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THE FAUNA OF THE CHAPMAN SANDSTONE OF MAINE

INCLUDING DESCRIPTIONS OF SOME RELATED SPECIES FROM THE MOOSE RIVER SANDSTONE

BY

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ASSISTED BY

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PREFACE.

By Henry Shaler Williams.

In the year 1897 I began an investigation of the Paleozoic rocks and fossils of Maine, in the hope of gaining through their study a better understanding than was then to be had from published literature of the relation between the well-known upper Paleozoic of Europe and that of the interior of the North American continent.

A preliminary report, based on the evidence already possessed and the new facts obtained by field work in Aroostook County, was published in 1900.[1] In that report I gathered lists of fossil faunas of Maine at that time published and discussed their bearing on the problems of classification and correlation of the formations concerned. I also there referred to the special importance of the fossils of the Chapman sandstone as the expression of an intermediate fauna linking together the faunas of New York and those of the Tilestone, or terminal Silurian, of Great Britain. As the Tilestone marked the uppermost boundary of the Silurian for the British section, a full exposition of the facts for correlation of the European and American geologic sections was important. As this boundary in Great Britain represented also the passage for a considerable area from the marine Silurian up into the estuarine conditions of the Old Red sandstone, it was believed that a careful study of the relations of the successive faunas and the changes in sedimentation associated with the several faunules would prove of value in establishing at least one stratigraphic boundary by which the sections of the two continents might be precisely compared.

The fauna of the Chapman sandstone was therefore selected for special study and description. Further collections were made from the typical localities in Aroostook County by Olaf O. Nylander for the United States Geological Survey, and additions were also made to the fauna of the Moose River sandstone, a related but later fauna, by a set of fossils collected by Harold W. Prince at Detroit, Somerset County, Maine. I was enabled to examine the Gaspe and Arisaig faunas through the courtesy of the officers of the Canadian Survey.

In order that the British related sections might be more accurately defined, the committee of the International Congress of Geology on stratigraphic classification was urged at the Berlin congress in 1898 to designate geologists of each country to establish with greater precision the system boundary lines, the typical definition of which was based on the sections of their respective countries. Although the chairman of the committee, Dr. Renevier, reported unfavorably upon this proposition, the English member of the committee, Prof. T. M. Hughes, of Cambridge, established the standard upper boundary of the Silurian at Dudley, thus furnishing an accurate definition of the "passage beds" in which the exact section is given and the exact faunal contents of each zone defined.[2]

During the preparation of the present work the English collections most closely associated with the Chapman fauna were also studied, but it was discovered that hardly any of the species are strictly identical, although many affinities are close. The pelecypods particularly in the British collections were found to show such variation in specific characters that redefinition and refiguring of many of the specimens would be necessary before it would be possible to make comparisons with precision.

[1] Williams, H. S., and Gregory, H. E., Contributions to the geology of Maine: U. S. Geol. Survey Bull. 165, 1900.

[2] Elles, G. L., and Slater, I. L., The highest Silurian rocks of the Ludlow district: Geol. Soc. London Quart. Jour., vol. 42, pp. 195-222, Pl. XXII, map, 1906.

In this country, while the investigations here recorded were in progress, Charles Schuchert, J. M. Clarke, C. E. Beecher, and others have contributed much additional information concerning the faunas of the Helderberg and Oriskany, so that greater precision of correlation with the sections in New York and the interior is now possible than when this work was begun. After the descriptions of most of the species had been written out and the figures prepared, some readjustment of nomenclature was necessitated by the publication by the State geologist of New York of descriptions of species of the same faunas of Maine from specimens furnished to him by Mr. Nylander.

As the work proceeded it became important to have lists of all the closely related species mentioned in American and European formations. In the preparation of these lists and the associated bibliography I had the valuable assistance of Mr. Carpel Leventhal Breger, who has also done an immense amount of enthusiastic work in recording the minute details of structure of the species under investigation.

In the preparation of the present paper it was originally intended to confine the study to an elaboration of the Chapman sandstone faunas alone, but comparison of species has led to the introduction of several species from closely related faunas, particularly those of the Moose River sandstone, of somewhat later age, exposed in Somerset County in central and northern Maine. Descriptions of a few of these species not previously named and described are included, but no attempt has been made to give an exhaustive account of the Moose River fauna.

Several other Paleozoic faunas of Maine await elaboration and will furnish material for interesting monographs.

Although it has been possible as a result of this work to throw some light upon the problem of correlation of formations on the two sides of the Atlantic, I fully appreciate that only a small beginning has been made. The present paper will, however, I think, serve to stimulate future paleontologists to continue this work and attain the rich results which this line of investigation promises to yield.

NOTE.—The omission of reference to much interesting literature bearing upon the correlation of the Chapman fauna now (1915) in the hands of geologists may be explained by the following statements: The manuscript of this professional paper was mainly complete in the year 1906. Delay in publication led to the elimination of several chapters in 1910, when it was entirely revised and prepared for publication. It has been in the custody of the Geological Survey since 1910, and it would require so much additional matter to properly discuss the questions which have arisen since the text was written that it has seemed best to print the paleontologic matter as it is and reserve for future discussion the correlation problems, which are still unsettled and upon which the fossils will throw new light.

HENRY S. WILLIAMS.

WASHINGTON, *March 5, 1915.*

THE FAUNA OF THE CHAPMAN SANDSTONE OF MAINE, INCLUDING DESCRIPTIONS OF SOME RELATED SPECIES FROM THE MOOSE RIVER SANDSTONE.

By Henry Shaler Williams, assisted by Carpel Leventhal Breger.

CHAPMAN SANDSTONE.

The Chapman sandstone is exposed over a small area in Chapman Township[1] (T. 11, R. 3), Aroostook County, Maine, a few miles west of Presque Isle and south of Aroostook River. This exposure is shown on the accompanying geologic map (fig. 1) by the southern half of the sandstone area west of Presque Isle, in the township marked "11–3." The northern part of the sandstone outcrop in Mapleton Township (T. 12, R. 3), marked "12–3," is the Mapleton sandstone. The two sandstone masses are separated by large knobs of andesite, marked "3, 3, 3" on the map, two of which are known locally as Edmunds Hill and Hobart Hill.

No contact of either of these sandstone masses with underlying sedimentary rocks has been seen, but structurally they appear to have been deposited unconformably upon the Silurian limestone or shale beds of the region. The general dip of both sandstones is northwesterly, and, as I stated in a previous report[2]—

> The Mapleton sandstones are believed to be of more recent age than the Chapman rocks but were probably continuous with them, and the two may represent the base and succeeding strata of the Gaspe sandstone of Gaspe Peninsula.

The Chapman sandstone includes at least 500 feet of medium fine grained brown to gray sandstone, in no place conglomeratic, much of it thick bedded, with some fine-grained shaly layers separating the beds. In these shaly sandstones occur most of the fossils, which are marine. Here and there fragments of plants (Psilophyton, etc.) appear in the sandstone. In the supposedly overlying Mapleton sandstone only plant fossils have been discovered.

The typical exposure of the Chapman sandstone is along the east (right) bank of the south branch of Presque Isle Stream, about a mile from the south line of Chapman Township and about a mile west of Tweedys, on the road running southwestward from Presque Isle. The specimens from this locality are labeled 1099 A. The specimens labeled 1099 L came from a single sandy stratum 150 feet from the top of the exposure at which collection 1099 A was obtained. Collection 1099 J came from an outcrop about 2 miles west of the locality of collection 1099 A, and collection 1099 K from a point 2½ miles west of the south branch of Presque Isle Stream.

The fossils labeled 1099 C are from the Chapman sandstone at the foot of Edmunds Hill, underlying the andesite which forms the mass of that knob. Specimens from the talus heap on the west side of Edmunds Hill are labeled 1099 M.

The following list shows the species and varieties belonging to the Chapman fauna, the localities from which they came being indicated in the columns on the right by letters which correspond to the letters distinguishing the collections mentioned above:

[1] Chapman Township was called Chapman Plantation on the map of Walling & Chace, published in 1862, which accounts for the use of the term Chapman Plantation in some of the literature of later date. The areas appear to be the same.

[2] Contributions to the geology of Maine: U. S. Geol. Survey Bull. 165, p. 88, 1900.

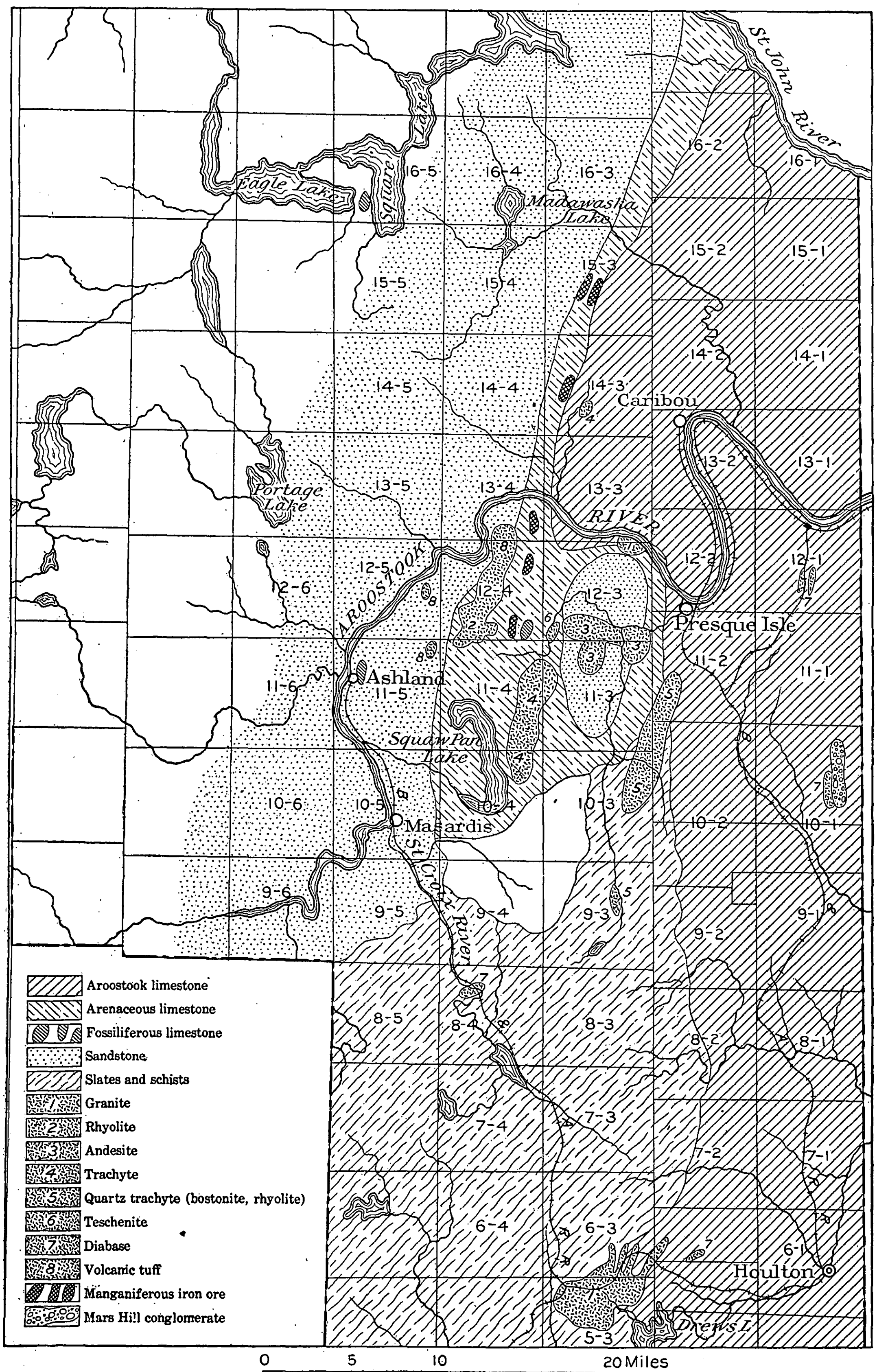

FIGURE 1.—Map of Aroostook County volcanic area, Maine. Reprinted from U. S. Geol. Survey Bull. 165, Pl. IV.

Fauna of the Chapman sandstone.

	Localities.						
1. Pleurodictyum cf. P. problematicum Goldfuss			A				
2. Favosites sp. indet.		M					
3. Cornulites serpularius Schlotheim	C						
4. Trachyderma (?Gyrichnites) speciosa sp. nov	C						
5. Polypora cf. P. lilæa Hall					J		
6. Polypora cf. P. psyche Billings	C						
7. Lingula minuscula sp. nov					J		
8. Orbiculoidea (Roemerella) discus Hall	C			L	J		
9. Crania sp. indet		M					
10. Leptostrophia perplana (Conrad)		M					
11. Leptæna rhomboidalis Wilckens	C	M					
12. Schuchertella deformis Hall	C	M					
13. Hipparionyx unguiformis Conrad	C	M					
14. Chonetes striatissimus sp. nov	C				J	K	
15. Chonetes novascoticus Hall		M					
16. Dalmanella planoconvexa Hall		M					
17. Dalmanella cf. D. circularis Sowerby		M					
18. Dalmanella (Mystrophora) elevata sp. nov	C						
19. Stenoscisma formosa Hall		M					
20. Stenoscisma formosa Hall (young)	C						
21. Rhynchonella cf. mainensis Billings	C						
22. Eatonia singularis Vanuxem		M					
23. Beachia chapmani sp. nov	C						
24. Megalanteris sp.?	C						
25. Rensselaeria mainensis Williams	C	M	A	L		K	B′
26. Eunella ellsi (Clarke)		M					
27. Cyrtina heteroclita α var. nov		M					
28. Cyrtina rostrata Hall	?C	M					
29. Spirifer concinnus Hall				L			B[1–3]
30. Spirifer cyclopterus Hall	C	M					B[2]
31. Spirifer sparsus Clarke	C			L	J		
32. Nucleospira ventricosa Hall	C					K	
33. Meristella cf. M. bella Hall		M					
34. Pentagonia (?) sp. indet	C						
35. Orthodesma carinifera sp. nov					J		
36. Grammysia acadica Billings, var	C						
37. Grammysia elymelloides sp. nov			A				
38. Grammysia modiomorphæ (Clarke)	C						
39. Physetomya sp. indet		M					
40. Elymella harrisi sp. nov	C						
41. Glossites amnigenoides sp. nov	C						
42. Glossites barrandii sp. nov		M					
43. Glossites cf. G. depressus Reed (not Hall)		M					
44. Cleidophorus curtus sp. nov	C						
45. Cleidophorus perovalis sp. nov		M					
46. Myoplusia chapmani sp. nov			A				
47. Tellinites chapmani sp. nov					J		
48. Tellinites curta sp. nov		M					
49. Tellinites (Koenenia) gibbosa Goldfuss var. kayseri Beushausen			A		J		
50. Tellinites gibbosa var. crassa Beushausen					J		
51. Paleoneilo (Ditichia) mainensis Clarke	C						
52. Paleoneilo (Ditichia) mainensis umbonata var. nov		?M	A		J		
53. Leda harrisi sp. nov					J		
54. Leda minuta sp. nov			A				
55. Nuculoidea cf. N. aquisgranensis Beushausen		M					
56. Nuculoidea bellatula sp. nov		M					
57. Nuculoidea cordata sp. nov	C						
58. Nuculoidea trigonale sp. nov		M					
59. Actinopterella aroostooki (Clarke)		M					
60. Actinopterella aroostooki erecta var. nov							B[4]
61. Actinopterella aroostooki planicosta var. nov	C						
62. Actinopterella concentrica sp. nov	C	M					
63. Actinopterella radialis (Clarke)				L			
64. Actinopterella sp. β			A				
65. Actinopterella sp. γ			A				
66. Actinopterella sp. δ						K	
67. Pteronitella quadrata sp. nov				L			
68. Limoptera pauciradiata chapmani var. nov	C						
69. Preavicula breva sp. nov					J		
70. Preavicula oblonga (Hall) gen. nov	C				J	K	
71. Leiopteria riesiana sp. nov				L			
72. Myalina maureriana sp. nov			A	L			
73. Myalina maureriana lata var. nov				L			

Fauna of the Chapman sandstone—Continued.

	Localities.						
74. Myalina maureriana pterinæoides (Clarke)				L			
75. Conocardium? dubia sp. nov			A				
76. Modiomorpha aroostook sp. nov				L			
77. Modiomorpha cf. M. protea Clarke	C						
78. Modiomorpha sp. indet							B [2]
79. Modiomorpha (cf. Endodesma) chapmani sp. nov	C	M					
80. Goniophora kayseri sp. nov		M					
81. Goniophora ω sp. nov					J		
82. Sphenotomorpha rigidula gen. et sp. nov						K	
83. Cimitaria chapmani sp. nov			A				
84. Anodontopsis maccoyiana sp. nov				L	J		
85. Schizodus? prunum sp. nov	C						
86. Schizodus? sp. indet	C						
87. Cypricardella bellatula sp. nov			A				
88. Cypricardella cf. C. bicostula Krantz		M					
89. Cypricardella rotundata sp. nov		M					
90. Cypricardella transversa sp. nov	C						
91. Paracyclas bulloides sp. nov					J		
92. Palæosolen chapmani sp. nov			A				
93. Platyceras (Orthonychia) aroostooki sp. nov	C						
94. Platyceras (Orthonychia) compressa sp. nov		M					
95. Platyceras chapmani sp. nov	C	M					
96. Platyceras edmundi sp. nov	C						
97. Platyceras (Orthonychia) hebes Clarke		M					
98. Platyceras (Orthonychia) hebes var. α		M					
99. Platyceras (Orthonychia) hebes var. β		M					
100. Strophostylus sp. cf. S. globosus Hall	C						
101. Bellerophon (Plectonotus) trilobatus Sowerby	C				J	K	
102. Tropidodiscus obex Clarke	C	M				K	B
103. Tropidodiscus minimus americanus var. nov					J		
104. Mesocœlia tenuella sp. nov				L			
105. Mesocœlia? sp. (near M. compacta Hall)			A				
106. Cœlidium cf. C. planogyratum Hall				L			
107. Goniostropha chapmani sp. nov					J		
108. Pseudotectus hitchcocki Clarke			A				
109. Pseudotectus? deciduus sp. nov					J		
110. Pseudotectus(?) sp. indet	C						
111. Holopea (Auriptygma) beushauseni Clarke	?C	?M	A	L	J	?K	
112. Tentaculites schlotheimi Koken	C	M				K	
113. Orthoceras sp. (? O. norumbegæ Clarke)	C	M					
114. Homalonotus laticaudatus sp. nov	C	M				K	
115. Homalonotus vanuxemi Hall					J		
116. Phacopidella chapmani sp. nov		M					
117. Dalmanites (? Synphoria) α sp. nov	C						
118. Dalmanites (? Synphoria) β sp. nov		M					
119. Zygobeyrichia extrema Ulrich	C		A		J		
120. Zygobeyrichia apicalis Ulrich	C		A		J		
121. Zygobeyrichia devonica Jones and Woodward	C		A		J		
122. Ctneobolbina (?) cornuta Ulrich	C		A		J		
123. Asterolepis clarkei Eastman					J		
124. Psilophyton princeps? Dawson (not with marine fossils)			A				
125. Indetermined wood stems (not with marine fossils)			A				

During the preparation of this report the State geologist of New York, J. M. Clarke, described a number of the species belonging to the Chapman fauna,[1] giving them specific names. Some of these species are identical with those for which my descriptions had already been written; for them Clarke's names have been substituted. Others imperfectly diagnosed by Clarke have been described in the present text. In the following list all these species are cited with references to the pages in Clarke's report where they are discussed. The names indented in the list are those assigned by Clarke to species herein described under different names, which are also given. This list and the one preceding comprise all the species known to belong to the Chapman fauna at the date of completion of this report.

[1] Clarke, J. M., Some new Devonic fossils: New York State Mus. Bull. 107, pp. 153-291, May, 1907.

Species from Chapman Township described by J. M. Clarke, 1907.

	Edmunds Hill.	Page in Clarke's report.
1.	Phacops (Phacopidella) nylanderi Clarke	166
2.	Tentaculites scalaris Schlotheim (see T. schlotheimi Koken of present report, p. 283)	174
3.	Orthoceras norumbegæ Clarke	177
4.	Platyceras hebes Clarke (see P. (Orthonychia) hebes of present report, p. 260)	185
5.	Platyceras kahlebergensis (Beushausen) (see P. chapmani sp. nov. of present report, p. 259)	185
6.	Loxonema cf. funatum (A. Roemer) (possibly L. jerseyense Weller)	186
7.	Holopea beushauseni Clarke (see H. (Auriptygma) beushauseni of present report, p. 281)	188
8.	Tropidodiscus obex Clarke (see present report, p. 270)	193
9.	Pterinopecten aroostooki Clarke (see Actinopterella aroostooki of present report, p. 187)	199
10.	Pterinea chapmani Clarke (apparently a species of Actinopterella)	203
11.	Pterinea edmundi Clarke (see Actinopterella aroostooki of present report, p. 189)	203
12.	Pterinea edmundi var. subrecta Clarke (see Actinopterella aroostooki var. erecta of present report, p. 189)	204
13.	Pterinea brisa Clarke (apparently a species of Limoptera)	208
14.	Modiomorpha vulcanalis Clarke (apparently a member of the Cyrtodonta group, also in part the Modiomorpha aroostooki of present report)	219
15.	Modiomorpha protea Clarke (see present report, p. 219)	220
16.	Grammysia modiomorphæ Clarke (see present report, p. 138)	221
17.	Spirifer aroostookensis Clarke	258
18.	Spirifer macropleuroides Clarke	259
19.	Chonetes aroostookensis Clarke (see C. novascoticus Hall of present report, p. 45)	264
20.	Chonetes paucistria Clarke	266
21.	Leptostrophia magnifica Hall, protype parva Clarke (see L. perplana (Conrad) of present report, p. 27)	274
22.	Hipparionyx minor Clarke (see H. unguiformis (Conrad) of present report, p. 41)	278
23.	Dalmanella drevermanni Clarke (see D. planoconvexa Hall of present report, p. 57)	286
	Presque Isle Stream.	
	Holopea beushauseni Clarke (see No. 7 above)	188
24.	Cœlidium tenue Clarke (see Mesocœlia tenuella of present report, p. 273)	190
25.	Eotomaria hitchcocki Clarke (see Pseudotectus hitchcocki of present report, p. 278)	190
26.	Pterinea cf. fasciculata Goldfuss (see Actinopterella concentrica sp. nov. of present report, p. 190)	204
27.	Pterinea radialis Clarke (see Actinopterella radialis (Clarke) of present report, p. 184)	207
28.	Pteronitella peninsulæ Clarke (see Actinopterella radialis (Clarke) of present report, p. 184)	212
29.	Myalina pterinæoides Clarke (see M. maureriana sp. nov. var. pterinæoides of present report, p. 215)	213
	Modiomorpha protea Clarke (see No. 15 above)	220
30.	Leptodomus communis Clarke	224
31.	Leptodomus corrugatus Clarke	224
32.	Paleoneilo mainensis Clarke (see P. (Ditichia) mainensis of present report, p. 168)	230
33.	Palæoneilo circulus Clarke (see Tellinites gibbosa var. kayseri Beushausen of present report, p. 165)	231
34.	Nucula cf. N. krachtæ A. Roemer (possibly Myoplusia chapmani sp. nov. of present report, p. 162)	232
35.	Paleosolen simplex Maurer (Chapman specimens are the young of P. chapmani, p. 251)	235
36.	Rensselaeria atlantica Clarke (see R. mainensis of present report, p. 72)	243
37.	Spirifer subcuspidatus var. latëincisus Scupin (see S. concinnus Hall of present report, p. 80)	254
38.	Spirifer cymindis Clarke (see S. cyclopterus Hall of present report, p. 88)	255
39.	Spirifer cymindis var. sparsa Clarke (see S. sparsus of present report, p. 105)	257

Examination of the lists of species shows that two somewhat distinct faunules are recognizable in the general Chapman sandstone collections. One of these faunules comprises the faunal aggregates from Edmunds Hill (localities 1099 C and 1099 M) and the other the collections from Presque Isle Stream and the region to the west (localities 1099 A, 1099 L, 1099 J, and 1099 K). As the general inclination of the beds over Chapman Township is northerly, it is probable that the Edmunds Hill faunule is from a zone stratigraphically higher than the beds on Presque Isle Stream, although it is possible that faulting may disturb the succession. Of the 127 species and varieties described in the present report 66 are peculiar to the Edmunds Hill faunule, 48 are peculiar to the beds along Presque Isle Stream, and 13 are species common to both. Thirty-five Chapman species have been recognized elsewhere.

