepionic, baby stage; (3) Neanic, adolescent; (4) Ephebic, adult; (5) Gerontic, old age.

Operculiform—resembling a lid or operculum.

Operculum—the lid or cover closing the opening of various shells, etc. In Hydrozoa, see I., 21; in gastropods, see I., 584, and Fig. 920; in cephalopods, see *aptychus* and *anaptychus*.

Opisthodetic—in pelecypods, referring to the ligament when present only behind the beak, as in *Venus*.

Opisthogyrate—curved backward. Applied to the umbos of pelecypod shells, as *Nucula* and *Trigonia*.

Orals—in crinoids, the five interradial plates surrounding the mouth (see II., 491, and Fig. 1810).

Oriskanian—upper part of lower Devonic.

Oriskany beds—lower Devonic of New York, Pennsylvania, etc.

Orr formation—upper Cambric of Utah.

Orthaulax bed—middle Oligocenic of Florida.

Orthoceracone—a straight Nautiloid cephalopod shell.

Orthoid—shaped like *Orthis* (see I., 185, 4).

Osage group—upper division of lower Mississippic of Mississippi Valley.

Osculum—an opening; in sponges, the large terminal opening (see Fig. 21).

Osgood beds—Niagaran of southern Ohio and Kentucky.

Ossicle—a little bone; also one of the small calcareous particles forming the skeleton of some echinoderms, as the star fish.

Ambulacral ossicle—for use in asteroids, see II., 571, and Fig. 1910.

Vertebral ossicle—for use in ophiuroids, see II., 570.

Oswayo group—upper Mississippic of southwestern New York.

Ouray limestone—Devonic and Mississippic of Colorado.

Oviform—egg-shaped.

Paddles—in eurypterids, the large or last pair of thoracic legs.

Paget formation—upper Cambric of the Canadian Rockies.

Pali—in corals, narrow vertical plates inserted between the columella and the inner ends of the septa (see Fig. 168).

Pallial—pertaining to the mantle of mollusks and brachiopods.

Pallial line—the line on the interior of the shell of mollusks, marking the attachment of the mantle. In pelecypods, see Fig. 476.

Pallial sinus—in many pelecypods, the reëntrant angle at the posterior end of the pallial line; it marks the point of attachment of the muscles of the siphon (see Fig. 476). In brachiopods, one of the main blood vascular canals; see *vascular markings*, also I., 174).

Palmars—in crinoids, the third series of brachial plates, lying above the axillary distichals (see Fig. 1907, *P*).

Palmate—resembling a hand with fingers spread.

Palpebral—pertaining to the eyelids.

Palpebral lobes—eyelids or supraorbital extensions from the fixed cheeks of trilobites (see Figs. 1542, 1557).

Pamelia limestone—upper middle Ordovicic of New York.

Pamunkey formation—lower Eocenic of Atlantic coast.

Papilla—a minute, cone-shaped projection.

Papillose—containing or covered with small rounded projections.

Parabasals—in crinoids, the second (upper and outer) cycle of basal plates; usually called basals.

Parabolic—like a parabola, a curve formed by the intersection of the surface of a cone by a plane parallel to one of its sides.

Paradoxides beds—middle Cambric of Atlantic coast, exclusive of basal bed.

Paragaster—the large central cavity of a sponge (see Fig. 21).

Paraptera—see II., 424.

Parasite—an animal which lives either upon or at the expense of another.

Parivinculum—in pelecypods, applied

to the ligament when it consists of a split cylinder in the form of a C-spring, as in *Venus.*

Pascagula beds — middle Miocenic of Mississippi.

Paspotansa—subdivision of Pamunkey formation, Eocenic of Atlantic coast.

Patelliform—shaped like *Patella;* a depressed hollow cone.

Patulous—expanded; slightly spreading.

Pawnee limestone—middle Carbonic of Kansas.

Pectinate—comb-like.

Pectinated rhombs—paired pore clusters in the calyx of certain cystoids (see Fig. 1775).

Pedicle—a stalk. In brachiopods, the fleshy stalk by which the animal is anchored (see I., 171).

Pedicle opening—in brachiopods, the opening at the beak of the pedicle valve for the passage of the anchoring pedicle.

Pedicle valve—in brachiopods, the ventral and usually the larger valve: through it the pedicle is extended posteriorly.

Peduncle—a stalk; a pedicle.

Pelagic—referring to the open sea. Those animals are pelagic which live in the open sea and are thus independent of the bottom.

Pen—in modern squids, the horny internal skeleton; the proöstracum.

Pendent—hanging suspended.

Pennington shale—upper Mississippic of southern Appalachians.

Penta—a prefix, meaning *five.*

Pentagonal—having five angles.

Pentameroid — similar to *Pentamerus* (see I., 178, 3).

Pentamerous—in five parts.

Penultimate—next to the last.

Pereiopoda—in Crustacea, the locomotor appendages proper (see Fig. 1692).

Perforate—with an opening; in echinoids, used in reference to the ambulacral areas; also to the presence of a pit in end of a mamelon.

Peri—a prefix, meaning *around* or *beyond.*

Periderm — the transparent, external, chitinous covering of Hydrozoa which expands into the cups or hydrothecæ.