SPECIES FROM MOOSE RIVER SANDSTONE.

In preparing descriptions of the Chapman sandstone fauna, specimens of allied faunas were brought in for comparison. Some of these it was found desirable to describe and illustrate in order to make clear the relation of the normal species of the Chapman fauna to the allied species of the same genetic series. Some of these extraneous fossils are well-known landmarks in the stratigraphic column and serve to indicate the relation of the fauna in which they occur to that of the Chapman sandstone. Most of these closely allied forms come from the formation known as the Moose River sandstone, which outcrops west of the region of the Chapman sandstone in Somerset County.

Study of this Moose River fauna leads to the opinion that it is of later age than the Chapman sandstone fauna. The Moose River sandstone contains several species common to the fauna of the Oriskany sandstone of New York State and the Appalachian region. It also contains *Spirifer gaspensis* Billings and some lamellibranchs which suggest that it has affinity with the fauna of the "Unter-Coblenzian" of the Rhenish Lower Devonian.

The principal fossil localities of the Moose River sandstone are given in the following list. Most of these collections were made by Gilbert Van Ingen in 1889 for the United States Geological Survey and were roughly identified in preliminary lists made by me and published in 1909.[1]

1059 C. Parlin Pond. A section beginning on Parlin Stream at the middle dam, where the stream runs more than a mile over the sandstones and shales of the Moose River formation.

1059 D. Jackman farm. A section on Canada Road, in the town of Jackman, 10 miles south of Moose River settlement and 5 miles north of Parlin Pond.

1059 D 1. A section on the east side of Canada road, at Bean Brook, 3 miles north of Parlin Pond Hotel.

1060 A. Ledges at the northwest end of Long Pond, forming islands in the lake.

1060 B 4. A ledge on the south shore of Long Pond, 5½ miles west of the outlet.

1061 A. A section on the south shore of Little Brassua Lake, along the Canadian Pacific Railway, beginning at milepost 237 and extending southward.

1061 B 1. A hard, tough sandstone, with shaly partings, on Stony Brook.

1062. Exposures on shores and islands of Big Brassua Lake.

1062 B. Brassua Stream, extending upstream from a point 2 miles above the lake.

1062 A 1, B 2, B 6, B 7, C 3. Outcrops along Brassua Stream.

1100 A. Detroit.

All the foregoing fossil localities of the Moose River sandstone are in Somerset County, Maine. The collections from Detroit, Maine, were furnished to the Geological Survey by Mr. Harold Prince, a resident of that village. According to Mr. Prince, "some were found in the ledge on Parlin Stream, 1½ or 2 miles below Parlin Pond, Somerset County, Maine; the others were found in drift rock at various points in an almost direct line from Parlin Pond to Detroit, in the southeast corner of the county. The larger brachiopods (Chonetes and Leptostrophia) were found in drift at the Forks Plantation."

In the present paper reference is made to the following species from the Moose River sandstone of Somerset County:

Locality 1062. Brassua Stream:
  Schuchertella woolworthana (Hall); p. 34, Pl. III, fig. 10.
  Spirifer duodenarius Hall; p. 104, Pl. IV, figs. 3, 4.
Locality 1061. Little Brassua Lake:
  Spirifer gaspensis Billings; p. 107, Pl. IV, fig. 7.

[1] Williams, H. S., and Gregory, H. E., Contributions to the geology of Maine: U. S. Geol. Survey Bull. 165, pp. 88 et seq., 1900.

Locality 1100 A. Parlin Pond, or in drift between pond and Detroit:
- Leptostrophia perplana (Conrad); p. 27, Pl. VIII, figs. 1, 2, 4, 5, 16; Pl. XI, fig. 17.
- Chonetes novascoticus var. canadensis Billings; p. 45, Pl. XI, fig. 16; Pl. X, figs. 30, 31; Pl. IX, figs. 20, 21.
- Chonostrophia complanata (Hall); p. 55, Pl. X, fig. 4.
- Spirifer arenosus Conrad; p. 84, Pl. II, figs. 15, 16, 19, 21; Pl. V, fig. 18.
- Spirifer murchisoni Castelnau; p. 95, Pl. I, figs. 3, 10, 23, 25, 26; Pl. II, fig. 9.
- Antispirifer harroldi gen. et sp. nov.; p. 116, Pl. V, figs. 1–13.
- Leptocœlia flabellites (Conrad); p. 120, Pl. V, figs. 19–30.
- Grammysia (Grammysioidea) princiana sp. nov.; p. 136, Pl. XX, fig. 8.
- Cypricardites detroitense sp. nov.; p. 155, Pl. XXIII, figs. 14, 15.
- Follmannella mainensis (Clarke); p. 179, Pl. XVI, figs. 1–6; Pl. XVII, figs. 1–11.
- Actinopterella tenuiradiata sp. nov.; p. 191, Pl. XVII, fig. 18.
- Megambonia cardiiformis Hall; p. 199, Pl. XXIV, fig. 4.
- Megambonia cardiiformis var. parviuscula var. nov.; p. 201, Pl. XIX, fig. 23.
- Platyostoma ventricosum; p. 262, Pl. XIII, figs. 15, 18.
- Patellostium revolvens sp. nov.; p. 265, Pl. XIV, figs. 14, 15, 20, 27.
- Plectonotus trilobatus (Sowerby); p. 266, Pl. XIV, fig. 19.
- Tropidodiscus somerseti sp. nov.; p. 271, Pl. XIV, fig. 22.
- Loxonema welleriana sp. nov.; p. 279, Pl. XIII, figs. 2, 3, 5.
- Loxonema jerseyense Weller; p. 280, Pl. XIII, figs. 1, 4.
- Tentaculites schlotheimi Koken; p. 283, Pl. XIV, figs. 23, 24; Pl. V, fig. 30.
- Tentaculites cf. elongatus Hall; p. 284, Pl. XIV, fig. 26.

OTHER FOSSILS DESCRIBED IN THIS REPORT.

In addition to the material from Moose River sandstone referred to above, specimens from other localities and formations are figured and discussed in the text, as follows:

Dennys River, Eastport quadrangle, Washington County, Maine, from the Pembroke formation:
- Chonetes bastini Williams, p. 48; Pl. VIII, fig. 25.

St. Helens Island, near Montreal, Canada, from a limestone breccia, some of the limestone fragments of which contain Helderberg, others Oriskany, and still others later fossils:
- Spirifer concinnus Hall; p. 80, Pl. II, fig. 4.
- Spirifer montrealensis sp. nov.; p. 113, Pl. I, fig. 2; Pl. II, figs. 2, 18.

Kayser, Mineral County, W. Va. (Oriskany):
- Spirifer arenosus Conrad; p. 84, Pl. III, fig. 1.
- Spirifer arenosus var. simplex var. nov.; p. 86, Pl. III, figs. 2–4, 7, 12.

Covington, W. Va. (Oriskany):
- Spirifer concinnus Hall; p. 80, Pl. III, fig. 5.

SPECIES OF THE CHAPMAN FAUNA AND A FEW RELATED FORMS FROM OTHER FORMATIONS.

CŒLENTERATA.

The Chapman fauna is evidently of marine habitat, but it is remarkably lacking in definite traces of Cœlenterata. The only forms that can be referred to that subkingdom are a few traces of the peculiar fossils which have for a long time been widely known under the name *Pleurodictyum problematicum* Goldfuss and a sandstone mold which is referred with doubt to Favosites; they are described beyond. Both of these genera are consistent with the other genera of the fauna in locating it stratigraphically in early Devonian time. The Pleurodictyum is significant of Lower Devonian (Gedennian, Taunusian, and Coblentzian) affinities in Europe, though its range in North America has been supposed to be scarcely lower than the Onondaga ("Corniferous") limestone. The small size of the Chapman form may signify either new and unfavorable environment or simply an early stage of evolution of the type. Whichever interpretation is given, the evidence points toward affinities with the Eo-Devonian faunas of Europe rather than with the Meso-Devonian faunas of the interior of North America or with the Silurian.

Subbranch CNIDARIA.

Class ANTHOZOA.

Subclass HEXACORALLA Haeckel.

Family FAVOSITIDÆ Milne-Edwards and Haime.

Genus PLEURODICTYUM Goldfuss 1820.

PLEURODICTYUM cf. P. PROBLEMATICUM Goldfuss.

Plate XXIV, figure 2.

A single small specimen, internal mold (magnified 2 diameters in fig. 2 of Pl. XXIV), shows the typical characters of Pleurodictyum. It has a small corallum; greatest diameter 14 millimeters. Corallites numerous (more than 70 can be counted on the specimen) and irregularly prismatic in form, with tubular pores connecting the neighboring corallites. The small-sized corallum and larger number of corallites distinguish it from the ordinary forms, as described, of *P. problematicum*, owing to the imperfect knowledge of Goldfuss's types and the loose usage of the specific name. We propose for our material the name Pleurodictyum cf. *P. problematicum* Goldfuss.

Locality: Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59681.

Genus FAVOSITES Lamarck.

FAVOSITES (?) sp. indet.

Plate XXII, figure 16.

The specimen figured appears to be a sandstone mold of the exterior surface of a hemispherical coral, the only structure evident being the subconical rounded fillings of what are interpreted to have been the open ends of the cells of some such coral as *Favosites helderbergiæ* Hall. In the original the axis of the cells opened obliquely to the surface. As well as can be estimated from the molds the cells were not more than 2 millimeters in diameter, but the coralla evidently attained a large size.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59682.

VERMES.

Suborder TUBICOLA (SEDENTARIA).

Genus CORNULITES Schlotheim.

CORNULITES SERPULARIUS Schlotheim cf. var. MAJOR Barrande.

Plate XIV, figure 25.

cf. 1867. *Cornulites major*. Barrande, Système silurien du centre de la Bohême, vol. 3, p. 174, pl. 16, fig. 13.
Calcaire moyen, étage F: Konieprus and Mnienian, Bohemia.
Bande inferior f[1]: Lochkov, Bohemia.
Bande superieure e[2]: Lodenitz and Listice, Bohemia.

cf. 1888. *Cornulites major*. Hall, Paleontology of New York, vol. 5, pt. 2, supplement, pl. 116 (A), fig. 14.

A complete synonymy of the various fossils called *Cornulites serpularius* by authors has not been attempted, but the following list includes most of the more important references:

1820. *Cornulites serpularius*. Schlotheim, Petrefaktenkunde, p. 378, pl. 29, fig. 7.
"Transition limestone": Gotland, Baltic Sweden.

1834. *Cornulites serpularius*. Kloeden, Versteinerungen d. Mark. Brandenburg, p. 227, pl. 3, fig. 13.
Glacial-drift bowlders: Mark. Brandenburg, Germany.

1839. *Cornulites serpularius*. Sowerby, in Murchison, The Silurian system, p. 627, pl. 26, fig. 5.
Wenlock shale: Western slopes of the Malvern Hills, Dudley, England.

1845. *Cornulites serpularius*. Murchison, De Verneuil, and Keyserling, Russia and the Urals, vol. 2, p. 27, pl. 27, fig. 10.

1851. *Cornulites serpularius*. McCoy, in Sedgwick and McCoy, British Paleozoic rocks and fossils, p. 63.
Upper Ludlow quartzite: Benson Knot and Brigsteer, Kendal, Westmoreland, England.
Wenlock limestone: Dudley, England.

1854. *Cornulites serpularius*. Keyserling, Soc. géol. France Bull., 2d ser., vol. 11, p. 152.
Neo-Silurian: Esthonia, Baltic Russia.

1859. *Cornulites serpularius*. Salter, in Murchison, Siluria, 2d ed., p. 221.

1865. *Cornulites serpularius*. Kjerulf, Veiviser ved geologiske Excursioner i Christiania, pp. 17, 23, 27.
Malmö limestone étage 8β [Aymestry]: Malmö, Norway.
Lower Malmö group étages 6 and 7 [Eo-Silurian]: Christiania region, Norway.
Oscarshall limy sandstone étage 5α [basal Silurian or Neo-Ordovician]: Husbergøen, Norway.

1872. *Cornulites serpularius*. Nicholson, Am. Jour. Sci., 3d ser., vol. 3, p. 202, figs. 1a, 1b.
Wenlock limestone: Dudley, England.

1876. *Cornulites proprius*. Hall, New York State Mus. Nat. Hist. Twenty-eighth Ann. Rept., advance ed., pl. 31, figs. 1–13; public ed., 1879, p. 182, pl. 31, figs. 1–13.
Waldron beds: Waldron, Ind.

1881. *Cornulites proprius*. Hall, Indiana State Geologist Eleventh Ann. Rept., p. 327, pl. 32, figs. 1–13.
Waldron beds: Waldron, Ind.

1888. *Cornulites proprius* and *serpularius*. Hall, Paleontology of New York, vol. 5, pt. 2, supplement, pp. 8, 21; pls. 115, 116, 116 (A).
Wenlock limestone. See Sowerby's localities, 1839.
Waldron beds: Waldron, Ind.

1905. Cornulites cf. *serpularius*. Williams, U. S. Geol. Survey Prof. Paper 35, p. 22.
Upper Silurian: Whitings Bay, Maine.

Some poorly preserved fragments which are apparently too large and somewhat too irregular in growth to belong to Tentaculites are referred to Schlotheim's species.

Tube a very gently tapering one, very nearly or quite straight; annulated; free (except perhaps in infancy); cross section elliptical. The sides of the cone converge very slightly; in a length of 6 millimeters the larger diameter has been observed to expand from 3.85 to 4.65

millimeters. In this length ten annulations occur. In a second specimen from the same layer of rock the larger diameter of the elliptical cone expands 3.9 to 4.8 millimeters in a distance of 5.8 millimeters; six annulations were counted. In the latter specimen, the internal mold figured, the annulations when examined closely are seen to bear a resemblance to the truncated broad ends of overlapping cones which have the apices directed toward the distal or broader end of the shell. The annulations are slanting or twisting, less frequently transverse; they are subequidistant. Finer surface markings not preserved.

The Chapman Cornulites differ from the ordinary Helderberg and Oriskany Cornulites in their larger size and in being free. The Cornulites hitherto known in North America from these formations comprise the following:

1860. *Cornulites flexuosus* var. *gracilis.* Hall and Dawson, Canadian Naturalist, vol. 5, no. 2, pp. 140, 155.
Oriskany iron-ore beds: Nictau, Nova Scotia.
Arisaig and Stonehouse [Upper Ludlow] formations: Arisaig, Nova Scotia.

1888. *Cornulites chrysalis.* Hall, Paleontology of New York, vol. 5, pt. 2, supplement, p. 20, pl. 116, figs. 26–28.
Helderberg [New Scotland] shaly limestone: Near Clarkesville, Albany County, N. Y.

1888. *Cornulites cingulatus.* Hall, idem, p. 20, pl. 116.
Helderberg: New York State ("locality doubtful").
Oriskany, Becraft Mountain, Columbia County, N. Y.

The Chapman specimens resemble very closely Barrande's *Cornulites major*, which differs from the normal *Cornulites serpularius* chiefly in its size, straighter form, and more regular and closely set annulations. In the Pembroke fauna of the Eastport quadrangle, Maine, the genus Cornulites attains a profuse and varied development, representing several large species, one of which resembles the Chapman sandstone form.

There is also a similarity between the Chapman Cornulites and certain free forms classed as Tentaculites, particularly the Oriskanian *Tentaculites elongatus* Hall. This Tentaculites is very commonly somewhat flexuous,[1] especially in the juvenile portion and in many specimens the annulations are not strictly transverse.

Locality: Chapman sandstone, Edmunds Hill (locality 1099 C), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59683.

Genus ORTONIA Nicholson.

The genus Ortonia was founded in 1872 by Nicholson[2] to include fixed, adherent, conical calcareous tubes which are attached along the whole of one side to some foreign body, typically a brachiopod or mollusk. The tubes are generally loosely gregarious, several occurring together on a foreign surface, but they are not in contact with one another except by accident. Hall in 1888[3] showed that this is one of the growth stages assumed by Cornulites. To represent this mode of growth in Cornulites the term Ortonia may be retained, but it is not strictly of generic value.

CORNULITES (ORTONIA) MAINENSIS sp. nov.

Plate XIV, figure 29.

Tubes conical, slightly flexuous, annulated exteriorly, interior smooth or with only obscure, transverse, distant striæ, elevated on the internal mold. Annulations on the exterior somewhat oblique. Surface covered with very fine longitudinal lines. The specimen shows eight tubes radiating from an approximately common center. All are attached throughout their length to a large Leptostrophia. The tubes are about 7.5 millimeters long; the width at the aperture is 2 millimeters. The surface annulations are fine, even, and closely set; they are distinct and even in the earlier portion of the tubes, but near the aperture become more uneven, more distant, and unequally so and somewhat more oblique. The annulations are in the form

[1] Consult Weller, Stuart, Paleontology of New Jersey, vol. 3, Paleozoic faunas, pl. 50, figs. 4, 5, 1903. See also Clarke, J. M., New York State Mus. Mem., vol. 3, No. 3, pl. 3, figs. 8, 9, 1900.

[2] Geol. Mag., vol. 9, 1872; vol. 10, 1873.

[3] Hall, James, Paleontology of New York, vol 5, pt. 2, supplement, p. 20, 1888.

of the exposed ends of overlapping cones, but these cones are directed with their apices toward the apex of the tube, the reverse of their direction in *Cornulites serpularius*. The radiate or longitudinal striæ are rather obscure but are evidently present.

Locality: Moose River sandstone, Detroit, Somerset County, Maine.

U. S. National Museum, catalogue No. 59684.

Comparisons.—A solitary *Cornulites cingulatus* found incrusting an Orthothetes in the Oriskany of Becraft Mountain, N. Y.,[1] bears close resemblance to this species. *Cornulites cingulatus* Hall, in its small size, incrusting habit, and constant irregularity in the distal annulations, strongly resembles *Ortonia mainensis*, but Hall's species is a solitary form and typically incrusts a bryozoan, whereas the Maine specimens are loosely gregarious upon brachiopod shells. A still more important distinction is that the Ortonia described above is nearly smooth on the interior, whereas *Cornulites cingulatus* is annulated on the interior.

There is a close resemblance between our specimen and the Ortonia described and figured as *Cornulites flexuosus* Hall.[2] This form, which occurs in the Ordovician, has the conic annulations on the exterior surface reversed in direction as in the Maine Ortonia. Both incrust strophomenoid brachiopods, and apparently the only observable distinctions between these two species, so greatly removed stratigraphically are of minor importance. The Maine species has the distal annulations more distant when compared with the youthful stage of the shell, indicating irregularity of growth at maturity or senility. This character is seemingly not so well developed in the Trenton *Cornulites (Ortonia) flexuosa*, which is also not quite so smooth on the interior as *Ortonia mainensis*.

The only Devonian Ortonia hitherto known, *O. intermedia* Nicholson,[3] is more regularly annulate and has a thicker shell.

Genus TRACHYDERMA Phillips.

Genus GYRICHNITES Whiteaves.

The genus Trachyderma was founded by Phillips[4] in 1848 to include annelidan remains differing from the common Serpulidæ in having a large, long, flexible, free tube or epidermis which is coriaceous, not calcareous. The tubes, which occur parallel to the bedding, are in described forms of Trachyderma from 5 to 25 millimeters thick, cylindrical through by far the greater part of their length, bluntly tapering at the extremities, and covered with raised transverse markings.

In the type species, *Trachyderma coriacea* Phillips, these transverse annulations are sharply elevated and bifurcate, with branches which reunite along certain longitudinal bands; but such highly developed bands are absent in many of the other species referred by authors to Trachyderma. In the latter, also, the transverse markings are less regular and much less highly developed. In *Trachyderma coriacea*, furthermore, there is what appears to be a small but sharply differentiated head. The presence of this head and the peculiar characters of the raised annulations, which resemble the vascular system of the lower worms, show that the type species, *Trachyderma coriacea*, not only in size but in preserved characters differs widely from *T. squamosa*. The second species described, *Trachyderma squamosa*, represents a much more common form, which was first figured and described by Sowerby. It is conceivable that the typical Trachyderma of Phillips is a young complete form, of which the species *T. squamosa* is an adult skin lacking head and tail; but as fossils these two species are quite distinct, and the Chapman forms belong to the *squamosa* group, as represented by the following species:

1839. *Serpulites longissimus.* Sowerby, in Murchison, The Silurian system, pt. 2, p. 608, pl. 5, fig. 1. "Locality, Ludlow, very abundant, Kingston, Herefordshire, and very generally throughout the upper Ludlow Rock of Salop, Hereford, Radnor," etc.

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[1] Clarke, J. M., New York State Mus. Mem., vol. 3, No. 3, pl. 2, fig. 35, 1900.

[2] Hall, James, Paleontology of New York, vol. 5, pt. 2, supplement, pl. 115, figs. 41–42, 1888, = *Tentaculites* (?) *flexuosa* Hall, idem, vol. 1, p. 92, pl. 29, fig. 6; p. 284, pl. 78, fig. 2.

[3] Nicholson, H. A., Paleontology of Ontario, 1874, p. 122. The species is from Arkona, Canada West, in beds containing a Hamilton fauna.

[4] Phillips, John, The Malvern Hills compared with the Paleozoic districts of Abberley, etc., with paleontological appendix: Mem. Geol. Survey Great Britain and Mus. Pract. Geology in London, vol. 2, pt. 1, pp. 230, 331, pl. 4, 1848.