Perignathic girdle—the girdle of calcareous pieces surrounding the peristome on the inside of an echinoderm test.

Periostracum—the epidermis or outer organic covering of shells.

Peripheral—relating to the circumference, the outside portion or surface.

Periphery — the circumference; the boundary line of any closed figure.

Periproct—in echinoids, a small, membrane-covered aperture on the upper side of the test. The anus opens near the center of this area (see Fig. 1911, *B,* pt.).

Peristome—the edge of an aperture; the membrane surrounding the mouth of an invertebrate animal. In bryozoa, the elevated rim of a cup or zoëcium (see Fig. 201, *c*). In echinoids, a large, membrane-covered aperture on the under side of the test. The mouth opens in the center of this (see Fig. 1911, *C,* pt.).

Peritheca—the more or less wrinkled calcareous envelope surrounding the basal portions of a compound corallum. It corresponds to the epitheca of a corallite.

Petal—in echinoids, a petaloid ambulacrum.

Petaloid—resembling in outline a leaf or petal. In echinoids, applied to those ambulacra in which the two pore-bearing zones of each ambulacrum separate between the apex and the circumference of the test and contract again (petal-like) more or less perfectly before reaching the circumference (see Figs. 1911, *p;* 1923, *a;* 1934, *g*).

Phosphatic—containing phosphorus.

Phragmocone—the chambered middle shell in some Dibranchiate cephalopods (see II., 24; also Figs. 1512, 1513, *b*).

Phyletic—pertaining to a phylum or to a subordinate group, the members of which are united by common descent.

Phyllode—in echinoids, see II., 574, and Fig. 1930, *d, e*.

Phylloid—leaf-shaped.

Phyllum—a leaf. A common termination of the generic names of corals.

Phylogeny—the life history of a group of organisms.

Phylogerontic—referring to the old age of an entire group.

Phylum—one of the primary divisions of the animal or vegetable kingdoms.

Pierre series—middle Cretacic of Great Plains region.

Pinnate—divided, feather-like, into segments along both sides of a common axis.

Pinnulate—provided with pinnules.

Pinnule—one of the jointed appendages bordering the arms or ambulacra of crinoids, blastoids or cystoids.

Pioche formation—lower Cambric of Utah.

Pittsford shale—lowest division of the Salina of New York.

Plankton—an organism that drifts aimlessly, without power to direct its own course.

Plano-convex—applied to objects with one side flat and the other convex.

Platteville limestone — middle Ordovicic of Iowa, etc.

Pleopod—see II., 388.

Pleura (plural of *pleuron*)—lateral portions of the thoracic rings or segments of trilobites, insects, etc. In the trilobites, each segment is divided into a central portion, the axis, and two lateral divisions, the pleura (see Fig. 1542).

Pleurotomarioid—see I., 594 G.

Plica (plural *plicæ*)—a fold.

Plication—a fold or ridge.

Pocono sandstone—lower Mississippic of Appalachians.

Pogonip limestone—upper Cambric to lower Ordovicic of Nevada.

Point Levis beds—lower Ordovicic of Quebec region.

Polygonal—having more than four angles.

Polyp—an individual animal belonging to the group of Hydrozoa, Anthozoa or Bryozoa (see Figs. 31, 56).

Polyparium—a single colony produced by the union of many polyps.

Polypary—a single frond or stalk of a hydrozoon.

Polypite—an individual polyp of a colony.

Porcellainous — like porcelain; hard, smooth and opaque.

Pore—a very small opening.

Biserial pores—in echinoids, see II., 574, and Fig. 1921, *d*. For pairs of pores in simple series, see Fig. 1920, *d*.

Pore-rhombs—clusters of pores arranged in rhombs, in the calyx of some cystoids.

Poriferous—pore-bearing.

Poriferous zone—in echinoids, see *interporiferous*.

Portage beds—upper Devonic of New York.

Port Ewen beds—division of Helderbergian.

Posterior—situated behind. In brachiopods, that portion of the shell at the beak; in pelecypods, the side with the pallial sinus; in gastropods, the apex of the spire.

Post-palmars—all of the plates superior to the axillary palmars in the arms of crinoids (see Fig. 1907, *PP*).

Potosi limestone—see *Yellville limestone*.

Potsdam sandstone—uppermost Cambric of New York province.

Prefix—one or more letters or syllables united with the beginning of a word to modify its meaning, as *bi*, meaning two, in biserial.

Prehensile—adapted to seize or grasp.

Preoral—situated in front of the mouth.

Pro—a prefix meaning before; see *meso*.