1848. *Trachyderma squamosa.* Phillips, op. cit., p. 332, pl. 4, figs. 3, 4.
1858. *Trachyderma* (?) *depressa.* Giebel, Silur. Fauna d. Unter-Harz, p. 15, pl. 6, fig. 10; as *Serpulites depressus.* See also Kayser, Emanuel, Die Fauna der ältesten Devon-Ablagerungen des Harzes, p. 48, pl. 34, fig. 13, 1878.
1864. *Trachyderma serrata.* Salter, Geol. Soc. London Quart. Jour., vol. 20, p. 290, pl. 15, fig. 9.
1900. *Trachyderma* (?) *clarkii.* Prosser, New York State Geologist Seventeenth Ann. Rept., pp. 149–150, pl. 6; as *Planolites clarkii.*

This group, in which the species from Maine is included, is characterized by the absence (?) of a distinctly demarcated head, no traces of whose possible presence have yet been observed. Longitudinal bands are also absent. The tube was coriaceous, large, long, free, flexuous, cylindrical; apparently not penetrating or crossing the bedding planes; more or less distinctly marked on the surface by transverse raised wrinkles or annulations.

That this group represents some annelidan tube and is not a "trail" is shown by the completely cylindrical outline; and that it is not a burrow is proved by its nearly constant occurrence parallel to the bedding planes of the rock. All the described species of Trachyderma from the Silurian and Devonian are recorded as being parallel to the bedding planes; but Salter [1] mentions a chitinous tube which he saw in Ordovician rocks erect and perpendicular to the bedding planes.

Some large trails, supposedly annelidan, from the lower part of the Gaspe sandstone, Gaspe, Quebec, were described by W. E. Logan in 1863. At a height of 1,100 feet above the Gaspe limestone several successive surfaces in slabs of sandstone "are marked by serpentine impressions, about an inch wide, deeply grooved into the stone, marked by small parallel transverse furrows which are about a quarter of an inch apart. These are perhaps worm tracks, and are associated with a few bivalve shells of the genus Rensselaeria, probably *R. ovoides.*" [2] These supposed tracks were subsequently figured and described as *Gyrichnites gaspensis* gen. et sp. nov.[3] According to Whiteaves's photographs of slabs of these remains the trails are only 12 to 15 millimeters in diameter, rather than an inch, as estimated by Logan. The annulations are strongly elevated, rounded, transverse, or more often somewhat oblique, about a third as wide as the interspaces, and from 10 to 14 have been counted in a length of 60 millimeters.

Whether *Gyrichnites gaspensis* represents "trails" or actual cylindrical tubes of Annelida could be definitely ascertained by examining both sides of split slabs bearing these fossils and noting whether the cross section is circular and closed or semicircular or crescentic and open above. This has apparently not yet been done. If it could be thus definitely shown that these fossils are really annelidan tubes (which appears very probable, judging from the depth of the impressions) and not trails, the group of species described above as Trachyderma of authors would find a place more easily under Gyrichnites.

The finding of this form, whether it be regarded as specifically or only generically related to the species described by Sowerby and Phillips, is interesting as showing affinity between the faunas of Arisaig, the Upper Ludlow of England, and the Chapman of Maine.

In the upper beds of the series along the north shore of Nova Scotia at Arisaig I have seen several specimens closely allied to *Serpulites longissimus* Sowerby. Fragments of them were obtained, but the better specimens could not be removed with the tools at hand. The black, shining appearance of the specimens indicated original leathery or chitinous skin, which was buried and crushed in the process.

In the Jermyn Street Museum, London, are several specimens, no two exactly alike. The larger forms are from one-third to one-half inch wide, with wrinkles crossing the center as if they had shrunk in drying and a stiffening of the edges indicating a sheath of some thickness. All these characters indicate close affinity, and the specimen from the Chapman sandstone closely resembles them. In the Jermyn Street Museum the specimen marked $\frac{\mathrm{IX}}{\mathrm{I}}$ 18 is labeled *Serpulites longissimus;* other specimens, marked $\frac{\mathrm{IX}}{3}$ 21 and $\frac{\mathrm{IX}}{3}$ 22, both from the Lower Ludlow,

[1] Geol. Soc. London Quart. Jour., vol. 20, p. 290, 1864.
[2] Geology of Canada, 1863, p. 399.
[3] Whiteaves, J. F., Roy. Soc. Canada Trans., 1882, p. 109, pls. 11, 12.

are labeled *Serpulites longissimus;* and specimen $\frac{\text{IX}}{3}$ 24 is called *Trachyderma squamosa*, but all four are much alike. *Trachyderma coriacea* is represented by specimens 48 and 49 of $\frac{\text{IX}}{5}$. As defined by Phillips it shows appearance of a head part, differing in this respect and in size from the larger form *Trachyderma squamosa*, specimens of which are marked 52, 53, and 54. In the latter set the cross wrinkles vary greatly in width, showing probably that the width and frequency of the wrinkles, though in a general way signifying the state of flexibility of the skin, were variable.

In the South Kensington Museum are several specimens of *Trachyderma squamosa* from the Wenlock and Aymestry and of *T. coriacea* from the Upper Ludlow.

Both of these species are in collections of the Upper Ludlow in the Sedgwick Museum of Cambridge, where the larger specimens are labeled *Serpulites longissimus* and the smaller form *Trachyderma coriacea*. In the Cambridge Museum, also, is a slab with *Orthoceras tenuicinctum* from the Upper Ludlow, Woolhope, on which is a fragment much like *Trachyderma squamosa*.

The Chapman specimen can be distinguished from any of the individual specimens from the Ludlow beds of Great Britain, but the discovery of the species in America only in the far eastern outcrops of Arisaig and Maine points to common origin for the North American and European forms of this peculiar fossil.

TRACHYDERMA (? GYRICHNITES) SPECIOSA sp. nov.

Plate XXII, figure 20.

Annelidan tube large, cylindrical, not calcareous, free, prostrate, not penetrating across the bedding planes, so far as is apparent. Tube curved, 9¼ to 9¾ millimeters wide, marked on the surface by transverse, parallel, low, rounded, raised annulations from two-fifths to three-fifths as wide as the intervening grooves; nine such grooves have been counted in a length of 45 millimeters. The single specimen, forming a central fragment in external molds, is 85 millimeters long. The specimen resembles a deeply grooved trail, but one end was originally cylindrical, so that it could not possibly have been a surface trail. The mold is parallel to the horizontal bedding planes in the beautifully laminated sandstone in which the specimen occurs. The transverse annulations on the surface, though rather low, are much more distinct on the specimen than on the photographed illustration. The tube is filled with sand at one point.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59685.

Comparisons.—The nearest analogous form is *Gyrichnites gaspensis* Whiteaves, from which the present specimen differs chiefly in its smaller width and its somewhat less pronounced annulations.

No remains of the chitinous or coriaceous test have been observed. Incidentally it may be stated that indications of the test are also lacking in specimens of *T.? clarkii* Prosser and *Gyrichnites gaspensis* Whiteaves, both of which are preserved in arenaceous beds. The test in *T. depressa* Giebel, which is preserved in calcareous rock, is stated by Kayser to be calcareous, not chitinous. The chitinous test positively exists in *T. squamosa* Phillips and similar species from Arisaig, Nova Scotia, and from the Eastport quadrangle, Maine.

MOLLUSCOIDEA.

Class BRYOZOA Ehrenberg.

A few fragments in an imperfect state of preservation represent the Bryozoa. Although none of them furnish very satisfactory evidence of their specific characters, a few of the better specimens have been selected for illustration. They represent the fenestelloid form, distinguished from Fenestella under the name Polypora McCoy, by having no median ridge on the celliferous side of the rays. As our specimens are only fragmentary molds of the fronds, instead of giving them distinct names I refer them provisionally to their nearest described analogues *P. lilæa* Hall and *P. psyche* Billings. Future search of the rocks may reveal better preserved specimens, from which closer identification may be possible.

POLYPORA cf. P. LILÆA Hall.

Plate XXII, figures 2, 4, 7, 9.

1874. *Polypora lilia.* Hall, New York State Mus. Nat. Hist. Twenty-sixth Ann. Rept., p. 96.
1879. *Fenestella (Polypora) lilæa.* Hall, idem, Thirty-second Ann. Rept., p. 165.
1880. *Fenestella (Polypora) lilæa.* Hall, idem, Thirty-second Ann. Rept., 2d ed., p. 27.
1883. *Fenestella (Polypora) lilæa.* Hall, New York State Geologist Ann. Rept. for 1882, pl. 18, figs. 19, 20.
1883. Retepora sp. nov. Hall, idem, figs. 21–22.
1887. *Fenestella (Polypora) lilæa.* Hall and Simpson, Paleontology of New York, vol. 6, p. 62, pl. 18, figs. 19–22.
1900. *Polypora lilæa.* Nickles and Bassler, U. S. Geol. Survey Bull. 173, p. 365.
All the above are recorded as from the "Lower Helderberg limestone" [Helderberg group], at Schoharie and near Clarksville, N. Y.

The specimens are flat, undulating, perforated fronds. The fenestrules are oblong in shape, eight to ten being present in each half centimeter of length, and are arranged in closely crowded diverging rows, which increase by implantation. In general size and proportions they very closely resemble Hall's species *Polypora lilæa,* to which they are referred.

Locality: Chapman sandstone, 2½ miles west of Presque Isle Stream and Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59686.

POLYPORA cf. P. PSYCHE Billings.

Plate XXII, figure 6.

1874. *Polypora psyche.* Billings, Canada Geol. Survey, Paleozoic fossils, vol. 2, p. 11, figs. 1, 2.
Gaspe limestone No. 8 [Grand Greve]: Indian Cove, Gaspe Bay, Quebec.
1900. *Polypora* (?) *psyche.* Nickles and Bassler, U. S. Geol. Survey Bull. 173, p. 367.
Oriskany [Gaspe limestone].

The fronds of this species have larger fenestrules than those of Polypora cf. *P. lilæa,* but in other respects resemble that species. In the specimens studied there are five or six fenestrules in the length of half a centimeter; in the corresponding length in Billings's figures there are four to five but not quite six fenestrules. Although the specific characters preserved are incomplete, they give some degree of definition to the specimens, which exhibit little else for determination. Specimens with large fenestrules referred to this species are less common than the finer forms, which have been provisionally identified with *P. lilæa.*

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59687.

Class BRACHIOPODA Cuvier.

Order ATREMATA Beecher.

Superfamily LINGULACEA Waagen.

Family LINGULIDÆ Gray.

Genus LINGULA Bruguière, 1789.

LINGULA MINUSCULA sp. nov.

Plate VI, figure 27.

Shell small; height 6.2 millimeters, maximum width 3.2 millimeters, two-fifths the length of the shell from the beak; sides nearly parallel; very gently rounded anterior and posterior extremities arcuate, subequal, the anterior very slightly narrower; cardinal angle about 90°, possibly more. Greatest convexity 1.3 millimeters just posterior to the middle. A rather flat, narrow ridge occurs here and extends as far as the point of maximum width of the shell. Posteriorly, this flattened ridge slopes down and narrows to the beak; anteriorly, it gradually merges into the convexity of the shell, which is a little more depressed toward the front than nearer the beak. On this ridge, the striæ [1] of growth are horizontal or even occasionally slightly insinuated. On the internal mold there are obscure indications of two subparallel, very faint lines [1] extending from the beak forward.

The surface ornamentation consists of fine, unequal, elevated, imbricose concentric striæ of growth. Under the lens some extremely fine radial or fibrous markings are observed, but these are probably associated with the fabrication of the shell and are not really "surface markings."

Locality: Chapman sandstone, a single specimen, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59688.

Comparisons.—Comparison of fossil Lingulidæ, except in extraordinary forms, is of little value in determining specific and stratigraphic relations. Many points of distinction in Lingula fossils can hardly be expressed intelligibly in words or even shown in figures, so that similar forms, which have been described under separate names but are nearly or quite identical, so far as their published figures and descriptions would indicate, may range from the Cambrian to the Recent. The Lingula here described can be compared with small *Lingula ligea* Hall, from the Upper Devonian of New York, and with *Lingula longissima* Pander,[2] from the Upper Ordovician, and no doubt a conscientious search would show that the species is very similar in visible characters to some Cambrian form or perhaps to some Cretaceous or Tertiary species.

Among Silurian and Lower Devonian species this Lingula may be very closely compared with narrow forms of the Downtonian-Passage beds, *Lingula cornea*,[3] *L. minima*,[4] and the Hercynian *Lingula ilsæ* Roemer.[5] From all these it differs in being slightly narrower anteriorly and in having the greatest width posterior to the middle; the beaks are much more obtuse than in *Lingula minima;* the shell is smaller than *L. ilsæ* and not nearly so broad as typical *L. cornea* Sowerby, though it strongly resembles the narrower forms referred to this species by Davidson. *Lingula artemis* Billings,[6] from the Gaspe limestone No. 5, is also very similar but has the ratio of length to width 3:2, whereas in the present form this ratio is about 2:1.

Order NEOTREMATA Beecher.

Superfamily DISCINACEA Waagen.

Family DISCINIDÆ.

Genus ORBICULOIDEA D'Orbigny, 1849.

Subgenus RŒMERELLA Hall and Clarke, 1892.

ORBICULOIDEA (RŒMERELLA) DISCUS (Hall).

Plate VI, figures 28–33.

1859. *Discina discus.* Hall, Paleontology of New York, vol. 3, p. 159, pl. 9, figs. 13–15.
Lower Helderberg shaly [New Scotland] limestone: Becraft Mountain, near Hudson, N. Y.
1876. *Discina discus.* Barrett, Lyceum Nat. Hist. New York Annals, vol. 11, p. 296.
Trilobite beds [uppermost Helderberg]: Bennett's quarry, Port Jervis, N. Y.
1877. *Discina discus.* Barrett, Am. Jour. Sci., 3d ser., vol. 13, p. 387.
Trilobite beds [uppermost Helderberg]: Bennett's quarry, Port Jervis, N. Y.

[1] The terms "lines" and "striæ" are here used in the technical sense according to which striæ are impressed and lines elevated.
[2] Davidson, Thomas, British fossil Brachiopoda, vol. 3 (Silurian), p. 51, pl. 3, figs. 28, 29, 1886.
[3] Idem, pl. 2, fig. 34.
[4] Idem, pl. 3, figs. 36, 37.
[5] Kayser, Emanuel, Die Fauna der ältesten Devon-Ablagerungen des Harzes, pl. 30, figs. 22, 23, 1878.
[6] Paleozoic fossils [of Canada], vol. 2, pt. 1, p. 14, fig. 4, 1874.

?1892. *Schizocrania* (?) *discus*. Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, p. 132.
Lower Helderberg group: New York.
1892. *Orbiculoidea discus*. Hall and Clarke, idem, pl. 4E, fig. 13.
Lower Helderberg group: Near Clarksville, Albany County, N. Y.[1]
1897. *Orbiculoidea discus*. Schuchert, U. S. Geol. Survey Bull. 87, p. 278.
Lower Helderberg: Near Hudson and in Albany County, N. Y.
1899. *Orbiculoidea discus* (?). Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), p. 351.
New Scotland shaly limestone: Oniskethau Creek, Albany County, N. Y.
1901. *Orbiculoidea discus*. Schuchert, Geol. Soc. America Bull., vol. 11, p. 282.
New Scotland and Becraft limestones: New York.
1903. Orbiculoidea cf. *O. discus*. Hartnagel, New York State Mus. Bull. 69, p. 1164.
New Scotland gray limestone: Hill east of Manlius Village, Onondaga County, N. Y.
1905. *Orbiculoidea discus* (?). Shimer, New York State Mus. Bull. 80, pp. 223–265.
Doubtfully identified from the lower and upper New Scotland, Trilobite Mountain, N. Y.

The description of the Maine material of this species is as follows: Shell large, free, circular, or nearly circular, with the length a trifle greater than the width. The upper (brachial) valve is larger than the lower (pedicle) valve; beak situated at distance of one-third to two-fifths the width of the shell from the margin, rarely central. Apex bluntly rounded, directed posteriorly. Posterior slope in profile straight or slightly sigmoid, anterior slope gently convex. Height of the valve between one-fourth and one-third the width. The lower (pedicle) valve, when uncrushed, has a depressed mammillate, subcentral beak. Posterior slope convex or sigmoidal; anterior slope or profile concave. The pedicle opening is elliptical to pear-shaped, continued posteriorly in a slit which nearly reaches the margin. Height of the valve between one-sixth and one-seventh the length. Shell substance chitinous, laminate; outer thin layer nacreous, with pearly luster preserved in one of the specimens.

Surface ornamentation, strongly elevated, concentric imbricose striæ, with intermediate finer concentric striæ in the well-preserved parts. Radial markings vary from sharp striæ visible to the naked eye to very fine, indistinct striæ. These radial striæ are feebly if at all preserved where the concentric lamellæ occur, but on partly exfoliated shells are evident and seemingly quite regular.

The specimens may be described as follows:

1. Plate VI, figure 32, from Presque Isle Stream. A large circular brachial valve in external mold; length 28 millimeters, width 28 millimeters, height 8 millimeters. Apex rounded, about 12 millimeters from the posterior margin; posterior profile concave. Concentric lamellose markings strongly developed, the raised edges equal to one-half or one-third the width of the intervening spaces; on the apical portion these concentric markings are close together and regular. Radial markings faint or absent.

2. Plate VI, figure 33, also from Presque Isle Stream. Another brachial valve in external mold; length 28.5 millimeters, width 27.3 millimeters, height 8.5 millimeters. Apex rounded, distant 10 millimeters from the posterior margin. Concentric markings close-set and regular in apical portion; more uneven and unequal in marginal areas. Radial striæ obscure but present. A piece of the pearly outer layer of the shell is preserved.

3. Plate VI, figure 31, also from Presque Isle Stream. A somewhat crushed pedicle valve, in part (anteriorly) in external mold and in part (posteriorly) in external cast. Length 30 millimeters, width 28 millimeters, depth 4 millimeters; widest in front. Anterior portion of valve deeply concave; includes the maximum depth. The depth is as great as or greater than in typical *Rœmerella grandis* (Vanuxem), specimens of which from the Hamilton of Cazenovia, N. Y., are at hand for comparison. Under the pedicle posterior passage, just back of the pedicle opening, the shell is convex; in the present large specimen it becomes again concave near the posterior margin. Distal end of pedicle opening 17 millimeters from the posterior margin. Fine, regular, close-set, radial striations are preserved on parts of exterior which show lamellose markings.

[1] Also identified by Dr. C. E. Smith in an unpublished section of the New Scotland, Countryman Hill, Helderberg Mountains, Albany County, N. Y.

4. Plate VI, figure 29, a brachial valve from Presque Isle Stream, incomplete, but originally about 26 millimeters long, 24½ millimeters wide, 7½ millimeters high; apex 10 millimeters from margin; shows concave posterior profile. Shell exfoliated, exposing uneven, fine, concentric lines of growth; very fine, unequal, radial striations are also well developed.

The four specimens described above could be regarded as typical Rœmerellas, the shells being like Orbiculoidea but large and with deeply concave pedicle valves. This pedicle valve must have fitted up into the domelike cavity of the brachial valve, and every part of the large pedicle valve was included within this cavity—that is, the valve as a whole was distinctly concave. This concavity of the pedicle valve is the distinguishing feature of the genus Rœmerella Hall and Clark.

5. Plate VI, figure 30, a large, exfoliated specimen from Edmunds Hill which must have been about 28 millimeters long, 25 millimeters wide, and apparently 4 millimeters high; possibly a pedicle valve; but if considered very broken, it might equally well be interpreted as the higher or brachial valve. Fine prominent radial striæ are preserved with concentric uneven lines of growth on the exfoliated parts. This shell shows pearly luster on one of the lamellæ. The surface markings are almost exactly the same as on No. 4, from locality 1099 J, and both specimens represent the same species.

6. Plate VI, figure 28, a small but important specimen from Edmunds Hill, is an exfoliated convex or flat pedicle valve, representing by its convexity the normal Orbiculoidea type. Length of specimen 16.5 millimeters, width 13 millimeters, height 2.75 millimeters; like No. 3, this specimen is widest in front. The valve as a whole is rather convex, thus differing from the Rœmerella type and agreeing with Orbiculoidea. The anterior slope or profile is concave, as in both Rœmerella and most species of Orbiculoidea. This anterior concavity is produced by the upturning of the anterior margin; near the apical part the shell is convex throughout the circumference, and the convexity is retained posteriorly. The profile is the same as that figured for *O. discus* by Hall,[1] except that in the present specimen the apex is central. The pedicle passage is fairly large; the distal end is in the middle of the shell, and posteriorly the passage is prolonged as a narrow groove or slit which nearly if not quite reaches the margin. The radial markings are fine linear wrinkles; in the exfoliated shell concentric striæ are feebly developed. This specimen has the same outline as No. 3, with the same anterior concavity in the pedicle valve, and is almost exactly the counterpart of the younger portion of that specimen.

Locality: Chapman sandstone, Presque Isle Stream (common); 2 miles west of Presque Isle Stream (rare); Edmunds Hill (occasional). All in Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59689, 59690, 59691.

Relation of Rœmerella to Orbiculoidea.—The facts already stated indicate that the young or middle-aged specimens present a strong Orbiculoidea aspect, with the pedicle valve convex or depressed-convex with reference to the brachial valve; at middle age the convexity of the pedicle valve begins to reverse, as is common in mature forms of most Orbiculoideas; and at maturity or senility the pedicle valve is strongly concave, fitting up into the domelike cavity of the brachial valve as in the genus Rœmerella. That Rœmerella is ordinarily not merely a mature stage of Orbiculoidea is proved by the fact that the great majority of Orbiculoideas at maturity have the pedicle valve convex as a whole, and that when most depressed the valve is only flat, not deeply concave and fitting into the brachial valve cavity. Furthermore, in the typical Rœmerella (*R. grandis*) the pedicle valve assumes its concave aspect early in the development of the individual and is the normal character at maturity, when the pedicle valve becomes concave as a whole. This would suggest that Rœmerella is a valid genus derived from Orbiculoidea by acceleration of the stage of recurvature in the pedicle valve. This accelerating recurvature may be traced from the present species, in which the pedicle valve retains its convex, Orbiculoidea character almost to maturity, through the Middle Devonian *Rœmerella grandis* (Vanuxem), in which the orbiculoidean convexity is apparent only in very young stages of growth and is then not well developed, and finally to the Upper Devonian *Rœmerella*

[1] Paleontology of New York, vol. 3, 1859, pl. 9, fig. 16a.

alleghania (Hall)[1] and an undescribed middle Neo-Devonian species from the vicinity of Van Etten, N. Y., in which the convexity of the pedicle valve, in the embryonic form, is barely discernible. It is quite possible that the concavity of the pedicle valve characteristic of the genus Rœmerella may be the effect of crushing upon an elastic shell.

Specific relations.—The *Orbiculoidea discus* of Hall was originally compared with the *Discina* (*Orbicula*) *forbesii* of Davidson.[2] This last-named species, from the Wenlock shales and limestones and the Woolhope beds, has, however, a very gibbous pedicle valve and belongs to the genus Schizotreta. A much closer relationship exists between *O. discus* Hall and *O. bainii* Sharpe, as is shown by the following references:

1846. Orbicula sp. Morris and Sharpe, Geol. Soc. London Quart. Jour., vol. 2, p. 277, pl. 10, fig. 5.
Devonian (?): Falkland Islands.

1856. *Orbicula bainii.* Sharpe, Geol. Soc. London Trans., 2d ser., vol. 7, p. 210, pl. 26, figs. 20–23.
Black schist: Gydow Pass (with Littorina).
Soft, light-colored argillaceous rock: Hottentots Kloof (with *Strophomena bainii*).
Dark-colored nodules: Cedarberg (with Chonetes).
All in South Africa; occurs also in Falkland Islands.