Prodeltidium—in brachiopods, the early deltidium before fusion with the posterior margin of the ventral or pedicle valve.
Prodissoconch—the first shelled condition of pelecypods.
Produced—drawn out; elongated.
Proliferation—the production of numerous zooids by budding, especially when the buds arise from other buds in succession.
Proliferous—reproducing buds from the calyx.
Prolific—producing many young.
Proöstracum—the anterior portion of the internal shell of Belemnoidea. It is delicate, corneo-calcareous and represents the forward prolongation of the dorsal part of the phragmocone. Seldom preserved in the fossil state.
Propodite—see II., 388.
Propriodorsan—see Fig. 1231.
Proprioventran—see Fig. 1231.
Prosiphonate—see *siphonal funnel.*
Prosogyrate—curved forward. Used in reference to the umbos of pelecypod shells (see Fig. 772).
Prospect Mountain quartzite—lower Cambric of Nevada.
Protaspis—the earliest recognized stage in the development of a trilobite test.
Protegulum—the first shelled condition of brachiopods.
Prothorax—see II., 420.
Protoconch—the minute embryonic shell of gastropods and cephalopods. In gastropods, see apex in Fig. 1203, *c.* In cephalopods, see II., 19.
Protolenus beds—lowest middle Cambric of the Atlantic coast.
Protopodite—see II., 387.
Prout limestone—middle Devonic (Hamilton) of Ohio.
Provinculum—in the nepionic stage of many pelecypods, the primitive taxodont hinge; this is apparently independent of the permanent dentition which begins later by the development of laminæ on the hinge plate (see also I., 363).
Proximal—nearest the body or center.
Pseudo—a prefix meaning *false.*
Pseudocolumella—in corals, the false column formed by a twisting of the septa at the center of the cup (see I., 48).
Pseudodeltidium—the convex plate formed by the union of the deltidial plates. Usually easily distinguished from the true deltidium by the vertical growth lines (see Fig. 432).
Pseudo-fossulæ—see I., 48.
Pseudo-plankton—an organism which is normally or only in early life benthonic, but later drifts about aimlessly, either free or attached to a floating object (the latter also called *Epiplankton*).
Pseudo-septa—in certain Bryozoa, the ends of the lunaria projecting into the cells (see Fig. 182, *a, f*).
Pseudotheca—the false wall of a coral formed by the thickening and fusion of the outer ends of the septa.
Punctate—dotted; with scattered pits.
Pustule—a small, blister-like elevation.
Pustulose—bearing pustules or blisters.
Put-in-Bay limestone—lower Monroan, Michigan, Ohio, etc.
Pygidium—the posterior or tail portion of the carapace of trilobites (see Figs. 1542, 1585, 1586).
Pyramidal—in the form of a pyramid.
Pyriform—pear-shaped.

Quadrangular—four-angled.
Quadrant—a fourth part; the quarter of a circle.
Quadrate—with four equal sides and four right angles; a square.
Quadri—a prefix, meaning *four.*
Quadrifid—Cut into four parts.
Quartermaster formation—Permic of northern Texas.
Quebec group—Cambro-Ordovicic complex of Canada.
Queen Charlotte formation—Comanchic of Queen Charlotte Islands.
Quincunx—an arrangement of five objects with one at each corner of a

square or rectangle and one in the middle.

Quinnimont formation—middle Potsville (lower Carbonic) of Appalachians.

Rachis—the central stem of the frond, in Bryozoa, etc.

Racine beds—lower Siluric (Niagaran) of Wisconsin, etc.

Radials—the five main plates of the calyx of a crinoid, resting on the basals and alternating with them; they are the lowest of the plates forming an unbroken line from the arms (see Figs. 1864, 1907, *R*). For use in echinoids, see *ocular plates.*

Radianal—in crinoids, the second anal plate (see II., 491).

Radicular—root-like.

Radii—ribs or striations diverging from the beak of a shell.

Radula—in gastropods and cephalopods, the file-like lingual ribbon used in boring into shells and for tearing up food.

Raisin River dolomite—lower Monroan of Michigan, Ohio, etc.

Raleigh formation—division of the Potsville, Virginia.

Ramifying—branching.

Ramose—branched.

Ramus—branch of a skeletal structure.

Rancocas formation—upper Cretacic of Atlantic coast.

Raritan formation—upper Comanchic of Atlantic coast.

Ray—in crinoids, one of the arms or arm trunks.

Reading quartzite—lower Cambric of Pennsylvania.

Rectangular—right-angled.

Red Bank sands—middle Cretacic (Monmouth) of Atlantic coast.

Red Wall limestone—Mississippic of Grand Canyon.

Regan sandstone—middle Cambric of Oklahoma.

Regular—applied to an echinoid with mouth at center of bottom of test and anus at center of top; endocyclic (see Fig. 1920).

Reniform—kidney-shaped.

Resilifer—the spoon-like shelly structure projecting from the hinge plate in some pelecypods (as *Mactra*) for the reception of the resilium; the chondrophore.

Resilium—the internal cartilage or compressible substance in the hinge of pelecypods.

Respiration—the act of breathing; the aggregate of those processes by which oxygen is introduced into the system and carbon dioxid is removed.

Resupinate—inverted in position. In brachiopods, applied to those shells with the brachial valve convex and the pedicle valve concave (ex. *Strophomena*).

Reticulate—resembling a net-work.

Retractile—capable of being withdrawn.

Retral—back; posterior.

Retrosiphonate—see *siphonal funnel.*

Retroversal—backward bending.

Rhabdosome—the colony of graptolites derived by budding from a single polyp.

Rhaetic—upper division of the Triassic.

Rhomboid—an oblique-angled parallelogram with only opposite sides equal. A rhomb has all four sides equal.

Rhomboidal—having the outline of a rhomboid.

Rhynchonelloid—resembling *Rhynchonella.*

Ribs—the radial or transverse folds upon shells. In brachiopods and pelecypods they are radial; in cephalopods they are transverse.

Richmond group—upper division of the Cincinnati group.

Rico formation—upper Carbonic of Colorado.

Riley series—upper(?) Cambric of Texas.

Ripleyan—middle Cretacic of the Atlantic coast.

Rochester shale—division of the Niagaran of New York.

Rockford limestone (*Goniatite limestone*)—basal Mississippic of Indiana.

Rockwood formation—Niagaran of the Appalachians.

Rogersville shale—middle Cambric of the southern Appalachians.

Rome formation—lower Cambric of the southern Appalachians.

Romney formation—middle Devonic of Maryland, etc.

Rondout waterline—upper Siluric of eastern North America.

Root—in crinoids, the expanded basal portion of the stem, used for fixation only (see Fig. 1895).

Rosendale waterlime—upper Siluric of eastern North America.

Rostrum—a beak. In ammonites, the projection of the ventral (outer) portion of the living chamber anteriorly; in Belemnoidea, the guard; in trilobites the spine terminating the glabella anteriorly (*Ampyx*) (see Figs. 1548, 1550); in *Balanus*, that one of the two unpaired plates of the fixed tubular portion of the shell next to the scuta.

Rotten limestone—lower(?) Cretacic (Coloradoan?) of the Gulf region.

Rubideau formation—lower Ordovicic of Ozark region.

Rugose—wrinkled.

Rutledge limestone—middle Cambric of southern Appalachians.

Saddles—forward bending portions of the sutures in the shells of cephalopods; they point *toward* the aperture of the shell. (See also II., *21*, *23*.)

St. Anne beds—lower Ordovicic of Newfoundland.

St. Clair limestone—lower Siluric of Arkansas.

St. Croix formation—upper Cambric of the Mississippi Valley.

St. Genevieve—upper Mississippic of Mississippi Valley.

St. Joe marble—lower-middle Mississippic of Arkansas.

St. John formation—a term covering middle and upper Cambric, and lower Ordovicic of eastern Canada.

St. Lawrence beds—subdivision of the St. Croix.

St. Louis limestone—middle Mississippic of Mississippi Valley.

St. Mary's formation—subdivision of the Chesapeakean.

St. Piran formation—lower Cambric of Canadian Rockies.

Salem limestone—middle Mississippic of Indiana (see *Spergen limestone*).

Salient—standing out prominently.

Salinan—general term for middle Siluric.

Sandia—lower Carbonic of New Mexico.

San Diego formation—lower Pliocenic of Pacific coast.

Sandsuck formation—lower Cambric of southern Appalachians.

San Fernando formation—lower Oligocenic of Trinidad.

San Lorenzo formation—Oligocenic of Pacific coast.

San Pablo formation—upper Miocenic of Pacific coast.

Santa Margarita formation—upper Miocenic of Pacific coast.

Saratoga formation, *Saratogan*—general term for the highest upper Cambric; also often used for the entire upper Cambric.

Sawatch quartzite—upper Cambric of western Colorado.

Scabrous—rough or harsh, with little projecting points.

Scalæ—small transverse plates in the genus *Unitrypa* of the Bryozoa, connecting the expanded summits of the carinæ (see Fig. *202*, *g*).

Scalariform—stair- or ladder-shaped.

Scarboro formation—Pleistocenic of Canada.

Schaghticoke shale—uppermost Cambric of eastern New York.

Schizochroal—in trilobites, that type of compound eye in which each facet has a separate covering, as in *Phacops*.

Schizodont dentition—in pelecypods, with coarse, variable, amorphous teeth, as *Unio*.
Schoharie beds—basal middle Devonic of New York, etc.
Sclerenchyma—calcareous tissue deposited by the coral polyp.
Sclerite—a hard separate skeletal element, as in corals and insects (see II., 419).
Scrobicula—see *areola*.
Scrobicular—pertaining to scrobiculæ (areolæ).
Scrobicular circle—in echinoids, the ring of granules marking the outer limit of the areole (see Fig. 1918, *b, c*).
Scuta—in *Balanus*, the more horizontal of the two pairs of movable plates which form the operculum.
Scutellum—see II., 420.
Scutum—see II., 420.
Scythic—division of the lower Triassic.
Sedentary—stationary, not moving from place to place.
Sediment—its influence on life, I., 2.
Segment—one of the parts into which a body naturally separates. In trilobites, the varying number of divisions of the thorax articulating with one another.
Sellersburg beds—middle Devonic of Indiana.
Semi—a prefix, meaning *half*.
Semilunar—crescentic, or resembling a half moon.
Semiovate—half egg-shaped.
Senecan series—upper Devonic of eastern North America.
Senile—old.
Septal—pertaining to a septum.
Septal radii—radiating ridges taking the place of septa in certain corals.
Septate—with partitions or septa.
Septum (plural *septa*)—a wall or partition. In corals, one of the radiating calcareous plates (see Fig. 162; for cardinal, counter and lateral or alar septa, see Fig. 75; see also *mesentery*). In some brachiopods, the median ridge on the inside of the valves extending forward from the beak (see Figs. 382, lower right, and 407, *S*). In cephalopods, the transverse partitions between the chambers (see Fig. 1230).
Sequanian (*Corallian*)—division of upper Jurassic.
Serrate—notched like a saw, with sharp notches.
Sessile—attached by a broad base, not by a stalk.
Seta (plural *setæ*)—a bristle; a stiff, stout hair.
Setigerous—bristle-bearing.
Sevier shales—upper Ordovicic of the eastern Appalachians.
Sewickley formation—upper Carbonic of Ohio, Pennsylvania, etc.
Shakopee dolomite—lower Ordovicic of upper Mississippi Valley.
Shandon quartzite—upper(?) Cambric of the Rio Grande.
Shark River beds—lower Eocenic of New Jersey.
Sharon group—upper Pottsville of Ohio.
Shasta group—the Comanchic of the Pacific coast.
Shawangunk conglomerate—middle Siluric of eastern United States.
Shawnee group—upper Carbonic of Kansas.
Shelby dolomite—Guelph of New York.
Shenandoah group—lower Cambric to lower Ordovicic of southern Appalachians.
Shenango shale—upper Mississippic of western Pennsylvania, etc.
Sherbrook formation—upper Cambric of Canadian Rockies.
Shinarump formation—lower Triassic of Colorado.
Shirley formation—upper Jurassic of Wyoming.
Shoulder—in gastropods, see I., p. 583.
Sicula—in graptolites, the earliest hydrotheca of a colony (see Figs. 40, 49).