1893. *Discina bainii.* Von Ammon, Gesell. Erdkunde Berlin Zeitschr., vol. 28, p. 359, fig. 4.
Devonian: Taquarassu, Matto Grosso, Brazil.

1897. *Orbiculoidea bainii.* Schuchert, U. S. Geol. Survey Bull. 87, p. 277.
"Middle" Devonian: Falkland Islands; Taquarassu, Matto Grosso, Brazil; South Africa.

1905. *Orbiculoidea bainii.* Reed, South African Mus. Annals, vol. 4, pt. 3, no. 7, p. 168, pl. 20, figs. 4, 5.
Bokkeveld beds (Devonian): North of Whipperthal and at Garula Poort, South Africa.

It is in fact by no means certain that *O. discus* and *O. bainii* are distinct. Both species are large and subcircular in outline or a trifle longer than wide; both have the same convex brachial valve with excentric beak, concave posterior slope, and height equal to one-third the width; in both the pedicle valve is slightly concave, with an excentric, large, oval, depressed pedicle opening connected by a narrow slit with the posterior margin; finally, the peculiar surface and interior markings of the shells are the same in both. If these two species are identical, the specific name *bainii* (1856) has priority over *discus* (1859) and will have to be adopted. Apparently the only distinction between the two forms is that the beaks are a trifle more excentric in *O. bainii* than in *O. discus.* In the South African species the apex of the valves is situated at a distance of one-third to one-fourth the diameter from the margin, whereas in the North American species the beaks are generally subcentral or at most one-third the length from the margin. Specimens thus having the beak at one-third the diameter from the margin[3] may as well be placed under *Orbiculoidea discus* Hall as under *Orbiculoidea bainii* Sharpe.

Orbiculoidea montis Clarke, from Grande Grave and Perce Rock, Province of Quebec, is similar to the large Chapman fossils, and more abundant material may show that the suspicion of their identity is well founded, but in the fossils from Quebec as figured the brachial valve is much higher and conical, the outline is more narrowly elliptical, and, finally, the shells are much larger than the Chapman sandstone fossils, the latter being only half the size of Clark's species.

Superfamily CRANIACEA Waagen.

Family CRANIIDÆ King.

Genus CRANIA Retzius.

CRANIA sp. indet.

Plate VI, figure 13.

A single free brachial valve in internal mold has the following characters: Shell strongly convex throughout, spatuloid in outline, widest behind (?); length 12.5 millimeters, maximum

[1] This is a Rœmerella, not an Orbiculoidea. A specimen in the Cornell University Museum from the Chemung of Pennsylvania distinctly shows the concavity of the pedicle valve.

[2] Soc. géol. France Bull., 2d ser., vol. 5, p. 334, pl. 3, fig. 45, May, 1848. Geol. Survey Great Britain Mem., vol. 2, pt. 1, p. 371, pl. 26, 1848. British fossil Brachiopoda, vol. 3 (Silurian), p. 73, pl. 7, figs. 14–18.

[3] Paleontology of New York, vol. 3, pl. 9, figs. 15, 16a (New York); the Maine specimens Nos. 782 and 783; the South African specimens figured by Sharpe, op. cit., Pl. XXVI, figs. 21a, 21b, 22, 23, and by Reed, op. cit., pl. 20, fig. 4.

width 12 millimeters, at about two-fifths or one-third the length of the shell from the end, height 3 millimeters. Apex one-third the length from the margin; posterior slope (under part of the shell) more convex than the anterior. A scar, which may represent the musculature or may be merely a fracture, is quadrangular quadripartite, extending from the apex half the distance to the anterior (?) margin. Ornamentation indistinct; obscure indications of coarse radial lines (?) or fine plications are visible.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Plantation, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59692.

Comparisons.—This shell has the outline of *Schizocrania* (?) *helderbergiæ* Hall and Clarke,[1] but the position of the beaks and greatest convexity are opposite in the two forms; both are at the narrow end in the New York form and at the broad end in the present specimen.

Crania bella occurs at Cape Bon Ami, Gaspe, in the Gaspe limestone No. 5. The flat pedicle valve of this fossil has the apex marginal, which would serve to include the shell in the same generic group with *Schizocrania* (?) *helderbergiæ*. It is described by Billings [2] as having the apex central and with a concave profile down one side, characters neither of which is observable in the Chapman specimen. The New York Oriskany fossil identified with Billings's species and figured by Clarke has the beak also central and is much too high in comparison with the Maine specimen. *Crania bella* has no radial sculpture. If the obscure markings of the Maine specimen are indications of radial sculpture the species may be closely compared with *Crania pulchella* Hall and Clarke. The latter species was originally described from the Lower Helderberg group near Clarksville, N. Y.,[3] but occurs also in the Oriskany of Becraft Mountain, Columbia County, N. Y.[4]

Order PROTREMATA Beecher.

Superfamily STROPHOMENACEA Schuchert.

Family STROPHOMENIDÆ King.

Genus LEPTOSTROPHIA Hall and Clarke, 1892.

The genus Leptostrophia was founded by Hall and Clarke for perplane Stropheodontas which have the pedicle valve depressed convex, nearly flat; the brachial valve flat or slightly concave; and the large musculature in the pedicle valve flabellate, expanding from the beak, indistinctly fading in front. The denticulations on the hinge line extend the width of the shell. The genotype is *Stropheodonta magnifica* Hall.

In this strongly marked stropheodontoid genus, which may be easily recognized by the flat shell and the large flabellate musculature of the pedicle valve, more than 20 forms regarded by their authors as distinct species have been described from the North American Silurian and Devonian. A list of these species,[5] with their occurrences, follows:

Clinton-Anticosti: *L. prisca* Hall, *L. julia* Billings.
Cobleskill limestone: *L. bipartita* Hall, *L. nearpassi* Barrett, *L. textilis* Hall (1852, not 1857).
Acadian neo-Silurian: *L. gilpeni* Dawson, *L. ornatella* Salter, *L. filosa* Sowerby.
Helderbergian: *L. planulata* Hall, *L. becki* Hall.
Oriskanian: *L. blainvillei* Billings, *L. irene* Billings *L. lincklæni* Hall, *L. magnifica* Hall, *L. magniventer* Hall, *L. oriskania* Clarke, *L. tullia* Billings.
Schoharie and "Corniferous": *L. perplana* Conrad, *L. crenistria* Hall.
Hamilton: *L. fragilis*, Hall; *L. junia* Hall, *L. pleuristriata* Conrad.
Tully limestone: *L. tulliensis* Williams.
Portage and Chemung: *L. interstrialis* Vanuxem.
Chemung: *L. delthyris* Conrad (*L. nervosa* Hall and authors).

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[1] Paleontology of New York, vol. 8, pt. 1, p. 179, pl. 4 G, fig. 35, 1892; from the Lower Helderberg group, near Clarksville, N. Y.
[2] Paleozoic fossils: Geol. Survey Canada, vol. 2, pt. 1, p. 15, fig. 5, 1874.
[3] Paleontology of New York, vol. 8, pt. 1, p. 180, pl. 4, fig. 3, 1892.
[4] Clarke, J. M., New York State Mus. Mem., vol. 3, p. 58, pl. 8, figs. 16, 18, 1900.
[5] For bibliographic references to such of these names as are not given in the succeeding pages, see Stropheodonta and Strophomena in Schuchert, Charles, A synopsis of American fossil Brachiopoda: U. S. Geol. Survey Bull. 87, 1897.

Not all the above names are worthy of specific rank, owing to the high degree of variability attained in some of the forms. This variability becomes most pronounced in the Acadian, late Silurian, and in the Helderberg and Oriskany "species." A close study of the Leptostrophias from these formations indicates that the plastic variability developed here prohibits very close specific demarcation, and suggests that the Cobleskill *L. nearpassi* and *L. textilis,* which are now considered synonyms of *L. bipartita,* should be included together with *L. tullia, L. blainvillei, L. oriskania, L. planulata, L. pleuristriata,* and *L. perplana* as a single species, or perhaps as varieties of a single species, to which the name *L. perplana* Conrad is applicable.

The proposal to unite into a single species these forms, which range from the Cobleskill limestone (late Silurian) to the Ithaca shale member of the Portage formation (middle Neo-Devonian), requires some explanation. This explanation is found in the fact that specimens occurring together at a single locality and there representing apparently a single though plastic specific type show the supposedly typical characters of several or all of the "species" listed above, from *Leptostrophia bipartita* to *L. perplana.* Thus there are in the Moose River sandstone at Little Brassua Lake, Somerset County, Maine, rather small to medium-sized Leptostrophias of the *L. oriskania* type which have 100 or more striations per 25 millimeters and the acute-angled musculature (60°) of *L. tullia* and *L. bipartita,* but which are without any undulations on the surface. Other specimens show the musculature with the angle gradually increasing to an obtuse-angled musculature with short curving margins (Leptostrophia cf. *L. oriskania*); the strengthening of the striations in some of the specimens links them with *L. blainvillei, L. planulata, L. pleuristriata,* and *L. perplana.*

The Leptostrophias from the Moose River sandstone at Little Brassua Lake constitute only a small part of the evidence available from Maine and elsewhere to show that *Leptostrophia perplana* and the synonyms listed above represent only a single variable species having unfixed combinations of characters which, were they sufficiently fixed, might rank as of separate specific value. These characters include angle of musculature, whether acute, right, or obtuse; musculature, short or half the length of the shell; marginal septa, short or half the length; striæ, 70 to 80, or 95 to 100, or more, per 25 millimeters; umbones smooth or striate; shell small, medium, or large sized; concentric undulations obscure or absent; shell flat or appreciably convex.

A study of the characters themselves shows that they intermingle and interlink in nearly every combination; and study of the stratigraphic range of these combinations supports the contention that *Leptostrophia bipartita, L. perplana,* and the rest represent only a single species. Characteristic specimens of *L. bipartita,* a Cobleskill "species," occur in the Moose River fauna, at Little Brassua Lake, Somerset County, Maine; and a hardly distinguishable type is represented in the Cornell University collections from the Onondaga ("Corniferous") limestone near Buffalo, N. Y. The type described as *L. pleuristriata* Conrad from the upper Hamilton at Delphi, N. Y., is specifically indistinguishable from broad musculatured forms of *L. planulata* from the Coeymans ("Lower Pentamerus") limestone of the Helderberg group.

The name *Leptostrophia perplana* (Conrad) not only has priority over all the others, but the type for which it was originally used by Conrad himself best interprets or represents the more frequent expression of the "species" of this group. The name *Leptostrophia perplana* (Conrad) will therefore include the following: *Leptostrophia textilis* Hall, *L. nearpassi* Barrett, *L. bipartita* Hall, *L. tullia* Billings, *L. oriskania* Clarke, *L. perplana* Conrad (and in part of authors), and *L. pleuristriata* Conrad. The species will, however, not include such forms as *Leptostrophia interstrialis* var. *delthyris* Conrad (the *Leptostrophia perplana* var. *nervosa* of authors), *L. crenistria* Hall, and *L. fragilis* Hall, which have hitherto been identified with Conrad's *L. perplana.*

This group of species of Leptostrophia is a good illustration of the phenomenon to which Vaughan[1] recently called attention in proposing the term "gens" or species group for "the aggregate of all the species which possess in common a large number of essential properties and are continuously related either in space or time." The important part of the phenomenon, which modifies the current conception of the law of the transmission of characters in heredity,

[1] Vaughan, Arthur, On the paleontological sequence in the Bristol area: Geol. Soc. London Quart. Jour., vol. 61, p. 183, May, 1905.

is the fact that the characters which serve the systematist in his discrimination of species fluctuate in the same manner as those used for discriminating varieties and, secondly, they continue to fluctuate in successive generations of reproduction.

LEPTOSTROPHIA PERPLANA (Conrad).[1]

Plate VIII, figures 1–7, 13–16; Plate XI, figure 17.

1837. "Producti." Jackson, First report on the geology of Maine, p. 128, pl. 1, fig. 7.
"Graywack" [probably Moose River sandstone: Somerset County]: Maine.

1842. *Strophomena perplana.* Conrad, Acad. Nat. Sci. Philadelphia Jour., vol. 8, p. 257, pl. 14, fig. 11.
Corniferous limestone: Schoharie, N. Y.

1842. *Strophomena pleuristriata.* Conrad, idem, p. 259.
"Silurian" [Hamilton formation, or perhaps Ithaca shale member of the Portage formation]: Near Smyrna, Chenango County, N. Y.

?1846. *Orthis concinna.* Morris and Sharpe, Geol. Soc. London Quart. Jour., vol. 2, p. 275, pl. 10, fig. 2.
Lower Devonian: Falkland Islands, South America.

1852. Leptæna sp. Hall, Paleontology of New York, vol. 2, p. 326, pl. 74, figs. 3a, 3b.
Leptæna bipartita. Hall, idem, p. 326, pl. 74, figs. 4a, 4b, 5a.
Strophodonta textilis. Hall, idem, p. 327, pl. 74, figs. 6a–6d.
All from the Coralline [Cobleskill] limestone: Schoharie, N. Y.

1859. *Strophodonta planulata.* Hall, Paleontology of New York, vol. 3, p. 184, pl. 16, figs. 9–12.
Pentamerus [Coeymans] limestone [of Helderberg group]: Schoharie, Dry Hill, and Litchfield, N. Y.

1859. *Strophomena bipartita.* Hall, New York State Cab. Nat. Hist. Twelfth Ann. Rept., p. 82.
Coralline [Cobleskill] limestone: Schoharie, N. Y.

1863. *Strophomena perplana.* Billings, Portland [Maine] Soc. Nat. Hist. Proc., vol. 1, pt. 2, p. 109.
Lower Helderberg: Square Lake, Aroostook County, Maine.

1863. *Strophomena perplana.* Billings and Logan, Geology of Canada, pp. 393, 410, 439.
Gaspe (Oriskany) limestones: Whitehead, Perce Rock, and Cape Barry, Gaspe, Quebec.
Gaspe sandstone (Oriskany): Douglastown River, Gaspe, Quebec.

1863. *Strophomena blainvillei.* Billings, idem, p. 398.
Gaspe sandstone: North side of inner basin, Gaspe, Quebec.

1867. *Strophodonta perplana* (pars). Hall, Paleontology of New York, vol. 4, pp. 92–98, pl. 11, fig. 22 (not pls. 12, 17, nor (?) 19).
Schoharie grit: Clarksville and Knox, Albany County and Schoharie, N. Y.
Corniferous limestone: Helderberg Mountains; Schoharie; and at Williamsville, Clarence Hollow, and Cherry Valley, in Erie County, N. Y.; Louisville, Ky.; Columbus, Ohio; falls of Ohio River, in Indiana.
Hamilton group: Eastern New York. Not (?) Cayuga and Seneca lakes, Moscow, York, Pavilion, Darien, and Eighteenmile Creek, N. Y.; Rock Island, Ill.; nor New Buffalo, Iowa [*L. crenistria* Hall and *L. fragilis* Hall]; not Chemung group at Chemung Narrows, N. Y., nor along the line of the Blossburg [Erie] Railroad, etc. [*L. interstrialis* var. *delthyris* Conrad].

1868. Strophomena (Stropheodonta) sp. Meek and Worthen, Illinois Geol. Survey, vol. 3, p. 412, pl. 9, fig. 6.
Yellow sandstone (age of Schoharie grit): Four miles west of Jonesboro, Union County, Ill.

?1874. *Strophomena perplana.* Nicholson, Paleontology of the Province of Ontario, p. 64, fig. 20.
Corniferous limestone: Port Colborne and Wainfleet, Ontario.

1874. *Strophomena blainvillei.* Billings, Paleozoic fossils, vol. 2, pl. 3, fig. 1.
Lower part of Gaspe sandstone: Gaspe, Quebec.

1874. *Strophomena tullia.* Billings, idem, pt. 1, p. 29, pl. 2, figs. 6, 6a.
Lower Devonian: Mount Joli and Perce Rock, Gaspe, Quebec.

1877. *Strophodonta planulata.* Barrett, Am. Jour. Sci., 3d ser., vol. 13, p. 386.
Lower Helderberg trilobite beds [uppermost Helderberg]: Bennett's quarry, near Port Jervis, N. Y.

1878. *Strophodonta nearpassi.* Barrett, idem, vol. 15, p. 372.
Coralline limestone [Cobleskill]: Nearpass Bluff, Montague, N. J.

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[1] If, as seems possible, some of the European Leptostrophias, particularly *Leptæna (Leptostrophia) explanata* Sowerby and authors, are to be united with *Leptostrophia perplana* (Conrad), it is believed that Conrad's specific name ought to be retained. Conrad's name was proposed in his article read before the Philadelphia Academy of Natural Sciences January 18, 1842, and the article was published certainly in 1842. Sowerby's species was described in an appendix to the long article of D'Archiac and De Verneuil on the Rhenish Lower Devonian deposits, read before the London Geological Society December 15, 1841; but whether Sowerby's appendix was incorporated with the original paper of D'Archiac and De Verneuil, or whether it was added subsequently, is unknown, though several indications point to the latter supposition. At any rate the article was not published before 1842, and possibly not before 1846, as the latter date is printed on the published whole volume of the "Transactions" in which Sowerby's descriptions appeared. Most authors, however, give the date 1842 for D'Archiac and De Verneuil's paper. In view of the long-established reputation of the Philadelphia academy for the prompt publication of its papers, and the fact that Conrad's article is known to have been published early in 1842, it would appear equitable that Conrad's name be preferred over Sowerby's.

1879. *Strophodonta perplana.* Rathbun,[1] Boston Soc. Nat. Hist. Proc. vol. 20, p. 25.
Lower Devonian: Rio Maecuru and Rio Curua, Para, Brazil.
1883. *Strophodonta perplana* (pars). Hall, New York State Geologist Second Ann. Rept., pl. 46, figs. 2, 3, 10?, 11?, 12? (not 4–9, 13).
Corniferous limestone and (?) Hamilton group: Western New York.
1883. *Strophomena perplana.* Ells, Canada Geol. Survey Rept. Progress for 1880–1882, p. 7 DD.
Lower Gaspe limestones (Helderberg): Upper part of Griffin Cove River near forks of Ruisseau de la Grande Carriere, Gaspe, Quebec.
1883. *Strophomena blainvillei.* Ells, idem, pp. 8 DD, 14 DD.
Upper Gaspe limestone: Perce Rock.
Lower Gaspe sandstones: York and Dartmouth rivers and near Gaspe village, Gaspe, Quebec.
1885. *Strophomena blainvillei.* Ells, idem, for 1882–1884, pp. 24 E, 30 E.
Lower Gaspe limestone (Lower Helderberg): Ruisseau de la Grande Carriere near Griffins Cove.
Gaspe Oriskany [whether sandstone or limestone is not stated]: Hills in the rear of Gaspe village, Quebec.
1886. *Strophodonta planulata.* S. G. Williams, Am. Jour. Sci., 3d ser., vol. 31, p. 142.
Lower Helderberg [Coeymans limestone]: Oriskany Falls, N. Y.
1889. *Strophodonta perplana.* Nettelroth, Kentucky fossil shells, p. 147, pl. 18, fig. 17.
Upper strata of the Devonian limestone: Falls of the Ohio in Kentucky and Indiana.
1889. *Stropheodonta perplana.* Schuchert, New York State Geologist Eighth Ann. Rept., p. 52.
Oriskany: Cayuga, Ontario.
1890. *Stropheodonta perplana.* Clarke, Mus. nac. Rio de Janeiro Arch., vol. 10, p. 153.
Devonian sandstones: Rio Maecuru and Rio Curua, Para, Brazil.
1890. *Strophodonta perplana.* Lesley, Pennsylvania Second Geol. Survey Rept. P4, p. 1116, figs.
Corniferous and Marcellus limestones: Centre Mills and Pine Grove, Perry County, Pa.
Hamilton shale: Bells Mills, Blair County, Pa.
Hamilton upper shales: Perry, Blair, and Huntingdon counties, Pa.
Cardiola shale: Newport Narrows, Perry County, Pa.
Chemung: Middle Ridge, Perry County, Pa.
Stony Brook beds? ("Upper Chemung"): Bloomsburg, Columbia County, Pa.
1890. *Strophodonta perplana* (?). Derby, Mus. nac. Rio de Janeiro Arch., vol. 9, p. 75.
(Middle?) Devonian sandstone: Chapada, 30 miles northeast of Cuyaba, Matto Grosso, Brazil.
?1891. *Strophodonta perplana.* Beecher, Am. Jour. Sci., 3d. ser., vol. 41, p. 357, pl. 17, fig. 17.
Hamilton: Falls of Ohio River.
not 1891. *Strophodonta perplana.* Whiteaves, Contributions to Canadian paleontology, vol. 1, p. 220 [probably *L. junia*]. Devonian (upper Hamilton?): Vermilion Falls, Peace River, Canada.
1892. Strophomena sp. Ulrich. Neues Jahrb. Beilage Band, vol. 8, p. 70.
Fine-grained light-gray graywacke: Between Pulquina and Agua Blanca, Bolivia.
Yellow sandstone: Between Totora and Chalhuani, Bolivia.
Both localities in the Icla shale, containing *Leptocœlia flabellites.*
1892. *Stropheodonta (Leptostrophia) perplana.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, p. 288, pl. 15, figs. 2, 3, ?10–12 (not figs. 4–9, 13).
Corniferous limestone, and ?Hamilton group: western New York.
1892. *Strophodonta (Leptostrophia) textilis.* Hall and Clarke, idem, p. 288.
Coralline [Cobleskill] limestone: New York.
1892. *Stropheodonta (Leptostrophia) blainvillei.* Hall and Clarke, idem, p. 288.
Gaspe sandstone: Gaspe, Quebec.
1892. *Stropheodonta (Leptostrophia) tullia.* Hall and Clarke, idem, p. 288.
Lower Devonian: Gaspe, Quebec.
1892. {*Leptostrophia* cf. *becki.* Clarke, Am. Jour. Sci., 3d ser., vol. 44, p. 413.
Leptostrophia cf. *perplana.* Clarke, idem.}
Oriskany siliceous limestone: Becraft Mountain, Columbia County, N. Y.
1897. *Stropheodonta (Leptostrophia) blainvillei.* Schuchert, U. S. Geol. Survey Bull. 87, p. 420.
Lower Devonian: Gaspe, Quebec.
1897. *Strophodonta nearpassi.* Schuchert, idem, p. 425.
Coralline limestone: Near Port Jervis, N. Y.; in New Jersey.
1897. *Stropheodonta planulata.* Schuchert, idem, p. 426.
Lower Helderberg: Schoharie, Dry Hill, and Litchfield, N. Y.
1897. *Stropheodonta (Leptostrophia) tullia.* Schuchert, idem, pp. 243, 427.
"Upper Helderberg" (Devonian): Mount Joli and Split Rock, Perce, Gaspe, Quebec.
1897. *Strophomena* (?) *bipartita.* Schuchert, idem, p. 429.
Coralline limestone: Schoharie, N. Y.

[1] Both Rathbun (1879) and Clarke (1890) note the very large size and variability of these Brazilian Leptostrophias. These features in the United States and Canada are confined chiefly to the Helderberg and Oriskany (?) forms.