Sigmoid—curved in two directions like the letter S.

Silicification—the process of combining or impregnating with silica, or the state of being so impregnated (see I., 4).

Simpson formation—middle Ordovicic of Oklahoma.

Sinistral—left-handed; applied to the reversed coiling of some gastropod shells, as *Physa* (see Fig. 1204, and compare with the *dextral* coiling of *Limnæa*, Fig. 1203).

Sinuate—wavy, winding.

Sinuosity—a notch or incision forming a wavy outline.

Sinus—an elongate down-bending or depression.

Hyponomic sinus—the single median, marginal, concave bend on the venter of some cephalopods; it indicates the position of the hyponome (see II., 23).

Median sinus—in some brachiopods, the central and usually the largest depression extending from the beak to the front of the shell and usually upon the pedicle valve.

Sipho—referring to siphuncle; a combining word (see *endosipho-lining* and *preseptal sipho*, II., 20).

Siphon—in some pelecypods, one of the two, more or less tubular prolongations of the posterior mantle edges; the ventral or branchial siphon gives entrance to water carrying food and oxygen, the dorsal or anal siphon gives exit to the water carrying waste matter (see I., 362). In cephalopods, the fleshy, hollow cord prolonged from the base of the mantle passing through a rounded aperture in each septum, and extending to the inner side of the first or initial chamber.

Siphonal—pertaining to the siphon.

Siphonal funnel—the tubular continuation of a septum around the siphon. When this is prolonged backwards, as in most nautiloids, it is spoken of as *retrosiphonate*, when prolonged forward, as in most ammonoids, it is *prosiphonate*. It forms part of the siphuncle (see also II., 20).

Siphonal lobe—the lobe in the suture of an ammonoid shell which corresponds in position to the siphuncle; the ventral lobe.

Siphuncle—in cephalopods, the segmented horny or calcareous, tubular wall secreted by and surrounding the fleshy siphon. It consists of the siphonal funnels and connecting sheaths (see Figs. 1240, 1254, *d*, 1282).

Skaneateles shale—middle Devonic of New York.

Slickensides—polished or striated surfaces on rock due to motion under great pressure.

Slit—for *slit* and *slit-band* in gastropods, see I., 583, and Fig. 830.

Snowbird formation—lower Cambric of southern Appalachians.

Sockets—see *dental sockets*.

Somite—one of the segments, either visible or ideal, of an arthropod or vertebrate body (see Fig. 1542).

Spatulate—shaped like a spatula; spoon-shaped.

Species—one of the smaller divisions in classification.

Specific name—the second of the two or three names applied to a single fossil.

Spence shale—middle Cambric of Utah, Idaho.

Spergen limestone—middle Mississippic of Mississippi Valley.

Spheroidal—somewhat like a sphere.

Spicule—a minute spike or dart. In sponges spicules vary much in shape from a single needle-like form to a very complex body of many points.

Spine—in gastropods, see I., 583.

Spiniform—spine-like.

Spinose—full of spines or thorns.

Spinulose—spine-bearing.

Spiracle—in blastoids, the five or ten round or slit-like openings surrounding the mouth opening (see Fig. 1786).

Spiralium—a spiral brachidium (see Figs. 220_3, 392, *c*).

Spire—in gastropod shells, all whorls or coils above the opening (see Fig. 861).

Imperforate spire—the spire in which the coils are in contact at the center.

Perforate spire—a spire in which the axis of coiling is hollow; this hollow is the *umbilicus*.

Spiriferoid—shaped like *Spirifer* (see I., 186, 4).

Spirogyrate—curved outward. Used in reference to the umbos of pelecypod shells (see Fig. 633).

Spondylium—in some species of brachiopods, the spoon-shaped plate or cup under the beak, formed by the union of the dental plates (see Fig. 338, *A*, 324, *g*).

Spongin—the horny or fibrous substance of many sponges, as of the common bath sponge.

Spring Creek limestone—middle Mississippic of Arkansas.

Squamæ—scales. In corals, the small shelves often present on the inside of the wall near the mural pores.

Squamous—covered with scales.

Stafford limestone—middle Devonic (Marcellus) of New York.

Star Peak limestone — upper Triassic (Karnic) of Nevada.

Stellate—star-shaped.

Stephen formation—middle Cambric of Canadian Rockies.

Sternum—the breast-bone. For use in crustaceans, see II., 386; in insects, II., 420.

Stigma (plural *stigmata*)—in insects, the external opening of a trachea (see Figs. 1722, 4, 5, 6, 8, and II., 424).

Stipe—stalk, branch.

Stockbridge dolomite—lower Cambric to lower Ordovicic of western New England.

Stolon—an extension of the body wall from which buds are developed.

Stones River limestone—middle Ordovicic of eastern North America.

Strawn—middle Carbonic (Des Moinian) of Texas.

Striæ—fine radiating or concentric lines on the surface of shells.

Strophomenoid—shaped like *Strophomena* (see I., 184, 4).

Stylet—for use in Crustacea, see Fig. 1696.

Styliolites — peculiar columnar and striated rock forms seen in some limestones at the junction of two layers.

Sub—a prefix, meaning *under, almost, of low degree, e. g.*, subangular, rather angular.

Subcosta—in insects, one of the wing veins (see Fig. 1724).

Subdorsan—see Fig. 1231.

Sub-petaloid—in echinoids, applied to those ambulacra in which the two pore-bearing zones of each ambulacrum separate between the apex and the circumference of the test and do not tend to close in the latter region. These are longer than petaloid ambulacra (see Figs. 1921, *d, e, f*, and 1928, *g*).

Sub-quadrangular — between quadrangular and oval in outline.

Sub-quadrate — nearly but not quite square.

Sub-spheroidal—imperfectly spheroidal.

Subtegminal—in crinoids, applied to the mouth opening when it is beneath the tegmen (see II., 492).

Subventran—see Fig. 1231.

Suffix—one or more letters or syllables united with the end of a word to modify its meaning, *e. g., oid*, meaning in the shape of, in spheroid.

Sulcate—with deep furrows or grooves.

Sulcus (plural *sulci*)—a furrow or groove.

Sumner — division of the Permic of Kansas.

Sundance—upper Jurassic of the Black Hills, etc.

Super—a prefix meaning *over, above, beyond.*

Superradial—in crinoids, see II., 489.

Superior—higher in position.

Supplementary—additional.

Supra—a prefix, meaning *over, beyond;* akin to super.

Suture—the line of junction between two parts. In crinoids, the line of union between adjacent plates. In gastropods, the external line of junction between two contiguous whorls. In cephalopods, the line of junction between wall of shell and septum, seen on breaking away the former (see II., 21, 22). In trilobites, the dividing line between the fixed and the free cheeks, commonly called *facial suture.*

Sweetland Creek shales—upper Devonic of Iowa.

Sylvan shale—lower Siluric of Oklahoma.

Sylvania sandstone—middle Monroan of Michigan, Ohio, etc.

Symmetry—the reversed repetition of parts with reference to an axis.

Bilateral symmetry—the symmetrical duplication of parts *on each side* of a vertical axis, as in Crustacea.

Radial symmetry—the symmetrical repetition of parts *around* a common vertical axis, as in Hydrozoa.

Synapticulæ—in corals, the conical or cylindrical transverse projections from the sides of the septa; those of adjacent septa frequently become united.

Synonym—among fossils, see I., 6.

Syrinx—in brachiopods, a shelly tube, open along its inner margin and partially enclosing the pedicle, developed in the delthyrium of some spire-bearing forms, as in *Syringothyris.*

Syzygy—in crinoids, see II., 490.

Tabulæ—the transverse continuous floors which extend across the whole coral (see Figs. 80, upper, and 110, lower).

Tabulate—in corals, referring to the presence of the tabulæ.

Taconic—An American term equivalent to the Cambric.

Tallahatta—middle Eocenic of Alabama.

Tampa limestone—middle Oligocenic of Florida.

Tarsus—in insects, the foot (see II., 420).

Taylor marl—middle Cretacic of Texas.

Taxodont dentition—in pelecypods, the arrangement of teeth to form a continuous row, as in *Arca* (see I., 361).

Teeth—articulating projections on the margins of the valves of bivalve shells. In brachiopods, the pair of wedge-shaped projections bounding the base of the delthyrium (see Fig. 301, *i*). In pelecypods, see *lateral* and *cardinal teeth.*

Tegmen—the vault or cover of the calyx of crinoids (see Fig. 1805).

Tegminal—referring to the tegmen (see II., 492).

Tegulæ—see II., 424.

Tehuacan limestone—lower Comanchic of Mexico.

Tejon—lower Eocenic of the Pacific coast.

Teleodont dentition—in pelecypods, see I., 361.

Telson—in the Merostomata, some of the Trilobita and Phyllocarida, the final segment of the abdomen; it is often sword-shaped (Fig. 1701).

Tentacle—a more or less slender, flexible process, used as an organ of touch or for capturing prey (see Figs. 31, 56, 1230).

Tenuous—thin, slender.

Terebratuloid—like the genus *Terebratula* (see I., 181, 3).