1897. *Stropheodonta (Leptostrophia) textilis.* Schuchert, idem, pp. 243, 427.
Coralline limestone: Schoharie, N. Y.
1897. *Strophodonta perplana.* Weller, Jour. Geology, vol. 5, No. 6, pp. 628, 629.
Corniferous limestone: Devils Bake Oven, near Grand Tower, Jackson County, Ill. (zones 11, 13).
1898. *Stropheodonta perplana* Conrad, Bownocker, Denison Univ. Sci. Lab. Bull., vol. 11, pl. 7.
Corniferous limestone: Harrisburg, Columbus, Marble Cliff, Marion, Kellys Island, and Radnor, Ohio.
1899. *Stropheodonta perplana.* Prosser, New York State Geologist Seventeenth Ann. Rept., for 1897, p. 352.
Schoharie grit: Near Clarksville, Albany County, N. Y.
1899. *Stropheodonta (Leptostrophia) perplana.* Schuchert, Am. Jour. Sci., 4th ser., vol. 7, p. 432.
Oriskany chert: Camden, Benton County, Tenn.
1900. *Stropheodonta perplana.* Schuchert, Geol. Soc. America Bull., vol. 11, p. 282.
Becraft limestone: New York.
?Lower Helderberg: Tennessee, Maine, and New Brunswick.
Trilobite beds (lower Oriskany): Port Jervis, N. Y. (p. 306).
Lower Oriskany: Becraft Mountain, N. Y. (p. 307), and Camden, Benton County, Tenn. (p. 322).
Upper Oriskany: New York; Oneida and North Cayuga townships, Ontario.
1900. *Stropheodonta planulata.* Schuchert, idem, p. 283.
Coeymans limestone: New York.
Lower Helderberg: Tennessee.
1900. *Leptostrophia oriskania.* Clarke, New York State Mus. Mem., vol. 3, No. 3, p. 53, pl. 7, figs. 29–35.
Oriskany siliceous limestone: Becraft Mountain, Columbia County, N. Y.; along West Shore Railroad, one-half mile southeast of Rondout Creek (p. 74); and at Glenerie, 7 miles north of Kingston, N. Y. (p. 74).
1903. *Stropheodonta bipartita.* Weller, Paleontology of New Jersey, vol. 3, pp. 63–72, 226, pl. 20, figs. 1–5.
Decker Ferry limestone: William Nearpass quarry (pp. 63–66), and adjoining farm south of Tri-States, 1¾ miles northeast of Hainesville (p. 69); 1¾ miles below Peters Valley (p. 70) Flatbrookville (p. 71); Upper Longwood (p. 72); all in New Jersey.
1903. *Stropheodonta planulata.* Weller, idem, p. 276, pl. 27, figs. 1, 2.
Coeymans limestone (Helderbergian): Nearpass Quarry Bluff, 2 miles northeast of Flatbrookville (p. 84), and in E. Harris's pasture below Flatbrookville, N. J.
1903. *Stropheodonta perplana.* Weller, idem, pp. 103, 366; pl. 51, figs. 12, 13.
Onondaga limestone: Delaware River, 2½ miles below Tri-States; also 1½ miles southwest of Peters Valley, N. J.
1903. *Stropheodonta bipartita* and *S. textilis.* Hartnagel, New York State Mus. Bull. 69.
Cobleskill limestone: Steven's farm, 3 miles east of Schoharie (p. 1117); extreme north end of West Mountain, Schoharie (p. 1124); and half a mile northwest of Carlisle (p. 1126); Schoharie County. Heard gypsum quarry 1 mile south of Lyndon; Onondaga County (p. 1161). Frontenac Island, Cayuga Lake (p. 1133). Also in western New York (p. 1128).
Wilbur limestone: Old cement mines, Rondout, N. Y.
1903. Leptostrophia cf. *L. planulata.* Van Ingen and Clark, idem, pp. 1188, 1206.
Coeymans limestone: Near Rondout, N. Y.
1903. *Leptostrophia oriskania.* Van Ingen and Clark, idem, pp. 1203, 1206.
Oriskany: Glenerie and Rondout, N. Y.
1903. *Leptostrophia perplana.* Van Ingen and Clark, idem, p. 1205.
Corniferous limestone: About Kingston, N. Y.
?1903. Stropheodonta cf. *concina.* Reed, South African Mus. Annals, vol. 4, p. 169, pl. 20, fig. 6.
Lower Devonian: Warm Bokkeveld, South Africa.
1905. *Leptostrophia tullia.* Clarke, New York State Mus. Bull. 80, pp. 143, 145.
Perce limestone: Perce Rock, Gaspe, Quebec.
1905. *Leptostrophia blainvillii.* Clarke, idem, p. 145.
Gaspe sandstone: Gaspe, Quebec.
1905. *Leptostrophia oriskania.* Clarke, idem, pp. 145, 152.
Grand Greve limestone: North shore of Gaspe Bay, Quebec.
1905. *Leptostrophia oriskania.* Shimer, idem, pp. 185, 227, 240, 264.
Dalmanites dentatus zone, or trilobite beds (lower Oriskany): Trilobite Mountain, N. Y.
1905. *Stropheodonta bipartita.* Hartnagel, idem, pp. 351, 352, 354.
Decker Ferry limestone, lower part: Fiddlers Elbow on Delaware & Hudson Canal, Orange County, N. Y.
Decker Ferry limestone, upper part: Along New York, Ontario & Western Railway (Kingston branch), one-half mile southwest of Accord, and on the Cuddeback farm, Cuddebackville, Orange County, N. Y.
Cobleskill limestone: Old quarry, 1 mile southeast of Cuddebackville, Orange County, N. Y.
1905. Stropheodonta cf. *S. planulata.* Williams and Kindle, U. S. Geol. Survey Bull. 244, pp. 28, 47.
Top of Hancock limestone (Lower Helderberg fossils): East fork of Powell River, just above flouring mill, Bigstone Gap, Wise County, Va.
1907. *Leptostrophia tardifi.* Clarke, New York State Mus. Bull. 107, p. 273, figs.
Lower Devonic: Perce Rock, Quebec.
1907. *Leptostrophia magnifica parva.* Clarke, idem, p. 274, figs.
Lower Devonic: Edmunds Hill, Chapman, Aroostook County, Maine.

Shell wider than long; length varying from three-fourths the width to nearly equal to the width; front of the shell arcuate, curving into the sides, which are slightly rounded, subparallel, and frequently slightly converging toward the hinge line. Hinge extremities auriculate or angular; rarely mucronate, and then only slightly so. Hinge straight; cardinal line in the pedicle valve slightly reclining from the beaks. Greatest width of shell along hinge line; in forms where the sides converge toward the hinge the greatest width is about midway the length of the shell. Pedicle valve depressed convex, brachial valve flat or concave. Greatest elevation of the shell is in the pedicle valve over the muscular area, a varying distance posterior to the middle. This maximum elevation is from one-eighth to one-fourteenth the width of the shell. Musculature of pedicle valve fan shaped, spreading from the beaks, rarely extending forward beyond the mid-length of the shell; not discernably cordate or insinuate in front. On each side of the muscular scar are defining ridges, which are generally pustulose; they extend from the beaks varying distances forward but not more than midway to the front, becoming gradually obsolescent forward. The angle formed by the defining ridges or outer edges of the musculature varies from acute (55°) to obtuse (125°). A thin, blunt median septum or ridge extends the length of the musculature, becoming thick and broad for about 2 millimeters under the beak. No scar of the diductor muscles is discernible in the pedicle valve. Between the hinge line and the sides of the musculature the inner surface of the pedicle valve is strongly pitted, the pitting becoming less conspicuous on approaching the hinge line.

The interior of the brachial valve shows the cardinal process strongly bilobed from its origin outward; internal casts of the brachial valve show it as two deep holes in front of the hinge line. These holes are somewhat elongate, reniform in outline, and nearly parallel. On the forward side of the base of the cardinal process, two diverging elevated ridges proceed outward, gradually flattening down to the level of the interior of the shell. Between these ridges, in a central position, a blunt septum extends forward a short distance.

The cardinal area of the pedicle valve is narrow, though quite apparent. The cardinal area of the brachial valve is linear or absent.

The surface is marked by fine, distinct, radiating, raised lines which are nearly uniform in size and strength over the whole surface; they are rounded or subangular, and straight or slightly flexuous on the body of the shell, but slightly curving near the hinge extremities. The lines increase freely, mainly by implantation, and at a distance of 20 millimeters from the beak number in the typical forms about 70 per 25 millimeters, though they vary from 60 to 100 or more in this distance in the varietal modifications. Obscure concentric undulations are often developed on the surface; but these are generally very obscure, and in exfoliated shells are seldom if ever discernible. More commonly, however, traces of them as oblique wrinkles may be observed near the hinge line.

The diagnostic characters by which this very variable species may be recognized are (1) the fine, slightly uneven, flexuous surface lineations, finer than in *L. beckei*, and not granulose nor so flexuous or distant as in *L. crenistria*, the lines subequal and not less than 60 per 25 millimeters; (2) the small musculature extending less than two-thirds the length of the shell and generally less than half; (3) the absence of any cordate insinuation in front of the musculature; (4) a strongly bilobed cardinal process, leaving two deep reniform holes in the internal mold of the brachial valve, the holes being only very slightly divergent and nearly parallel.

Remarks on the Maine specimens from the Moose River sandstone are given in the following paragraphs.

Figure 1 of Plate VIII shows an internal mold of a large pedicle valve, preserving also a fragment of shell, length 34 millimeters; the greatest width, 45 millimeters, is two-fifths the length from the hinge. Sides rounded, converging toward the hinge; depth of valve, 3.4 millimeters; musculature obtuse, 115°; radiating lines flexuous, increasing by implantation, but largely also by bifurcation; at 25 millimeters from the beak there are near the middle about 13 lines per 5 millimeters, and the furrows between the lines are deeply pitted. No undulations. This is a typical large specimen of *L. blainvillei* (Billings).

Figure 17 of Plate XI resembles the form just described, but has obscure undulations on the internal mold. At a distance of 20 to 25 millimeters from the beak 12 radiating lines were counted in 5 millimeters at the front, and 18 lines in the same space on the side of the shell; furrows between the lines are pitted. This specimen combines characters of *L. blainvillei* and *L. oriskania* and of a Leptostrophia from the Onondaga limestone at Buffalo, N. Y.

Another unfigured brachial valve is in length 18 millimeters; nearly flat. A low median ridge or narrow platform extends half the length of the shell; two similar, shorter ridges or platforms diverge from the beak, one on each side of the median line. The radial lines increase by bifurcation; 15 may be counted in a width of 5 millimeters at a distance of 15 millimeters from the beak. There are no concentric undulations.

A large typical specimen of *Leptostrophia magnifica* Hall from the collections of Mr. Harold Prince exhibits an elongated outline; length, 36 millimeters; width the same. The musculature boundaries diverge at an angle of 85° to 90°; the scars extend three-fifths the length of the shell and are divisible into four conspicuous strap-shaped portions, or "lingules." The surface lines are sharply elevated, and closely set in internal molds, but as preserved on the exterior they are low and rounded; 19 lines may be counted in a space of 5 millimeters at a distance of 30 millimeters from the beak; they increase by bifurcation and implantation. Occasionally a finer line alternates with the coarser normal lines over small portions of the surface, simulating the ornamentation of the Silurian *Leptostrophia filosa* (Sowerby). A couple of very obscure concentric undulations are discernible near the front of the musculature.

This large, elongate, finely lineate Leptostrophia, with the acute and very long musculature, is identifiable with Hall's *Leptostrophia magnifica*, a characteristic Oriskany type. (Compare the specimen described with *L. magnifica* from the Oriskany of New Jersey.[1]) The characteristically Oriskany type of *Leptostrophia magnifica* as it occurs in the Moose River sandstone fauna (which contains *Spirifer arenosus*, *Spirifer murchisoni*, *Leptocœlia flabellites*, and other characteristic Oriskany horizon markers) does not appear to be connected by any transitional gradations with the accompanying *Leptostrophia blainvillei* Billings and *L. perplana* Conrad. This has been the chief reason for considering *L. magnifica* as a distinct species. Apart from the large size of the shell, the large musculature is of itself by no means a characteristic development of Oriskany time, for there occurs in the Manlius limestone or in the lower part of the overlying Helderberg at Litchfield, N. Y., a large musculatured Leptostrophia not easily distinguishable from *L. magnifica*.

Specimens from the Chapman sandstone at Edmunds Hill are described below.

Figure 3, Plate VIII, represents a large pedicle valve in internal mold; length 35 millimeters, width 40 millimeters, boundaries of musculature form obtuse angle (125°) and extend slightly beyond half the length of the shell, having 7 or 8 "lingules" each side of the middle; surface radial lines 14 to 15 per 5 millimeters at a distance of 30 millimeters from the beak; the furrows between the lines seem to be pitted in the better-preserved spots of the shell. No undulations. This specimen is a large *L. blainvillei* in form but is also similar, except for the obtuse musculature, to some specimens of *L. planulata* found at Jerusalem Hill, Litchfield, N. Y., in the Coeymans ("Pentamerus") limestone of the Helderberg group.

Figure 7, Plate VIII, shows a smaller specimen with similar ornamentation. It is 25 millimeters wide and has an acute musculature (80°–85°). Type of *L. planulata* and *pleuristria*.

Figure 13, Plate VIII, represents an external mold of a pedicle valve; length 25 millimeters, width 27 millimeters; extreme width along hinge 30 millimeters; sides of shell curved, converging toward hinge; hinge extremities sharply auriculate. Boundaries of musculature apparently acute (85°). Radial lines increase by implantation, 22 in a space of 10 millimeters at a distance of 25 millimeters from beak. One or two very obscure wrinkles near middle of shell; stronger, more numerous short oblique wrinkles along the hinge line. No traces of pits between the elevated lines. This shell combines characters of *L. tullia* and *L. planulata* and in the coarse radial lines approaches *L. becki*. It fairly represents a typical specimen of *L. planulata* Hall.

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[1] Weller, Stuart, Paleontology of New Jersey, Paleozoic faunas, p. 345, pl. 45, figs. 10, 11, 1903.

Figure 15, Plate VIII, is similar to the last specimen, but is larger, being 30 millimeters long.

Figure 6, Plate VIII, represents a small pedicle valve in internal mold, musculature acute (55°), extending less than half the length of the shell; radial lines 25 in 8 millimeters at a distance of 15 millimeters from the beak, furrows between the lines pitted. Width of specimen about 30 millimeters. The acute angle of the musculature boundaries is similar to that of *L. tullia* and *L. bipartita*, and the number of radial lines is midway between the two.

Figure 14, Plate VIII, is a large pedicle valve in external mold; length 35 millimeters, width 38 millimeters; sides rounded and converging toward the hinge line. Boundaries of musculature make acute angles, apparently about 60°. Surface radial lines increase by implantation; 12 in the space of 5 millimeters at 15 millimeters fiom the beak. Furrows between the elevated lines apparently pitted. Over several parts of the surface the radial lines seem to alternate, a finer one being implanted between each pair of normal lines (cf. *L. filosa* Sowerby). More than half a dozen obscure uneven undulations are barely visible. This shell is very close to *L. tullia* Billings and *L. planulata* Hall.

Locality: Chapman sandstone, west side of Edmunds Hill (common), Edmunds Hill (occasional), Presque Isle Stream (occasional), Aroostook County, Maine. Moose River sandstone, Parlin Pond (rare), Little Brassua Lake (abundant), Somerset County, Maine.

U. S. National Museum, catalogue Nos. 59693, 59694, 59695, 59696, 59697.

Genus LEPTÆNA Dalman, 1828.

LEPTÆNA RHOMBOIDALIS (Wilckens).

Plate VIII, figures 8–12.

1769. *Conchita rhomboidalis*. Wilckens, Nachricht von selten Versteinerungen, p.77, pl. 8, figs. 43, 44.
1841. *Strophomena undulosa*. Conrad, New York Geol. Survey Fifth Ann. Rept., p. 54.
1842. *Strophomena depressa*. Vanuxem, Geology of New York, Rept. Third Dist., p. 79, fig. 5,
1842. *Strophomena undulatus*. Vanuxem, idem, p. 139, fig. 3.
1843. *Strophomena depressa*. Hall, idem, Rept. Fourth Dist., p. 77, fig. 5; p. 104, fig. 2.
1843. *Strophomena undulata*. Hall, idem, p. 175, fig. 3.
1843. *Productus? sulcatus*. Castelnau, Essai sur le système Silurien d'Amérique septentrionale, p. 39, pl. 13, fig. 7.
1843. *Productus silcifer*. De Verneuil, idem, p. 39.
1847. *Strophomena undulata*. Yandell and Shumard, Contributions to the geology of Kentucky, p. 11.
1847. *Leptæna tenuistriata*. Hall, Paleontology of New York, vol. 1, p. 108, pl. 31A, fig. 4.
1852. *Leptæna depressa*. Hall, idem, vol. 2, p. 62, pl. 21, fig. 8; p. 257, pl. 53, fig. 6.
1856. *Strophomena depressa*. Billings, Canadian Nat. Geol., vol. 1, p. 59, pl. 1, fig. 5.
1858. *Leptæna depressa*. Rogers, Geology of Pennsylvania, vol. 2, pt. 2, p. 823, fig. 630.
1859. *Strophomena rugosa*. Hall, Paleontology of New York, vol. 3, p. 195, pl. 19, fig. 1.
1860. *Strophomena depressa*. Roemer, Silurian fauna of western Tennessee, p. 65, pl. 5, fig. 2.
1861. *Strophomena rhomboidalis*. Billings, Canadian Jour., vol. 6, p. 336, figs. 111, 112.
1863. *Strophomena rhomboidalis*. Billings, Geology of Canada, p. 311, fig. 314; p. 367, fig. 373.
1863. *Strophomena rhomboidalis*. Billings, Portland Soc. Nat. Hist. Proc., p. 107, pl. 3, fig. 1.
1863. *Strophomena analoga*. Davidson, Geol. Soc. London Quart. Jour., vol. 19, p. 173, pl. 99, fig. 18.
1865. *Leptæna quadrilatera*. Shaler, Mus. Comp. Zool. Bull. 4, p. 65.
1867. *Strophomena rhomboidalis*. Hall, Paleontology of New York, vol. 4, p. 76, pl. 12, figs. 16–18; p. 414, pl. 15, figs. 15, 16.
1868. *Strophomena rhomboidalis*. Meek and Worthen, Illinois Geol. Survey, vol. 3, p. 426, pl. 10, fig. 7
1873. *Strophomena rhomboidalis*. Meek, Paleontology of Ohio, vol. 1, p. 75, pl. 5, fig. 6.
1874. *Strophomena rhomboidalis*. Billings, Paleozoic fossils, vol. 2, p. 27.
1874. *Strophomena gibbosa*. James, Cincinnati Quart. Jour. Sci., vol. 1, p. 333.
1875. *Strophomena rhomboidalis*. White, U. S. Geog. Surveys W. 100th Mer., vol. 4, p. 85, pl. 5, fig. 5.
1875. *Strophomena tenuistriata*. Miller, Cincinnati Quart. Jour. Sci., vol. 2, p. 55.
1877. *Strophomena rhomboidalis*. Hall and Whitfield, U. S. Geol. Expl. 40th Par., vol. 4, p. 253, pl. 4, fig. 4.
1878. *Strophomena analoga*. Dawson, Acadian geology, 3d ed., p. 295, fig. 95.
1879. *Strophomena rhomboidalis*. Hall, New York State Mus. Nat. Hist. Twenty-eighth Rept., p. 151. pl. 22, figs. 4–10.
1881. *Strophomena rhomboidalis*. Miller, Cincinnati Soc. Nat. Hist. Jour., vol. 4, p. 1.
1882. *Strophomena rhomboidalis*. Hall, Indiana State Geologist Eleventh Rept., p. 288, pl. 22, figs. 4–10.

1883. *Strophomena rhomboidalis.* Hall, New York State Geologist Second Ann. Rept., pl. 38, figs. 17-31.
1883. *Strophomena tenuistriata.* Hall, idem, pl. 38, figs. 12-16.
1884. *Strophomena rhomboidalis.* Walcott, U. S. Geol. Survey Mon. 8, p. 118.
1889. *Strophomena rhomboidalis.* Beecher and Clarke, New York State Mus. Mem., vol. 1, p. 18, figs. 1-13.
1889. *Strophomena rhomboidalis.* Nettelroth, Kentucky fossil shells: Kentucky Geol. Survey Mem., p. 150, pl. 18, figs. 1-3.
1890. *Strophomena rhomboidalis.* Foerste, Boston Soc. Nat. Hist. Proc., vol. 24, p. 298.
1891. *Strophomena rhomboidalis.* Beecher, Am. Jour. Sci., 3d ser., vol. 41, p. 357, pl. 17, figs. 18-21.
1892. *Leptæna tenuistriata.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, pl. 8, figs. 12-16.
1892. *Leptæna rhomboidalis.* Hall and Clarke, idem, vol. 8, pt. 1, p. 279, pl. 8, figs. 17-31; pl. 15A, figs. 40-42; pls. 21-24.
1892. *Leptæna (Strophomena) rhomboidalis.* Beecher, Am. Jour. Sci., 3d ser., vol. 44, p. 150, pl. 1, figs. 7-9.
1895. *Strophomena rhomboidalis.* Herrick, Geology of Ohio, vol. 7, pl. 20, fig. 6.
1895. *Leptæna rhomboidalis.* Foerste, idem, vol. 7, p. 566.
1895. *Plectambonites rhomboidalis.* Keyes, Missouri Geol. Survey, vol. 5, p. 70, fig. 6.

The description of the Maine material representing this species is as follows:

Shell convex-concave, quadrately semicircular; length varying from three-fourths width to equal width. Greatest width along the hinge line. Shell flat in younger portion, abruptly geniculate in front. The geniculate portion is short, two-fifths to one-fourth as long as the flat portion and bent at about a right angle to it. The flat portion is covered with strong undulations, as many as 10 or 11 in about 15 millimeters. These undulations cease where the shell becomes bent and are absent on the geniculated portion. Musculature of pedicle valve oval, about as wide as long and extending nearly half the length; deeply sunken into the shell and surrounded by a raised ridge, formed by the dental lamellæ, which curve around the musculature, converge, and nearly unite in front. The surface ornamentation consists of radiating flexuous elevated lines, interrupted and variable in strength; on passing over the wrinkled portion of the shell the lines may be well developed on the crest of the wrinkles and become obsolescent in the grooves; or, vice versa, the lines may be well developed in the grooves and obsolescent on the crests. The geniculate portion of the shell is marked by radiate lines. The lines are about equal to the interspaces. At a distance of 12 millimeters from the beak 11 have been counted in the space of 3 millimeters. Punctæ or minute canals extend forward and outward through the shell substance and are arranged in rows opening exteriorly on the elevated radiate lines.[1]

The Chapman specimens are all small, having the following dimensions:

Dimensions of specimens of Leptæna rhomboidalis.

Length (millimeters).	Breadth (millimeters).	Height of geniculation (millimeters).	Shape of umbonal portion.
9	13	5	Concave.
18	19	7½	Convex.
....	22	....	Convex.
19	23	4½	Flat.

The geniculation is very abrupt in all the specimens upon which it is visible, so that these shells can not possibly be considered to belong to the variety *ventricosa* Hall.