Terete—cylindric and slightly tapering.

Terga—in *Balanus*, the more vertical of the two pairs of movable plates which form the operculum. In insects, see II., 420.

Tergite—see II., 420.

Test—the protective covering of some invertebrate animals. *Shell* is applied to such covering of brachiopods and mollusks, where it is secreted by a mantle; *test* to that of echinoids, crustaceans, etc., where the secretion is internal or by the whole surface of the body.

Tetrameral—in corals, the arrangement of all the septa of an individual into four groups.

Theca—the bounding wall of a coral growing as an independent structure from the bottom of the cup, as do the septa, and connecting the outer edges of the septa.

Thecal—pertaining to a wall.

Thoracic—pertaining to the thorax.

Thorax—central part of the body of trilobites and other arthropods (see Fig. 1542).

Tibia—in insects, that segment of the leg next the foot (see II., 420).

Tichenor limestone—middle Devonic of New York.

Tinton formation—middle Cretacic of Atlantic coast.

Tirolic divisions—part of upper marine Triassic.

Tithonian—upper Jurassic (including both Portlandian and Purbeckian).

Tomstown limestone—lower Cambric of Pennsylvania.

Torrejon group—lower Eocenic of New Mexico.

Trabeculæ—small rods or bars. In corals, see I., 81.

Trachiæ—in insects, air tubes penetrating the body.

Transverse—at right angles to the lengh. Applied also to shells which are wider than long.

Traverse group—middle Devonic of Michigan.

Travis Peak beds—lower Comanchic of Texas.

Trentonian—general name for upper Ordovicic.

Trenton limestone—upper Ordovicic of New York, etc.

Tri—a prefix, meaning *three* or *three-fold*.

Trigonal—three-angled.

Trimerelloid—see I., 177, 3.

Trinity (*Trinitan*)—general name for the lower Comanchic.

Trivium—in some echinoids, the three anterior ambulacra approach one another closely and are separated from the two posterior ambulacra by a wide space. The three anterior form the "*trivium*," and the two posterior the "*bivium*."

Trochanter—in insects, that segment of the leg next to the basal segment (see II., 420).

Trochantin—see II., 420.

Trochiform—in form like *Trochus*; cone-shaped (see I., 592, *e*).

Trochoceracone—an asymmetrically coiled Nautiloid shell (see II., 19, and Figs. 1288 and 1290).

Troy limestone—lower Cambric of eastern New York.

Tube-feet—in star-fish and sea-urchins, the extensible, fleshy, foot-like protrusions from the ambulacral areas, by means of which the animal moves.

Tubercle—a knob-like process. In echinoids, see II., 574, and Fig. 1918, *b*, *c*).

Tuberose—having knobs.

Tubule—a small tube or pipe.

Tullahoma formation—lower Mississippic of Tennesee and Kentucky.

Tully limestone—basal upper Devonic of central New York.

Tumid—swollen, inflated.

Turbinate—shaped like a top. In gastropods, those shells whose whorls decrease rapidly from a broad base to the pointed apex.

Turreted—furnished with one or more turrets or towers. Applied to gastropods with elongate shells composed of many distinct whorls (see Fig. 1064).

Turriliticone—an asymmetrically coiled Ammonoid shell (see II., 19).

Turritelliform—shaped like *Turritella;* spire slender, of many whorls (see Fig. 1064).

Type—an individual animal from which a recognizable description or figure has been prepared and upon which a specific name has been based.

Co-type—each of the several specimens from which a single species has been described when no single specimen has been indicated as holotype; called also *syntype.*

Genotype—the *one* species upon which a genus is founded.

Holotype—the *one* specimen upon which a species is founded.

Type of genus—see *genotype.*

Uffington shale—upper Allegheny (middle Carbonic) of West Virginia.

Uintah group—upper Eocenic of Utah.

Uintah quartzite—basal Cambric (or pre-Cambric) of Wasatch Mountains.

Ulsterian series—a division of the middle Devonic.

Ultimate—last.

Umbilicated—provided with an umbilicus.

Umbilicus—an external depression or opening at the center of many loosely coiled shells. It is usually at the base of gastropods and at the sides of cephalopods (see Figs. 851, *f, g,* and 1405).

Umbo—the area about and including the beak in bivalve shells (see Fig. 218, *u.* In pelecypods, Fig. 476).

Undulating—formed with elevations and depressions, resembling waves.

Undulation—a wave-like elevation.

Uni—a prefix, meaning *one.*

Unilocular—of one chamber.

Uniserial—in one row or series. For application in crinoids, see II., 490, and Fig. 1806.

Ute limestone—upper Cambric and lower Ordovicic of Wasatch Mountains.

Utica shales—upper Ordovicic of Canada, New York, Pennsylvania, etc.

Valves—the one or more pieces of which a shell consists. Brachiopods and pelecypods are bivalve; gastropods and cephalopods are univalve.

Valvular—pertaining to a valve.

Vaqueros formation—lower Miocenic of the Pacific coast.

Varicose—irregularly enlarged.

Varietal name—see *variety.*

Variety—the last of the three names (not the author's name) sometimes applied to a single fossil. Most fossils have but two names, the generic and the specific.