Locality: Chapman sandstone; three pedicle valves found at Edmunds Hill and another at west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59698, 59699.

[1] Paleontology of New York, vol. 3, pl. 19, fig. 1 L+, 1878.

Genus SCHUCHERTELLA Girty, 1906.

SCHUCHERTELLA WOOLWORTHANA (Hall).

Plate III, figure 10.

1842. *Orthis umbraculum* [not Schlotheim]. D'Archiac and De Verneuil, Geol. Soc. London Trans., 2d ser., vol. 6, p. 396.
Devonian: Kentucky [not Plymouth, England, nor the Eifel, Germany, nor Ferques, France=*O. umbraculum* Schlotheim s. str.].

1843. *Orthis umbraculum* [not Schlotheim]. F. A. Roemer, Die Versteinerungen des Harzgebirges, p. 11, pl. 4, fig. 4.
(Spiriferen) sandstone: On the Kahleberge and the Schalke, Harz Mountains, Germany [not Gerolstein in the Eifel=*O. umbraculum* Schlotheim s. str.].

??1843. *Orthis vetusta*. F. A. Roemer, idem, p. 11.
Dark limestone [Hercynian]: Hilkenschwende in the Harz, Germany.

1845. *Orthis crenistria* [not Phillips]. De Verneuil, Soc. géol. France Bull., 2d ser., vol. 2, p. 458.
[Upper Eo-Devonian]: Province of Asturias, Spain.

1846. *Orthis sulivani*. Morris and Sharpe, Geol. Soc. London Quart. Jour., vol. 2, p. 275, pl. 10, fig. 1.
Lower Devonian: Falkland Islands.

1850. *Orthis devonica* [not Keyserling]. De Verneuil, Soc. géol. France Bull., 2d ser., vol. 7, p. 161.
[Upper Eo-Devonian]: Veneros and Sabero (Leon), Ferrones and Arnao (Asturias), Spain [not Ferques, France; Russia; nor Persia].

1850. *Leptæna umbraculum* [not Schlotheim]. F. A. Roemer,[1] Beiträge zur geologischen Kenntniss des nordwestlichen Harzgebirges, p. 105.
"Upper Silurian" (?) [Hercynian]: Harz Mountains, Germany.

1850. *Orthis umbraculum* [not Schlotheim]. Zeiler, Naturh. Ver. preuss. Rheinlände Verh., vol. 7, p. 143.
Coblentzian graywacke: Coblentz and vicinity, Germany.

1850. *Orthis devonica* [not Keyserling]. De Verneuil, Soc. géol. France Bull., 2d ser., vol. 7, p. 781.
Devonian [higher Eo-Devonian]: St. Jean-sur-Mayenne, France, and Asturias, Spain (not Ize, Ferques, Vire, Les Courtoisieres, France; Russia; nor Persia).

1852. *Leptæna vetusta*. F. A. Roemer, Beiträge zur geologischen Kenntniss des nordwestlichen Harzgebirges, p. 98, pl. 15, fig. 1.
Silurian [Hercynian] limestone: Hilkenschwende, in the Harz Mountains, Germany.

1853. *Orthis hipparionyx* [not Vanuxem]. Schnur, Palaeontographica, vol. 3, p. 217, pl. 40, figs. 1a, b, c.
[Eo-Devonian] lowest limestone beds and graywacke not far below: Prüm, in the Eifel, Germany.

1854. *Orthis hipponyx*. Wirtgen and Zeiller, Naturh. Ver. preuss. Rheinlände Verh., vol. 11, p. 478.
Rhein graywacke: Lahneck, Niederlahnstein, Rhense, Laubach, Giels, Winningen, Hatzenport, Brodenbach, Burgen, Asterstein, and Unkel, Rhenish Germany.

1854. *Orthis umbraculum* [not Schlotheim]. Tschihatscheff, Soc. géol. France Bull., 2d ser., vol. 11, p. 413.
Rhénan: "Guenkson" Valley, between Alemdagh and Boulgourludagh, Asiatic side of the Bosphorus, Asia Minor.

1856. { *Orthis hipparionyx*. De Verneuil and Barrande, idem, vol. 12, p. 1016.
Orthis devonica. De Verneuil and Barrande, idem. }
Lower Devonian: Puerto del Ciervo, Spain; France; and the Rhine.

1856. *Strophomena sulivani*. Sharpe, Geol. Soc. London Trans., 2d ser, vol. 1, p. 209, pl. 26, figs. 18–19.
Dark-colored schist and reddish argillaceous rock [Eo-Devonian]: Warm Bokkeveld, South Africa.

1856. *Strophomena bainii* Sharpe, idem, p. 208, pl. 26, figs. 13, 17.
Lower Devonian: Warm Bokkeveld, South Africa.

1857. *Strophomena woolworthana*. Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 48, figs.
Lower Helderberg [New Scotland] shaly limestone: Albany and Schoharie counties, N. Y.

1857. *Strophomena obovata*. Zeiler, Naturh. Ver. preuss. Rheinlände Verh., vol. 14, p. 51, pl. 4, figs. 19–20.
Sandy graywacke (Lower Devonian): Burgen-an-der-Mosel, Germany.

Not 1857. *Orthis hipparionyx*. Krantz, idem, p. 153 [*S. umbraculum* s. str.].
Lower Devonian: Menzenberg (near Unkel), Germany.

1858. *Leptæna vetusta*. Giebel, Die silurische Fauna des Unterharzes, p. 50, pl. 4, fig. 2.
"Silurian" [Hercynian] limestone: Magdesprung and Hilkenschwende, in the Harz Mountains, Germany.

1859. *Strophomena woolworthana*. Hall, Paleontology of New York, vol. 3, p. 192, pl. 17, figs. 1, 2.
Shaly limestone [New Scotland] of the Lower Helderberg: Helderberg Mountains, Schoharie, Carlisle, and Hudson, N. Y.

1860. *Streptorhynchus pandora*. Billings, Canadian Jour., vol. 5, p. 226, figs. 12, 13.
Corniferous limestone: Cayuga, Ontario.

[1] This was believed to be identical with Vanuxem's *Hipparionyx proximus*, but is now regarded as a member of the group of *Schuchertella sulivanti*. It is of enormous size, with rounded shoulders, giving the shell a circular outline.

1863. *Streptorhynchus pandora*. Billings, Geology of Canada, p. 369, fig. 384.
Corniferous limestone: West of Grand River in Haldemand and Norfolk counties, Canada West.
1863. *Streptorhynchus woolworthana*. Billings, idem, p. 957, fig. 449.
Lower Helderberg: New York.
1864. *Orthis umbraculum*. De Verneuil, Soc. géol. France Bull., 2d ser., vol. 21, p. 151.
Lower Devonian: Gueuk-sou Valley between Alemdagh and Boulgourladagh, Asiatic Asia Minor.
1864. *Orthis hipparionyx* (?). Davidson, British fossil Brachiopoda, Devonian, p. 90, pl. 17, figs. 8–11.
Lower Devonian: Looe, Cornwall, England.
1866. *Orthisina umbraculum*. F. A. Roemer, Die Versteinerungen des Harzgebirges nach den Formationen geordnet, p. 20.
Spiriferen sandstone: Kahleberg, Harz Mountains, Germany.
1866. *Orthis devonica*. De Verneuil, in Tschihatscheff, Asie Mineure, Paléontologie (Géologie, pt. 4), p. 34, and Appendix, 1869, p. 486.
Lower Devonian: Near Kartal, Asia Minor.
1870. Orthis cf. *O. umbraculum*. Quenstedt, Petrefactenkunde Deutschlands, pl. 56, fig. 35.
Rhenish Lower Devonian: No locality given.
1870. *Orthis strigosa*. Quenstedt, idem, pl. 56, figs. 55, 56.
Rhenish Lower Devonian: Lauback Valley, near Coblentz, Germany.
1871. *Streptorhynchus umbraculum* and var. *gigas*. Kayser, Deutsche geol. Gesell. Zeitschr., vol. 21, pp. 316, 319, 328, 366, 371.
Lowest Coblenzian: Between Oberstadtfeld and Niederstadtfeld, near Daun.
Ahrien-Coblenzian transition graywacke: Waxweiler and Daleiden.
Coblenzian calcareous lenses: Prüm, Hersdorf, and Schonecken.
Cultrijugatus zone: Elwerath, near Prüm.
All localities in the Eifel, Germany.
?1874. *Streptorhynchus agassizi*. Hartt,[1] Buffalo Soc. Nat. Sci. Bull., vol. 1, p. 248, pl. 9, figs. 3, 4, 10, 16, 17, 23, 25, 26, 28–30.
Middle Devonian sandstone: Erere, Brazil.
1874. *Streptorhynchus pandora*. Nicholson, Paleontology of Ontario, p. 70.
Corniferous limestone: Port Colborne and Hagersville, Ontario.
1877. *Hemipronites chemungensis* var. *arctostriata*. Meek,[2] U. S. Geol. Expl. 40th Par., vol. 4, p. 35, pl. 3, fig. 2.
Devonian dark limestone: The Gate, northwest of Eureka, Nev.
1877. *Streptorhynchus gigas* [not McCoy]. Oehlert, Soc. géol. France Bull., 3d ser., vol. 5, p. 598.
Lower Devonian: La Baconniere, Mayenne, France.
1877. *Streptorhynchus devonicus*. Oehlert, idem, p. 598.
Lower Devonian: La Baconniere, St. Jean and St. Germain, Mayenne; in the Sarthe; and generally throughout western France.
1877. *Streptorhynchus umbraculum* [not Schlotheim]. Oehlert, idem, p. 599.
Lower Devonian: Mayenne, France.
1878. *Streptorhynchus umbraculum* [not Schlotheim]. Kayser, Geol. Specialkarte Preuss. Abh., vol. 2, pt. 4, p. 197, pl. 29, figs. 1, 2.
Hercynian limestone and accompanying sandy shales: Klosterhalz, in the Harz Mountains, Germany.
1878. *Streptorhynchus agassizi*. Rathbun [not Hartt?], Boston Soc. Nat. Hist. Proc., vol. 20, p. 24.
Devonian [Eo-Devonian] sandstone: Rio Maecuru [3] and ?Rio Curua, Brazil.
[??Meso-Devonian]: Erere, Brazil.
1882. *Streptorhynchus umbraculum* [not Schlotheim]. Barrois, Soc. géol. Nord Mém., vol. 2, p. 239 (pars) (not pl. 9, fig. 2).
Arnao [Cultrijugatus] limestone: San Roman, Asturias, Spain.
Ferroñes limestone: Moniello and Raneces, Asturias, Spain.
Nieva [*Spirifer hystericus*] limestone: St. Jean de Nieva and Arcas, Asturias, Spain.
1882. *Streptorhynchus umbraculum*. Follmann, Naturh. Ver. preuss. Rheinlände Verh., vol. 39, pp. 147, 148, 178.
Graywacke (with Chondrites, *Spirifer cultrijugatus*, *Chonetes plebeia*, and *C. dilatata*): North of Bausendorf on the road to Hontheim; mountain side between the Schaufelsbach and Elterbach, right side of the Alf Valley (p. 148), and in the overlying shales in the Alf Valley (p. 154); all in the Eifel, Germany.
Upper graywacke and Chondrites layers: Olkenbach, Germany.
Lower (brachiopod) shales: Olkenbach and near Coblenz, Germany.

[1] Hartt states (p. 249): "Cardinal process small, thin, bifid above, with the two small processes on each side projecting backward. A small projection in the center below extends a little forward and toward the ventral valve." This "small projection" may represent the median stump of the cardinal process noted by Hall and by Davidson in the Middle Devonian types, or Hartt may refer merely to the median septum, which is weakly developed. An examination of Hartt's material has been made in the Cornell University Museum collections, but in the short time which could be devoted to the matter, no specimens could be found sufficiently well preserved to note the requisite details of the cardinal process. According to Hartt, the delthyrium has the width equal to or slightly greater than the height. In the Lower Devonian type the delthyrium is commonly wider, but there is very little difference in regard to this point.

[2] Meek's specimens are regarded by Walcott (1884) as being more conformable with *O. pandora* than *O. arctostriata*.

[3] Maecuru forms have brachial valve more convex, pedicle umbo more elevated; dental plates reach forward farther, and cardinal process is broader than in Erere forms. Abundant at Rio Maecuru, rare on Rio Curua.

1882. *Strophodonta woolworthana.* Stevenson, Pennsylvania Second Geol. Survey Rept. T2, p. 134.
Lower Helderberg chert beds just below the Oriskany; Long Ridge, near Beaver Dam Run, King Township, Bedford County, Pa.

1883. *Streptorhynchus woolworthana.* Hall, New York State Geologist Second Ann. Rept., pl. 39, figs. 25–31.
Lower Helderberg group: Near Clarksville, N. Y.

?1884. *Streptorhynchus chemungensis* (pars). Walcott, U. S. Geol. Survey Mon. 8, pl. 13, fig. 7 [not fig. 16].
Devonian limestone: Eureka district, Nev.; Lone Mountain, 18 miles northwest of Eureka; also on north end of Pinon Range, Nev.

1885. *Streptorhynchus umbraculum* [not Schlotheim]. Gosselet, Soc. géol. Nord Annales, vol. 13, p. 358.
Upper Taunusian: In vicinity of Jusseret, Luxembourg.

1886. *Streptorhynchus woolworthanus.* Darton, Am. Jour. Sci., 3d ser., vol. 31, pp. 212–214.
Lower Helderberg: Cornwall station, Orange County, N. Y.

1887. *Streptorhynchus umbraculum* [not Schlotheim]. Schulz, Naturh. Ver. preuss. Rheinlände Verh., vol. 44, pp. 143, 144, 145.
Uppermost Coblenzian shales [underlying the Meso-Devonian Orthoceras shales]: Near Olpe, Meggen, Altenkunden, Langenei, Saalhausen, and Wingeshausen, Germany.

1888. *Streptorhynchus umbraculum* [not Schlotheim]. Stuart-Menteath, Soc. géol. France Bull., 3d ser., vol. 16, p. 411.
[Upper Eo-Devonian limestone]: South of Sumbilla and at Eyharce, in the western Pyrenees.

1889. *Streptorhynchus pandora.* Miller, North American geology and paleontology, p. 379.
Schoharie grit and Corniferous limestone.

1889. *Streptorhynchus woolworthanum.* Miller, idem, p. 379.
Lower Helderberg group.

1889. *Streptorhynchus umbraculum* [not Schlotheim]. Kayser, K. k. preuss. geol. Landesanstalt Abh., Neue Folge, Heft 1, p. 100 (?pl. 12, fig. 4), pl. 18, figs. 1–5.
Upper Coblenzian (most abundant): Coblenz quartzite; Lower Coblenzian; Taunus quartzite (doubtful); Rhine Valley.[1]
Lower Devonian quartzite sandstone: Kahleberg, in the Upper Harz Mountains, Germany.

1889. *Strophomena woolworthana* (identified by James Hall): Pennsylvania Second Geol. Survey Rept. O3, pp. 207, 212.
Lower Helderberg limestone [New Scotland]: North slope of the Hogback below the mouth of Big Bushkill Creek, Pike County, Pa. (p. 207).
Hamilton strata: Marshalls Creek, Monroe County, Pa. (p. 212).

1889. *Streptorhynchus pandora.* Schuchert, New York State Geologist Eighth Ann. Rept. (for 1888), p. 52.
Oriskany: North Cayuga, Canada West.

1891. *Streptorhynchus umbraculum* [not Schlotheim]. Follmann, Naturh. Ver. preuss. Rheinlände Verh., vol. 45.
Middle Coblenzian (Coblenz quartzite): Ehrenbreitenstein (p. 131), Oberlahnstein (p. 149).
Upper Coblenzian (lower part or Chondrites beds): Oberlahnstein (p. 150).
Upper Coblenzian (upper beds with *S. cultrijugatus*): Many localities about the Coblenz district (pp. 134, 135, 136, 145, 147, 152, 153) and in the Eifel (p. 158).

1892. *Orthothetes woolworthana.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, p. 255, pl. 9, figs. 25–31.
Lower Helderberg group: Near Clarksville, N. Y.

1892. Orthothetes sp. α. Ulrich, Neues Jahrb., Beilage Band 8, p. 76, pl. 4, fig. 30.
Huamampampa sandstone (lower beds): Heights between Huamampampa and Icla, Bolivia.

1892. Orthothetes sp. β. Ulrich, idem, p. 76.
Huamampampa sandstone (lower beds): Between Tortora and Chalhuani, Bolivia.

1895. *Streptorhynchus umbraculum* [not Schlotheim]. Kayser, Soc. géol. Belgique Mém., vol. 22, p. 209, pl. 4, fig. 13.
Upper Rhenan: Pepinster, Belgium.

1896. *Orthothetes hipponyx.* Oehlert, Soc. géol. France Bull., 3d ser., vol. 24, p. 856, pl. 27, figs. 12–16 (not 9–11).
Lower Devonian: Santa Lucia, Spain.

1897. *Orthis* (?) *sulivanti.* Schuchert, U. S. Geol. Survey Bull. 87, p. 293.
Lower Devonian: Falkland Islands.

1897. *Orthothetes chemungensis* var. *pandora.* Weller, Jour. Geology, vol. 5, No. 6, p. 629.
Corniferous limestone: Devil's Bake Oven, near Grand Tower, Jackson County, Ill. (zones 11, 13).

1898. *Streptorhynchus umbraculum.* Poussin, Soc. géol. Belgique Mém., vol. 25, p. 32.
Uppermost Eo-Devonian: Eseneux, Belgium.

1898. *Orthothetes chemungensis* [not Conrad]. Bownocker, Denison Univ. Sci. Lab. Bull., vol. 11, pl. 7.
Corniferous limestones: Harrisburg, Columbus, Marble Cliff, Marion, Kelleys Island, and Radnor, Ohio.

1898. *Orthothetes umbraculum* [not Schlotheim]. Kayser, Paläont. Inst. Univ. Wien Mitt., Bd. 12, Heft 1, p. 38.
Lower Devonian calcareous beds: Between Pendik and Kartal, north shore of Marmora Sea, Asia Minor.
Lower Devonian (upper beds): Rhine district, Germany.

[1] The figured specimens shown in pl. 18 are from the Upper Coblenzian (Bausendorf near Wittlich, figs. 1, 4; Miellen below Ems, fig. 2) and from the Lower Coblenzian (Stadtfeld, fig. 3; Zenschied, in the Eifel, fig. 5).

1899. Orthothetes cf. *O. woolworthana.* Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), pp. 341, 351.
New Scotland shaly limestone: Oniskethau Creek (p. 351).
Becraft limestone: Countryman Hill (p. 341) and Oniskethau Creek, Albany County, N. Y.[1]

1899. *Orthothetes pandora.* Prosser, idem, p. 352.
Schoharie grit: Oniskethau Creek, Albany County, N. Y.

1899. *Orthothetes woolworthanus.* Schuchert, Am. Jour. Sci., 4th ser., vol. 7, p. 432.
Oriskany chert: Camden, Benton County, Tenn.

1900. *Orthothetes chemungensis arctistriatus* [not Hall]. Kindle, Indiana Dept. Geology and Nat. Res., Twenty-fifth Ann. Rept., p. 593, pl. 6, fig. 3.
Jeffersonville limestone: Falls of the Ohio, Lancaster, Scipio, Kent, and Newbern, Ind.

1900. *Orthothetes woolworthanus.* Schuchert, Geol. Soc. America Bull., vol. 11, pp. 283, 293, 307, 322.
Lower Helderberg (New Scotland): New York and Tennessee.
Oriskany: Becraft Mountain, N. Y., and Camden, Benton County, Tenn.

1900. *Orthothetes pandora.* Schuchert, idem, pp. 293, 325.
Upper Oriskany: Oneida and North Cayuga townships, Ontario.

1901. *Orthothetes woolworthanus.* Prosser, New York State Geologist Eighteenth Ann. Rept. (for 1898), pp. 55, 58.
New Scotland shaly limestone: Indian Ladder section, Countryman Hill (p. 55), and High Point, Altamont (p. 58); Albany County, N. Y.

1903. *Orthothetes agassizi.* Katzer, Geologie des unteren Amazonasgebietes, pl. 11, fig. 6.
Lower Devonian: Rio Curua and Rio Maecuru, Para, Brazil.
Middle (?) Devonian: Erere, Para, Brazil.

1903. *Orthothetes woolworthanus.* Weller, Paleontology of New Jersey, vol. 3.
Coeymans limestone: Just below Flatbrookville (pp. 85, 278, pl. 27, fig. 5).
New Scotland cherty limestone: One-half mile below Hainesville (pp. 88, 303, pl. 34, figs. 4. 5).

1903. *Orthothetes pandora.* Weller, idem.
Onondaga limestone: 4 miles, and 2 miles northeast of Flatbrookville (pp. 104, 367).
Newfoundland grit: West of Greenwood Lake (pp. 105, 373, pl. 52, fig. 8). (Not p. 380, pl. 53, fig. 6, which is probably *O. arctostriatus.*)

1903. *Orthothetes woolworthanus.* Grabau, New York State Mus. Bull. 69, p. 1059.
New Scotland shales: Becraft Mountain, Columbia County, N. Y.

1903. *Orthothetes woolworthanus.* Van Ingen and Clark, idem, pp. 1188, 1190, 1191, 1197, 1203, 1206.
Basal Coeymans lower, middle, and upper New Scotland, and lowermost Port Ewen: About Rondout, N. Y.
Oriskany: Glenerie, N. Y.

1903. *Orthothetes sulivani* (Morris and Sharpe). Reed, South African Mus. Annals, vol. 4, pt. 3, p. 170, pl. 20, fig. 8.
Bokkeveld sandstone: Nitkonst and Gydo Pass, Ceres; and Wolvaart's farm, near Ceres Village; Cape Colony.

1905. *Orthothetes woolworthanus* mut. *gaspensis.* Clarke, New York State Mus. Bull. 80, pt. 145.
Grand Greve limestones: North Shore of Gaspe Bay, Quebec.

1905. *Orthothetes woolworthanus.* Shimer, idem, p. 242, 265.
Upper New Scotland (pp. 195, 200, 208, 220); Becraft (p. 233); Port Ewen (p. 197); Lower Oriskany or *Dalmanites dentatus* zone (p. 185); Upper Oriskany or *Spirifer murchisoni* zone (p. 189): Tribolite Mountain, N. Y.

1905. *Orthothetes woolworthanus,* Williams and Kindle, U. S. Geol. Survey Bull. 244, pp. 28, 40, 47.
"Oriskany" [Lower Helderberg] coarse sandstone: East Fork of Powell River, Wise County, Va.
"Oriskany" [Lower Helderberg] sandy and cherty beds: Southern Railway northeast of Big Stone Gap, Wise County, Va.
Lewistown limestone [upper Lower Helderberg]: Half a mile north of Covington, Alleghany County, Va.

1907. *Orthothetes (Schuchertella) woolworthanus gaspensis.* Clarke, New York State Mus. Bull. 107, p. 279, figs.
Lower Devonic: Grand Greve and Shiphead, Quebec.

A typical brachial valve of this species was found at Big Brassua Lake, Somerset County, Maine, in the Moose River sandstone. The specimen has the following characters:

Shell regular, not distorted; length 32 millimeters, width 38 millimeters; greatest width just in front of the hinge line; sides of shell nearly straight; front semicircular; greatest convexity of the brachial valve in front, depressed convex toward the umbone; mesial sinus very obscure or absent. On the interior of the brachial valve the vascular markings are represented by radiating undulose wrinkles. The musculature is flabellate, extending about one-third the length or a trifle more. It is a little wider than long and is marked by a low round median septum or ridge. Posteriorly the musculature is bounded by a vertical partition composed of the crural bases bearing the lobed cardinal process at the apex. The radial ornamentation

[1] Mr. Broger has collected this species in Prosser's Countryman Hill section in the New Scotland limestone.

is preserved on the internal mold in the typical Schuchertella fashion, forming a fringe or border of close-set regular lines around the margin of the shell from one cardinal angle to the other. These lines on the internal mold are rounded, strongly elevated, wider than the interspaces, and as numerous on the sides of the shell just in front of the hinge as they are on the front of the shell. When the specimen was entire there must have been from 155 to 160 lines on the margin, or 22 in 10 millimeters. The lines are equal except for an occasional newly implanted line which, though finer at first, quickly grows to the strength of the others. The lines increase by implantation.

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Remarks on Schuchertella woolworthana.—This species was described from the New Scotland ("Delthyris shaly") limestone of the Helderberg Mountains and Schoharie, Carlisle, Hudson, and Catskill, N. Y., and is commonly presumed to be a New Scotland species. It occurs also in corresponding beds in Tennessee. As is indicated in the synonymy, this species is now seen to have the following range:

Coeymans limestone: Becraft Mountain and Litchfield, N. Y., and northern New Jersey.

New Scotland limestone: New York, New Jersey, and Pennsylvania, and in supposedly corresponding beds in Tennessee.

Becraft limestone: Trilobite Mountain, near Port Jervis, N. Y.

Port Ewen limestone: Becraft Mountain, New York; and in supposedly corresponding horizons in Virginia and at Gaspe Bay, Quebec.

Oriskany sandstone: Glenerie, N. Y.; and in beds containing Oriskany fossils at Camden, Tenn.

Hamilton formation (Meso-Devonian): Pennsylvania (identified by James Hall).

Specific relations.—*Schuchertella woolworthana* belongs to the group of Schuchertella with medium to large sized shells, not deformed, marked by a large number of closely set, equal or subequal, generally noncrenulated radiating lines. The occurrence of fine lines alternating with coarse ones occurs only in exceptional specimens, and the lines are in nearly all specimens close together, not distant or "pectinate." The delthyrium is wider than high. This group includes *S. subplanus* Conrad, *S. pandora* Billings, *S. agassizi* Rathbun, *S. sulivani* Morris and Sharpe, and *S. umbraculum* von Schlotheim (pars).

In *S. subplanus* the valves are subequal and slightly convex, the cardinal area of the pedicle valve is slightly larger than that of the brachial valve, and the radial lines increase by bifurcation and number scarcely 100 on the margin of the shell. In *S. woolworthana* the valves are unequal; the pedicle valve commonly becomes concave in front; the cardinal area in the pedicle valve is much higher than that of the dorsal valve; the radial lines increase rapidly by implantation, and commonly number as many as 150 on the margin, though specimens with only 100 lines have been observed. The number of lines is somewhat less in *S. agassizi* Rathbun, from Erere, Brazil. *Schuchertella woolworthana*, from the Helderberg and Oriskany of northeast America; *S. pandora*, of the Schoharie grit and the Hamilton formation; *S. sulivani*, from the Lower Devonian of the Falkland Islands and South Africa; and *S. umbraculum* Schlotheim and authors (pars), are four "species" which it is difficult to separate. No distinction can be pointed out between *S. woolworthana* and *S. pandora* Billings as regards outline, curvature, surface markings, internal musculature markings, delthyrium, and cardinal process.

Schuchertella bainii and *S. sulivani*, from the Lower Devonian of South Africa and the Falkland Islands, agree very well with *S. pandora* and *S. woolworthana* in visible described characters. The South African species have only 110 to 130 radial surface lines on the margin,[1] but in the original description of the species from the Falkland Islands, Morris and Sharpe note as many as 150 lines, which corresponds with the number observed in some of the North American forms of *S. woolworthana*. It must not be understood that 150 lines on the margin is a persistent feature in *S. woolworthana*. Specimens with this large number are very common, as are also individuals with 100 or less; the commonest number is perhaps about 130. In *S. bainii* the lines increase by intercalation and also by bifurcation; in *S. sulivani*, as identified in South America, apparently only by bifurcation.

[1] Reed, F. R. C., South African Mus. Annals, vol. 4, pt. 3, p. 170, 1904.

Schuchertella woolworthana is more nearly related to many of the shells called by European authors *S. umbraculum* than is any other American species, not excepting *S. chemungensis* Conrad, which typically has a narrow delthyrium.[1] Indeed, some specimens of *S. woolworthana* from the Coeymans limestone, Litchfield, N. Y., are almost indistinguishable superficially from specimens of *S. umbraculum* from the Eifel. Were the labels lost, it would be difficult to distinguish the specimens.

One of the most important and constant features in the Middle Devonian *Schuchertella umbraculum* Schlotheim is the presence, in nearly all fairly well preserved specimens from the type locality, Gerolstein, and elsewhere in the Eifel, of granulations on the tops of the radiate lines. These granulations are conspicuous, according to many authors, particularly Schnur,[2] who described the surface as "rough, like a file."

In the Lower Devonian, Schuchertellas with granulose radial sculpture are unknown. European authors have commonly combined these Lower Devonian Schuchertellas with *S. umbraculum*, but Oehlert has proposed (1897) to confine Schlotheim's name to the species from the Middle Devonian and to separate the Lower Devonian type under the name *S. hipponyx* Schnur. Practically the only distinction between the Lower Devonian *S. hipponyx* and the Middle Devonian *S. umbraculum*, apart from the cardinal process structure to be noted below, is the absence of the granulose character of the surface lines in the former and, commonly, their prominence in the latter, though occasionally Middle Devonian specimens of *S. umbraculum* fail to show any granulations. The Lower Devonian *Orthothetes pandora* Billings, as it occurs in the "Corniferous" of Canada, has no granulations, but Hall, perhaps erroneously, identified with it some granulate New York specimens.

If this distinction as to granulation of surface lines is to be accepted as of specific value, *S. woolworthana*, *S. pandora* Billings, *S. agassizi* Rathbun, and *S. bainii* and *S. sulivani* Morris and Sharpe will be included with the *S. hipponyx* Schnur as constituting a single specific group, to which the name *Schuchertella sulivani* Morris and Sharpe may be given. In America this Lower Devonian type, as represented by *S. pandora*, *S. woolworthana*, and *S. agassizi*, appears to run up into the Middle Devonian. The *S. umbraculum* type in America is represented apparently only by the specimens (erroneously?) recorded by Hall[3] as *S. pandora* Billings. Hall's specimens conform with Schlotheim's *S. umbraculum* not only in showing granulated surface lines but also in having a small stump between the two branches of the cardinal process. This stump appears in *S. umbraculum*, as it occurs in England and as it has been figured by Davidson. In the Canadian specimens of *S. pandora* not only are the surface lines persistently not crenulated, as both Billings and Nicholson observed, but Billings has called attention to the fact that the two divisions of the cardinal process do not have any median stump or process between them. It has been shown by Hall[3] and by Hall and Clarke[4] that *S. woolworthana* agrees with *S. pandora* Billings (not *S. pandora* Hall) in lacking the median stump between the two divisions of the cardinal process. Thus in the granular-lined *S. umbraculum* there appears to be a median process between the two processes of the cardinal apophysis, but this median stump is absent in the smoothly lined *S. pandora* Billings and *S. woolworthana* Hall. These two distinctions taken together may prove of some importance in disentangling the synonymy of *S. hipponyx* Schnur (= *S. sulivani* Morris and Sharpe), and *S. umbraculum* Schlotheim s. str.

[1] In the specimens of *S. chemungensis* with fine radial surface lines and in Upper Devonian and Carboniferous forms in general which might otherwise be regarded as similar to *S. woolworthana* the delthyrium is much narrower than in the latter species. (Cf. Paleontology of New York, vol. 4, pl. 10, figs. 11, 12, 14, 16, and 23, 1867.) In the Lower and Middle Devonian species *S. woolworthana*, *S. pandora* Billings, *S. agassizi* Rathbun, *S. sulivani* and *bainii* Morris and Sharpe, *S. hipponyx* Schnur, and *S. umbraculum* Schlotheim, the delthyrium is wide, twice as broad as high, whereas in the Upper Devonian typical *S. chemungensis* Conrad as well as in the Mississippian *S. desiderata* Hall and Clarke the delthyrium is much narrower. In the typical Carboniferous forms of *Schuchertella crenistria* Phillips the delthyrium is also narrow, as has been emphasized by De Verneuil (Soc. géol. France Bull., 2d ser., vol. 7, p. 161, footnote).

[2] Palaeontographica, vol. 3, p. 216, 1853.

[3] Paleontology of New York, vol. 4, p. 69, 1867.

[4] Paleontology of New York, vol. 8, pt. 1, 1892.

SCHUCHERTELLA DEFORMIS Hall.

Plate VII, figures 6a and 6b.

1857. *Orthis deformis*. Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 44.
Helderberg Mountains, New York [no more precise locality or formation mentioned].
1859. *Orthis deformis*. Hall, Paleontology of New York, vol. 3, p. 174, pl. 10A, fig. 13, pl. 15, fig. 3.
Lower Helderberg shaly limestone [New Scotland]: Helderberg Mountains, N. Y.
1883. *Streptorhynchus deformis*. Hall, New York State Geologist Second Ann. Rept., pl. 39, fig. 32.
Lower Helderberg group: Borst's mill, Schoharie County, N. Y.
1892. *Orthothetes deformis*. Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, p. 255, pl. 9, fig. 32.
Lower Helderberg group: Borst's mill, Schoharie County, N. Y.
1897. *Orthothetes deformis*. Schuchert, U. S. Geol. Survey Bull. 87, p. 296.
Lower Helderberg: Albany County, N. Y.; Cumberland, Md.
1900. *Orthothetes deformis*. Schuchert, Geol. Soc. America Bull., vol. 11, pp. 264, 283.
Lower Helderberg (New Scotland): New York and Maryland-Virginia area.
1903. *Orthothetes deformis*. Schuchert, U. S. Nat. Mus. Proc., vol. 26, p. 418.
Manlius limestone: Devils Backbone, near Cumberland, Md.

This characteristic form is represented by a pedicle and a brachial valve. The pedicle valve has a length of 15 millimeters; the hinge line is straight, about 17 millimeters long; cardinal extremities pointed, not extended; sides slightly converging toward hinge; maximum width in middle, 19.75 millimeters; front of shell broadly elliptical. Pedicle valve convex throughout; umbonal portion ventricose, swollen, somewhat distorted; shell becoming depressed in front by an indefinable undulation; maximum depth one-fourth the length. Cardinal area rather high (3.5 millimeters), perpendicular to the swollen umbonal portion of the shell; area finely striate vertically; delthyrium acute-angled (nearly 60°). Radial surface lines rounded, numerous, increasing by intercalation very freely in front; interspaces slightly wider than the lines in some parts, whereas in other parts the lines are narrower than the intervening furrows. About 75 lines have been counted on the margin of this small specimen, or 10 to 12 in the space of 5 millimeters.

The brachial valve is somewhat distorted, ventricose, subcircular in outline; length, 23.5 millimeters; greatest width, 27.5 millimeters in the middle; cardinal extremities broadly rounded; hinge short; umbonal portion strongly convex; maximum depth, 9.75 millimeters at about the middle of shell; median septum low, rounded, less than half the length of the shell. Radial surface lines rounded, closely set, equal, increasing by implantation, curving hardly perceptibly on the sides.[1] The specimen when complete must have had about 110 surface lines on the margin. In a very well preserved part of the shell the surface of each radial surface line is covered with two to four extremely fine, threadlike striæ.[2] No concentric growth lines are present.

This species can be readily recognized, for it is twisted or deformed and has a much swollen umbone in the pedicle valve. In front of this swollen umbone the pedicle valve is depressed-convex, flat, or concave, and is wrinkled concentrically. The cardinal area of the pedicle valve is high, delthyrium acute, less than 60°; cardinal area in the brachial valve linear or absent. The brachial valve is ventricose behind and very strongly convex throughout, much more so than the pedicle valve. The cardinal extremities are rounded. Radial surface lines are fine, close set, and equal in size, increasing by intercalation.

The Maine material corresponds very closely with the New York specimens. The specimens described are presumably young. The depression in front by an indefinable undulation is evidently the beginning of the depression which in older shells characterizes the greater part of the surface in the anterior portion.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59701.

[1] This character is one of the principal criteria to distinguish this specimen from superficially similar, small, circular valves of Hipparionyx occurring in the same locality. In Hipparionyx the surface lines curve very strongly on the sides, and near the hinge are directed upward.

[2] This character also appears in well-preserved parts of the shell in typical specimens of *S. deformis* from the lower part of the Helderberg group (Coeymans limestone), of Litchfield, N. Y.

Comparisons.—In spite of its deformation, *S. deformis* presents some characters which are pretty constant in appearance and which will serve to distinguish it easily from the other American forms. *S. deformis* is the first deformed Schuchertella recorded in North American faunas, with the probable exception of a very similar and yet peculiar Schuchertella (?) from the Decker limestone in New Jersey. This form, called by Weller [1] *S. deckerensis*, resembles *S. deformis* in convexity and ornamentation, but whereas in *S. deformis* the umbo is the most convex or gibbous portion of the pedicle valve, in *S. deckerensis* Weller this part of the shell is deeply concave and is merely a large cicatrix of attachment. In Europe similar deformed Schuchertellas, widely distributed in the Lower Devonian and occurring also in the Middle and Upper Devonian, are grouped under the name *S. devonicus*, but this name, as indicated by the following synonymy, evidently covers several species.

1849. *Orthis crenistria* var. *devonica*. Keyserling, Geogn. Beobachtungen, p. 221, pl. 7, fig. 7.
1849. *Leptæna devonica*. D'Orbigny, Prodrome, vol. 1, p. 90.
1850, 1855. *Orthis devonica*. Soc. géol. France Bull., new ser., vol. 7, p. 161; vol. 12, p. 1016.
1865. *Streptorhynchus devonicus*. Davidson, British fossil Brachiopoda (Devonian), p. 80.
1869. *Orthis devonica*. De Verneuil, in Tschihatscheff, Asie Mineure, Paléontologie, p. 34.
1878. *Streptorhynchus devonicus*. Kayser, Die fauna der ältesten Devon-Ablagerungen des Harzes, p. 199, pl. 29, figs. 3–4, 1878.

A deformed Schuchertella from the Koniepruss an beds (étage F) of Konieprus, Bohemia, was described in 1847 as *Orthis distorta* Barrande.[2] These beds are now regarded as of the age of the American Helderberg to Onondaga ("Corniferous").[3] The species occurs also in the Thuringian Tentaculite beds.[4] This species is regarded by Kayser [5] as identical with *S. deformis* Hall, and the strong similarity between the two is also noted by Schuchert [6] and may be affirmed here. In the American species, however, the brachial valve is much more gibbous than the pedicle valve, which is sometimes flat or even concave. In the Bohemian species the two valves are subequally and gently convex,[7] and the brachial valve is apparently never gibbous as in *S. deformis* Hall.

Genus HIPPARIONYX (Vanuxem, 1842) Hall and Clarke, 1892.

HIPPARIONYX UNGUIFORMIS Conrad.

Plate VII, figures 1–5, 7, 8.

1838. *Leptæna unguiformis*. Conrad, New York Geol. Survey Second Ann. Rept., p. 112 (name only).
"Second group": New York.
1840. *Strophomena unguiformis*. Conrad, New York Geol. Survey Fourth Ann. Rept., p. 203 (name only).
Oriskany sandstone: Schoharie, N. Y.
1841. *Atrypa unguiformis*. Conrad, New York Geol. Survey Fifth Ann. Rept., p. 36 (name only).
Middle series, including the Oriskany: New York.
1842. *Hipparionyx proximus*. Vanuxem, Geology of New York, Rept. Third Dist., p. 124, fig. 29, No. 4.
Oriskany sandstone: [Third geological district, central New York.]
1843. *Atrypa unguiformis*. Conrad (*Hipparionyx proximus* Vanuxem), Hall, Geology of New York, Rept. Fourth Dist., p. 149, fig. 4.
Oriskany sandstone: New York.
1843. *Orthis conradi*.[8] Castelnau, Essai sur le système silurien de l'Amérique septentrionale, p. 37, pl. 15, fig. 4.
Schoharie, N. Y.
1843. *Orthis unguiformis*. Castelnau, idem, p. 37, pl. 15, fig. 3.
Schoharie, N. Y.
cf. 1853. *Orthis hipparionyx*. Schnur, Palaeontographica, vol. 3, p. 217, pl. 40, fig. 1.
Graywacke beds: Prüm, in the Eifel, Germany.

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[1] Paleontology of New Jersey, Paleozoic faunas, p. 229, pl. 20, figs. 6 and 7.
[2] Barrande, Joachim, in Haidinger, Wilhelm, Naturwissenschaftliche Abhandlungen, vol. 2, p. 205, pl. 19, fig. 2, 1847–48.
[3] Schuchert, Charles, Geol. Soc. America Bull., vol. 11, p. 264, 1900.
[4] Richter, Deutsch. geol. Gesell. Zeitschr., vol. 18, p. 416, pl. 6, figs. 8–10.
[5] Kayser, Emanuel, Die Fauna der ältesten Devon-Ablagerungen des Harzes, p. 199, 1878.
[6] Op. cit., p. 264.
[7] Barrande, Joachim, Système silurien du centre de la Bohême, vol. 5, pl. 58, figs. 4–5; pl. 60, fig. 4, 1852.
[8] This species is described on p. 37 before *O. unguiformis*, but from the description it is evident that the latter was a well-known fossil. Castelnau says of *O. conradi*: "Cette espèce a assez la forme de l'*unguiformis*; comme elle, elle est orbiculaire," etc.

1858. *Atrypa unguiformis*. Rogers, Geology of Pennsylvania, vol. 2, pt. 2, p. 826, fig. 631.
Meridian formation: Pennsylvania.

1859. *Orthis hipparionyx*. Hall, Paleontology of New York, vol. 3, p. 407, pl. 89, figs. 1–4; pl. 90, figs. 1–7; pl. 91, figs. 4, 5; pl. 94, fig. 4.
Oriskany sandstone: Albany, Schoharie, Herkimer, Oneida, and Onondaga counties, N. Y.

1859. *Strophodonta intermedia*. Hall, idem, p. 482, pl. 95 (A), figs. 13–14.
Oriskany sandstone: Cumberland, Md.

1860. *Atrypa unguiformis*. Dawson, Canadian Naturalist, vol. 5, p. 140.
Oriskany iron ore beds: Nictaux, Nova Scotia.

1860. *Orthis unguiformis*. Emmons, Manual of geology, p. 129, fig. 115, Nos. 4, 5 (also in 2d ed., 1863).
Oriskany: No locality indicated.

cf. 1865. *Orthis hipparionyx*? Davidson,[1] British fossil Brachiopoda (Devonian), vol. 3, p. 90, pl. 17, figs. 8–11.
Devonian sandstone, Looe, Cornwall.

1878. *Orthis hipparionyx*. Ashburner, Pennsylvania Second Geol. Survey Rept. F, p. 239.
Oriskany (Meridian) ferruginous sandstone: Railway cut at Three Springs and at the ends of Royer and Sandy ridges, Huntingdon County, Pa.

1881. *Orthis hipparionyx* (?). Davidson,[2] vol. 4, pt. 4, p. 347, pl. 39, fig. 1.
Budleigh-Salterton pebble bed.

1882. *Orthis hipparionyx*. I. C. White, Pennsylvania Second Geol. Survey Rept. G6, p. 124.
Oriskany sandstone: Brodhead Creek, Monroe County, Pa.

1883. *Streptorhynchus hipparionyx*. Hall, New York State Geologist Second Ann. Rept., pl. 39, figs. 33–36.
Oriskany: New York; Cumberland, Md.

1887. *Orthis hipparionyx*. Ami, Canada Geol. Survey Ann. Rept., new ser., vol. 2, p. 9N.
Oriskany slates and sandstones: Campbell River, at mouth of Don River, New Brunswick.

1889. *Orthis hipparionyx*. Claypole, Pennsylvania Second Geol. Survey Rept. O3, p. 130.
Oriskany sandstone: Various outcrops in Perry County, Pa.

1889. *Orthis hipparionyx*. Simpson, idem, p. 209.
Oriskany sandstone: Royers Ridge, north of road crossing at Orbisonia, Huntingdon County, Pa.

1889. *Strophodonta intermedia*. Schuchert, New York State Geologist Eighth Ann. Rept. (for 1888), p. 52.
Oriskany: Cumberland, Md.

1889. *Orthis hipparionyx*. Lesley, Pennsylvania Second Geol. Survey Rept. P4, p. 517, figs.
Oriskany sandstone: Huntingdon, Perry, and Monroe counties, Pa. (For localities see 1878, Ashburner; 1882, I. C. White; 1889, Simpson; 1889, Claypole.)

1891. *Atrypa unguiformis*. Dawson, Acadian geology, 4th ed., p. 499.
Nictaux iron ore and accompanying slates: Nictaux River, Nova Scotia.

1892. *Hipparionyx proximus*. Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, p. 257, pl. 9, figs. 33–36; pl. 15A, figs. 9–11.
Oriskany sandstone: New York; Cumberland, Md.; Cayuga, Ontario.

1892. *Hipparionyx proximus*. Clarke, Am. Jour. Sci., 3d ser., vol. 44, p. 413.
Oriskany: Becraft Mountain, N. Y.

1899. *Hipparionyx proximus?*. Prosser and Rowe, New York State Geologist Seventeenth Ann. Rept. (for 1897), p. 342.
Oriskany dark quartzitic sandstone: Countryman Hill section, Helderberg Mountains, N. Y.[3]

1899. *Hipparionyx proximus?*. Schuchert, Am. Jour. Sci., 4th ser., vol. 7, p. 431.
Camden chert: Camden, Benton County, Tenn.

1900. *Hipparionyx proximus*. Schuchert, Geol. Soc. America Bull., vol. 9, pp. 314, 315, 321, 325.
Camden chert: Camden, Benton County, Tenn. (p. 321).
"Monterey" formation: Cumberland, Md.
Oriskany: Branch of Potomac River, Pendleton County, W. Va. (p. 315); Oneida and North Cayuga townships, Ontario (p. 325).

1900. *Hipparionyx proximus*. Clarke, New York State Mus. Mem., vol. 3, No. 3, pp. 52, 74.
Oriskany: Becraft Mountain, N. Y. (p. 52); Glenerie, N. Y. (p. 74).

1901. *Hipparionyx proximus*. Prosser, New York State Geologist Eighteenth Ann. Rept., p. 59.
Oriskany dark calcareous sandstone: Altamont section, Helderberg Mountains, N. Y.

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[1] The form from Looe, Cornwall, is the species subsequently figured by Davidson under the same name from the Triassic pebble beds of Budleigh Salterton, near Exmouth, Devonshire. The form occurring in these two places is not *Hipparionyx unguiformis*, the muscular scars in the British shells being very much smaller.