Varix (plural *varices*)—in gastropod shells, a row of spines or a ridge, extending across each of the whorls, denoting the former position of the outer lip, as in *Murex.* In cephalopods, see II., 23.

Vascular—pertaining to the tubes or vessels for the circulation of plant or animal fluids.

Vascular sinuses or markings—impressions upon the inside of brachiopod shells, indicating the presence in the living animal of folds (pallial sinuses) in the mantle to carry the primitive "blood" (see Figs. 221, *s, ps, o;* 305, 309, *v*).

Vaulted—arched.

Veins—for arrangement in insects, see II., 420, and Fig. 1724.

Venter—the abdomen. In most cephalopod shells, the exterior of the coil.

Ventrad—toward the venter.

Ventral—pertaining to the lower or abdominal side or venter.

Ventral lobe—see *siphonal lobe.*

Ventral valve—in brachiopods, the pedicle valve.

Ventricose—very convex; strongly swollen.

Ventrocentran—see Fig. 1231.

Vermicular sandstone—upper Kinderhook of Mississippi Valley.

Vermont quartzites—lower Cambric of northern Appalachians.

Verticil—several objects forming a circle around an axis, as of leaves about a stem at the same node.

Vesicle—a bladder-like vessel, a cell.

Vesicular—bearing vesicles or hollow cavities.

Vestibule—in Bryozoa, a tubular shaft at the bottom of which the zoëcial aperture occurs.

Vicksburgian—general term for lower Oligocenic.

Vicksburg limestone—lower Oligocenic of Gulf coast.

Vincentown sands—upper Cretacic (Jerseyan) of Atlantic coast.

Viola limestone—upper Ordovicic of Oklahoma.

Virgula—in graptolites, the median axis or strengthening rod extending the entire length of a branch (see Fig. 50).

Viscera—the internal organs of the body.

Vitreous—glassy.

Volution—a spiral turn; a whorl.

Wabaunsee formation—Permo-Carbonic of Kansas.

Waccama formation—lower Pliocenic of Carolinas.

Waldron shale—Niagaran of Indiana and Tennessee.

Walnut clay—Fredericksburgian or middle Comanchic.

Wapanucka limestone—Arkansan (lower Carbonic) of Oklahoma.

Wappinger limestone—lower Cambric to lower Ordovicic of eastern New York.

Wapsipinicon limestone—middle Devonic of Iowa.

Warsaw shales and limestones—upper division of Osage group, lower Mississippic of Mississippi Valley.

Wasatch limestone—Mississippic of Wasatch Mountains.

Washita division—upper Comanchic, general term.

Waukeshaw beds—Niagaran of Wisconsin.

Waverlyan, Waverly group—lower Mississippic of eastern North America.

Waynesboro formation—middle Cambric of Pennsylvania-Maryland.

Waynesburg formation—upper Monongahela of Ohio, Pennsylvania, etc.

Wellington division—subdivision of the Sumner, Kansas.

Wenonah formation—middle Cretacic of Atlantic coast.

Weverton sandstone—lower Cambric of Pennsylvania and Maryland.

White Horse formation—Permic of northern Texas.

White Pine shale—Mississippic of Nevada.

White River beds—Oligocenic of South Dakota.

Whitewood limestone—upper Ordovicic of Black Hills.

Whorl—a single turn or volution of a coiled shell.

Wilbur limestone—upper Siluric of the Helderberg Mountains.

Wind River beds—lower to middle Eocenic of Wyoming.

Windsor limestone—Carbonic of Nova Scotia.

Wing—in pelecypods, the posterior and larger expansion along the hinge line.

Woodbury clay—middle Cretacic of Atlantic coast.

Woods Bluff beds—lower Eocenic of Alabama.

Woodstock formation—subdivision of Pamunkey of Atlantic coast.

Wreford formation—subdivision of the Chase of Kansas.

Wyoming formation—Triassic of the Front Range region.

Yellville limestone—upper Cambric and lower Ordovicic of the Ozarks.

York shale—lower Cambric of southern Pennsylvania.

Yule limestone—lower Ordovicic of western Colorado.

Zoarium—a colony of Bryozoa formed

by the repeated budding from a single individual.

Zoëcium—the membranous or calcareous cup surrounding the base of the expanded zoöid and into which the animal can withdraw for protection.

Zoöid—an individual animal of a colony of Hydrozoa, Anthozoa or Bryozoa.

Zygous—paired. In cephalopods, referring to the paired lobes and saddles. All are paired except the siphonal and antisiphonal lobes.

INDEX OF GENERA.

Volumes I. and II.

In this index are included also names of subgenera, families, orders, classes and phyla. The numbers refer to the volume and page. Names of genera and subgenera regarded as synonyms are printed in *italics*. The gender of each genus and subgenus is indicated by the letters m (masculine), f (feminine), or n (neuter).

INDEX OF SPECIES.

Volumes I. and II.

Names of varieties are printed as species. The numbers refer to the volume and page. The gender of each genus and subgenus is indicated by the letters m (masculine), f (feminine), or n (neuter). When a species name of adjective form is followed by two or more genera or subgenera of differing gender, there are placed after it the appropriate endings in the order—masculine, feminine and neuter. Names of genera, subgenera and species regarded as synonyms are, when possible, printed in *italics.*