[2] The configuration of this shell is unlike *Hipparionyx unguiformis* and the muscular markings are smaller. It appears quite certain that this particular specimen is not *Hipparionyx unguiformis*, as was pointed out by Hall and Clarke (Paleontology of New York, vol. 8, p. 257).

[3] Mr. Breger has collected material from this outcrop in the roadbed above Mr. Parrish's house, where the Hipparionyx is very rare and, as is noted by Prosser, small. There is not, as he remembers the material, sufficient cause to doubt the identification.

Though this species is very common and very large in the arenaceous Oriskany of central New York, where it is one of the characteristic and typical fossils of that formation, it is small and rare in the Helderberg Mountains; not recorded from Trilobite Mountain; very rare and small in New Jersey; rare and small at Camden, Tenn.; absent at Perce Rock and in the Gaspe beds of Quebec; absent at Rondout, though common and typical near by at Glenerie and Becraft Mountain; rare at White Sulphur Springs; and absent in the other Appalachian Oriskany localities recorded by Williams and Kindle.

1903. *Hipparionyx proximus.* Weller, New Jersey Geol. Survey, Paleontology, vol. 3, pp. 101, 346, pl. 45, fig. 12.
Spirifer murchisoni zone or upper Oriskany (siliceous limestone): Peters Valley, N. J.
1903. *Hipparionyx proximus.* Van Ingen and Clark, New York State Mus. Bull. 69, pp. 1203, 1206.
Oriskany sands and cherty limestones: Glenerie, N. Y.
1905. *Hipparionyx proximus.* Williams and Kindle, U. S. Geol. Survey Bull. 244, pp. 34, 47.
Oriskany coarse sandstone: Rear of Alabama Row, White Sulphur Springs Hotel, W. Va.
1905. *Hipparionyx proximus.* Harris, Guide to the geology of Union Springs, p. 4, pl. 12, figs. 1–2.
Oriskany sandstone: Yawger's Woods, Union Springs, N. Y.
1905. *Hipparionyx proximus.* Clarke, New York State Mus. Bull. 80, pp. 145, 148.
Grande Greve limestones: North shore of Gaspe Bay, Quebec.
1905. *Hipparionyx proximus.* Clarke, New York State Mus. Bull. 82, p. 41.
Oriskany granular quartzite: Tully quadrangle, N. Y.
Oriskany sandstone: Yawger's Woods, near Union Springs, and at Oriskany Falls, N. Y.

This remarkable species occurs in Maine in several modifications, all of which are likewise represented by typical material from New York. The seven specimens in the Maine collections are all pedicle valves and all small; the largest is 35 millimeters long. The outline is commonly subcircular, with length and breadth as 7: 8, widest in the middle. This is the form occurring in locality 1099 M, but the specimens from Edmunds Hill are more elongate and have the length equal to the breadth. The pedicle valve is convex for a small space on the umbo, depressed on the sides and body of the shell and flat or very slightly concave in front. The hinge line is short, straight, or slightly arcuate; cardinal area very low. The musculature is flabellate, large, more than half the length of the shell. It is bounded on the sides by the dental lamellæ which diverge at an acute angle [1] (Pl. VII, fig. 5), or at a right angle (Pl. VII, fig. 2), and continue as low broad ridges which curve inward and approach a rounded mesial septum. The medial septum is developed in the forward part of the musculature and extends as far back as the adductor cicatrix, which is oval and elevated. There is no median septum in the umbonal part of the musculature in the pedicle valve. In front of the musculature the interior of the shell is raised by a pitted callosity, probably representing the ovarian pits and duct. Surface marked by fine subequal radial lines which curve strongly on the sides and appreciably upward (and outward) about the umbo and cardinal extremities. The greatest curvature of the lines is near the margin of the shell. The lines are round, subequal, strongly elevated, and as wide as their interspaces, number 11 or 12—rarely 10 or 13—in the space of 5 millimeters, and increase by implantation. Obscure indications in the Maine and New York specimens of finer, fiber-like lines over the surface may be due to maceration of the shell. In internal molds of pedicle (and brachial) valves the radial lines are commonly represented by a narrow fringe or border of short lines around the margin of the shell, along the posterior margin nearly to the cardinal extremities. The lines in this fringe are vertical or nearly so, resembling on a coarser scale the denticulations of stropheodontoids.

This nearly vertical lining along the posterior margin played no part in hinge articulation, as in stropheodonts; the structure described is both functionally and structurally very distinct from the denticulations in stropheodonts.

After the preceding description was written a small brachial valve which can safely be referred to this species was found in the collections from Edmunds Hill. The specimen (an external mold and also an internal mold) shows strong upward curving of the radial lines on the posterior margins. The specimen is broadly subcircular, 26 millimeters long, 35 millimeters wide (greatest width in the middle), and 7 millimeters high; the greatest convexity is just back of the middle. The marginal fringe of short lines around the edge is present. The lines increase by bifurcation, are very strongly elevated, about as wide as the interspaces, and number 12 or occasionally 13 in 5 millimeters at 15 to 20 millimeters from the beak.

Locality: Chapman sandstone, Edmunds Hill, and west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59702, 59703.

[1] Paleontology of New York, vol. 3, pls. 89, 90, 1859.

Family PRODUCTIDÆ Gray.

Genus CHONETES Fischer de Waldheim, 1837.

CHONETES STRIATISSIMUS sp. nov.

Plate VIII, figure 24; Plate IX, figures 1–10, 13, 14, 17, 18; Plate X, figure 17.

Shell depressed, convexo-concave, finely lineate, and with a midrib on the pedicle valve. Outline transversely subquadrate approaching the semicircular, width varying from a little over 1.5 to 1.8 times the length; greatest width in front of the hinge line just back of the middle. Hinge line straight, very little less than the maximum width of the shell; hinge extremities sharp cornered, obtuse; sides of the shell subparallel, slightly diverging, and nearly straight for about half the length, then broadly curving into the front margin of the shell, which is strongly arcuate. The pedicle valve is depressed convex and without any definitely flattened demarcated ears; the slight convexity is maintained, more or less uniformly, over all the surface. A typical average specimen (No. 749, Pl. IX, fig. 2), 18 millimeters wide and 10 millimeters long, has a height of 1.5 millimeters. The maximum height and gibbosity (about one-seventh the length) are on the umbonal portion; the beak does not extend appreciably over the hinge line. The brachial valve is flat over its greater extent and becomes slightly concave in the front in medium-sized shells. Cardinal area linear in the pedicle valve; not evident in the brachial valve.

In the pedicle valve the teeth are strong, thick, short, leaving in the internal mold two short, shallow, broad excavations which are strongly divergent. Between the teeth there is a median septum which is very narrow and short, extending one-fourth the length of the shell or less. The muscular and vascular impressions are not observed in any of the specimens at hand. In the brachial valve there is a blunt low ridge or septum extending one-third the length of the shell, and on each side of it there diverges a similar but fainter and slightly shorter ridge. The crural processes diverge at an angle of about 180°, being nearly parallel to the hinge.

The grooves between the radial elevated surface lines are deeply pitted, but the pitted structure does not reach the surface and is not discernible on the outside of the shell. On the inner laminæ of the shell, especially on the internal molds, these rows of pits between the elevated lines are very plainly seen. They represent, on the inner surface of the shell, little elevated punctæ or spinules with an inclosed pore, and in passing from the inside surface of the shell toward the outside they are inclined backward. These punctæ are, as has been stated, developed in the striæ or grooves between the radial lines and are not to be seen on the elevated lines nor on the external surface of the shell.

The surface is covered with rounded to subangular, very fine radiating lines, barely visible to the naked eye, about 30 (varying between 28 and 34) in the space of 5 millimeters and in a medium-sized adult shell about 200 in number on the margin. The radially lined surface extends up to the hinge border and to the beak. These lines are uniform in size, somewhat flexuous, nearly as fine on the margin of an old shell as on the younger portion of the shell, and are also strongly impressed on internal molds. The mode of increase is by both bifurcation and implantation, one method or the other being variably predominant on different individuals. In the pedicle valve there is found on the surface a median keel or much stronger rib, formed by the coalescence of two or sometimes three radial lines and extending to the tip of the beak. This median keel is less pronounced on the internal mold, where it is hardly definable except in front; and in the brachial valve there is no corresponding feature.

Very fine, closely set concentric striæ are visible under the lens and are especially prominent in front of the hinge line on the sides, particularly in the brachial valve. The remains of three, four, or possibly five spines may be seen on each side of the center along the hinge margin of the pedicle valve. These extend outward and backward at an angle with the hinge line of over 60°, curving slightly, with the convex side of the curve outward. The distinguishing features of this easily recognized species are the fine radial lines (commonly about 30 lines in the space of 5 millimeters), the median keel, and the depressed convexity.

Locality: In the Chapman sandstone, 2 miles west of Presque Isle Stream, very common; 2½ miles west of Presque Isle Stream (1099 K), common; Edmunds Hill (1099 C), common; west side of Edmunds Hill (1099 M), a varietal modification is common; all in Chapman Township, Aroostook County, Maine. Along the west side of Edmunds Hill the more coarsely lined species *Chonetes novascoticus* Hall is the dominant Chonetes; the more finely lined shells referable to *Chonetes striatissimus* are common in apparently only a single layer. This layer contains *Chonetes striatissimus* and *Spirifer cyclopterus* in abundance; no lamellibranchs were observed. *Chonetes novascoticus* occurs in lithologically similar rock. It is possible that *Chonetes striatissimus* may be an offshoot from the *Chonetes novascoticus* stock, but the two are not connected in the Chapman sandstone fauna by any intermediate forms.

U. S. National Museum, catalogue Nos. 59704, 59705, 59706.

Comparisons.—Among the Chonetes species resembling *C. striatissimus* are the Carboniferous forms *C. shumardianus* De Koninck[1] and *C. papilionacea* Phillips.[2] Neither of these Carboniferous species has a median rib, nor is their large size ever approached by *C. striatissimus*, so far as known, though they agree in the depressed convexity and fine striation.

The nearest allies are the similarly fine-lined *Chonetes venustus* Barrande[3] and *C. bohemicus* Barrande[4] from étage F, Bohemia. *Chonetes bohemicus* is a gibbous shell, much more so than *C. striatissimus; C. venustus*, though less gibbous than *C. bohemicus*, has an extended hinge with acute extremities and well-developed auricles, whereas in *C. striatissimus* the hinge is never extended—in fact, is less than the maximum width—and ears are not developed. The median riblet of *C. striatissimus* is not at all developed in *C. venustus* and rarely if at all in *C. bohemicus*. (See Barrande's pl. 46, fig. 2a.)

CHONETES NOVASCOTICUS Hall.[5]

Plate IX, figures 11, 12, 15, 16, 19; Plate X, figures 1, 2, 3, 5–16, 18–29, 32, 33.

1837. "Producti." Jackson, First report on the geology of the State of Maine, p. 128, pl. 1, figs. 5, 8.
Graywacke: Maine.[6]

1860. *Chonetes nova-scotica*. Hall, in Dawson, J. W., Silurian and Devonian rocks of Nova Scotia, p. 13.
Upper Arisaig (upper Silurian); Arisaig, Nova Scotia.

1860. *Chonetes Nova-Scotica*. Hall, Canadian Naturalist, vol. 5, p. 144, fig. 2.
Upper Arisaig (upper Silurian): Arisaig, East River, Pictou, and Nictaux, Nova Scotia.

1862. *Chonetes nova-scoticus*. C. H. Hitchcock, Maine Board Agr. and Geology, Sixth Ann. Rept., p. 238.
Lower Helderburg: Pembroke, Maine.

1878. *Chonetes Nova-Scotica*. Dawson, Acadian geology, 3d ed., pp. 498, 595, fig. 199.
Upper Arisaig (upper Silurian): Arisaig and East River, Pictou, Nova Scotia.
Nictaux limestone, upper Silurian, older than the Ferriferous beds: Nictaux, Nova Scotia.

?1879. *Chonetes Nova-Scotica*. Hall, New York State Mus. Twenty-eighth Ann. Rept., p. 155, pl. 22, figs. 11–14.
Waldron shales: Waldron, Ind.[7]

?1882. *Chonetes Nova-Scotica*. Hall, Indiana Dept. Geology and Nat. Hist. Eleventh Ann. Rept., p. 293, pl. 22, figs. 11–14.
Waldron shales: Waldron, Ind.

not 1890. Chonetes cf. *C. Nova Scotica* Clarke, Mus. Nac. Rio Janeiro Arch., vol. 9, p. 24.
Silurian: Rio Trombetas, Para, Brazil.

1900. *Chonetes nova scotica*. Williams, U. S. Geol. Survey Bull. 165, p. 79.
Chapman sandstone: Chapman Plantation, Aroostook County, Maine (locality 1099).

1907. *Chonetes aroostookensis*. Clarke, New York State Mus. Bull. 107, p. 264, figs. Lower Devonic [Chapman sandstone]: Edmunds Hill, Chapman, Maine.

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[1] De Koninck, L. G., Recherches sur les animaux fossiles; Monographie du genre Chonetes, 1847, p. 192, pl. 20, fig. 1. The species is from the Keokuk limestone (Mississippian) of Kentucky and Indiana.

[2] Idem, p. 187, pl. 19, fig. 2. This species occurs in the Lower Carboniferous limestones of England, Ireland, France, Belgium, Russia, etc.

[3] Barrande, Joachim, Système silurien du centre de la Bohême, vol. 5, pl. 46, figs. I, 1–6, 1852.

[4] Idem, pl. 46, figs. II, 1–6.

[5] Compare *C. tenuicostata* Oehlert, Soc. géol. France Bull., 3d ser., vol. 5, p. 599, pl. 10, figs. 13–13a, 1877 (Lower Devonian: LaBaconniere and St. Germain, Mayenne, France); also *C. filistriata* Walcott, U. S. Geol. Survey Mon. 8, p. 127, pl. 13, fig. 15, 1884 (Lower Devonian limestone: Combs Peak, Eureka district, Nev.); and *Chonetes sarcinulatus* Schlotheim and *C. latus* Von Buch (see text).

[6] Jackson's figures appear to represent a compressed form of the species which is abundant in the gray shales of the Pembroke formation of the Eastport quadrangle, Maine. The old Hardon Clarke farm near Kelly Point, Pembroke Neck, was probably the source of Jackson's material.

[7] The largest Waldron specimen has a width of 16 millimeters, but the general size of the material is less, perhaps 10 or 11 or 14 millimeters. All the specimens from Waldron belong, according to Hall, to the form with a strong median ray on the pedicle valve. The Waldron material differs from the Nova Scotian in the small size, in the persistence of the median ray or buttress, and in the disposition of the spines and other details, and is probably a distinct species.

The shell is of rather large size when mature; small specimens are about 6 by 10 millimeters; average specimens are about 10 by 15 millimeters, and large individuals attain a width of 30 millimeters and a length of 14 millimeters. Depressed convexo-concave. Radial surface lines fine, but coarser than in *C. striatissimus;* midrib developed only occasionally.

Outline semicircular; width greater than length, varying from 1½ to 2 times the length. Hinge line straight, commonly equaling the greatest width of the shell, though occasionally a little less. Sides nearly perpendicular to the hinge line, curving in front; front margin a broad, shallow arch. The pedicle valve is depressed-convex; the convexity is greatest over the posterior central portion and the umbo; a more or less uniform slope is maintained toward the front and toward the sides, so that the ears are not definitely demarcated. Occasionally there is an obscure sinus in the pedicle valve. Maximum depth of a shell 12.5 millimeters long is somewhat less than 2 millimeters, or approximately one-seventh the length. The brachial valve is slightly concave throughout. Cardinal area discernible in both valves; slightly higher in the pedicle than in the brachial valve. Shell structure pitted as in *Chonetes striatissimus*, the description under that species being also applicable here. The cardinal process was seen to be forked in one of the brachial valves.

The surface is covered with rounded or subangular, moderately fine, radial lines. Usually there are 17 to 19 lines in the space of 5 millimeters, the extremes being 15 and 22 in mature shells. In young shells there may be 22 to 24 lines in 5 millimeters. Mature shells attaining a width of 10 or 11 millimeters or a length of 19 or 20 millimeters have from 110 to 130 lines on the margin, generally nearer the former number. A stronger median riblet is occasionally present, but more frequently absent; in the larger specimens it is commonly absent. The radial lines are somewhat flexuous, are apparently as evident on the interior as on the exterior molds, and cover the entire surface. The mode of increase is both by bifurcation and by implantation, one method or the other predominating in different shells. As is very common in the leptenoid genera, the striæ increase by bifurcation more commonly in the brachial valve than in the pedicle valve. Increase of the number of lines by implantation is more conspicuous in the pedicle valve. Fine concentric striæ are developed, as in *Chonetes striatissimus*, but they are generally inconspicuous. Four or five spines in the better-preserved mature shells are visible on each side of the center along the hinge line; in younger shells there are three or four spines on each side. The spines are long, diverge slightly, and curve upward (backward).

The species is commonly distinguished from *Chonetes striatissimus* by its depressed convexity and much coarser radial sculpture, though in some extreme modifications of *Chonetes novascoticus* the radial lines approach in coarseness some of the less finely sculptured modifications of *Chonetes striatissimus*.

Locality: Chapman sandstone; abundant on the west side of Edmunds Hill, Chapman Township, Aroostook County, Maine. A few specimens of *C. striatissimus* and some forms somewhat intermediate between the two occur here, but there appear to be two distinct species. Occasionally found also 2½ miles west of Presque Isle Stream.

Chonetes novascoticus Hall is an abundant fossil in the upper beds of the Arisaig series in Nova Scotia, from which the type specimens were derived. Closely related forms also appear abundantly in a broad belt of late Silurian rocks (Pembroke formation) extending through New Brunswick into the Cobscook Bay district of southeastern Maine. They have been recognized in collections from Nerepis, about 30 miles northwest of St. Johns, New Brunswick, and at numerous points on Pembroke Neck, Denbow Neck, and the Edmunds shore in Cobscook Bay.

U. S. National Museum, catalogue No. 59707.

Comparisons.—Some specimens of *Chonetes novascoticus* approach in outline and ornamentation the *Chonetes striatella* of Dalman, from the Silurian of Europe, but the European species rarely has a median riblet and is appreciably more convex than *C. novascoticus*. Moreover, a mature shell of *C. striatella* (11 millimeters long and 20 millimeters wide) has only from 80 to 95 striæ, and according to De Koninck [1] there are never more than 100 striæ, while in mature

[1] De Koninck, L. G., op. cit., p. 202.

C. novascoticus, both from Arisaig and from Maine, there are generally over 100 and often as many as 146 radial lines at the margin. Finally *C. novascoticus* attains a larger size than *C. striatella*.

In its fairly large size, broad outline, and medium-fine surface sculpture *Chonetes novascoticus* recalls *C. coronatus* Hall,[1] *C. falklandicus* Morris and Sharpe,[2] *C. arcei* Ulrich,[3] *C. gibbosa* Kayser,[4] *C. polytrichia* Roemer,[5] *C. hardrensis* Phillips,[6] and *C. melonicus* Billings.[7] These species are all more gibbous than *C. novascoticus* and have (except *C. gibbosa*, *C. hardrensis*, *C. melonicus*, and *C. polytrichia*) fewer and coarser radial lines. None of these species ever show a median rib, and there are also other individual distinctions.

In the depressed convexity, size, outline, and fine radial lines *Chonetes comstocki* Hartt[8] resembles *C. novascoticus*, but the radial lines are slightly coarser. *Chonetes tenuicostata* Oehlert[9] is a similar form, possibly identical with *C. novascoticus*. The French species attains a length of 15 millimeters, a width of 23 millimeters, and a thickness of 3 millimeters, and has 120 to 130 radial lines at the margin.

Perhaps the closest allies are the Silurian shell, generally called *Chonetes lata* Von Buch or *C. striatella* var. *lata* by European authors, and the Devonian species designated by European geologists *Chonetes sarcinulatus* Schlotheim. There has always been doubt among paleontologists as to what fossil was intended for the original of the latter species. Schlotheim's type was a fairly large, apparently very finely ribbed and punctate shell. A Chonetes of the same shape, outline, and markings as Schlotheim's figures, having on the surface 100 or more fine lines, occurs in the Lower Devonian, widely distributed over Europe. This Chonetes has been identified with *C. sarcinulata* by De Verneuil, Von Buch, F. Roemer, Schnur, Kayser, the Sandbergers, and others. De Koninck,[10] however, maintains that finely striate shells ought to be referred to *C. striatella* Dalman and that the fine punctate striation of Schlotheim's fossil is not surface ornamentation but a common mode of preservation of the internal mold of thick shells which, on the surface, have an entirely different ornamentation. This surface ornamentation in what De Koninck maintains to be the real *C. sarcinulatus* is not fine radial sculpture with 100 or more lines at the margin but much coarser markings, amounting almost to plications, about 16 to 18 in number on the body of the shell and regularly bifurcating in front, so that on the margin there are about 35 very coarse, rounded lines or riblets—occasionally more, but commonly less than that number. To this type of Chonetes, however, the name *C. plebeia* Schnur has been given; and among German geologists the name *Chonetes plebeia* or *Chonetes sarcinulata* var. *plebeia* is invariably applied to such shells as have a small number of coarse bifurcating radial lines or ribs,[11] whereas the name *C. sarcinulatus* in the typical sense is used by the Germans for the more finely sculptured Chonetes.[12] Oehlert regards as Schlotheim's type an insinuate Chonetes with fairly high cardinal area and with 46 to 56 strong striæ, a form similar to that which among the Germans is known as *C. polytrichia* Roemer. Roemer's types, however, have 150 fine striæ. The American *C. novascoticus* may be compared with this multistriate form of *Chonetes sarcinulatus*, but the European form is not sufficiently well described

[1] Hall, James, Paleontology of New York, vol. 4, pl. 21, figs. 9-12, 1867. See Schuchert, Charles, U. S. Geol. Survey Bull. 87, p. 173, 1897, for additional references.

[2] Reed, F. R. C., Brachiopoda from the Bokkeveld beds: South African Mus. Annals, vol. 4, pl. 171, figs. 9-10, 1903. The species occurs in the Falkland Islands, Argentina, Brazil, and South Africa in Lower to Middle Devonian.

[3] Ulrich, A., Neues Jahrb., Beilage Band, vol. 8, p. 77, pl. 4, figs. 35, 36, 1892. Occurs in Middle or more probably Lower Devonian of Bolivia and South Africa.

[4] Kayser, Emanuel, Die Fauna der ältesten Devon-Ablagerungen des Harzes, p. 204, pl. 30, fig. 10, 1878; Lower Devonian (Klosterholtz limestone), Harz Mountains, Germany.

[5] Roemer, F. A., Beiträge zur geologischen Kenntniss des nordwestlichens Harzgebirges, pt. 3, p. 115, pl. 17, fig. 3, 1853 (as *Leptæna polytrichia*); lowest Devonian ("Silurian") limestone, Klosterholtz, Harz Mountains, Germany. This species has a broad sinus in the pedicle valve.

[6] Davidson, Thomas, British Devonian Brachiopoda, p. 94, pl. 19, figs. 6-7; Upper Devonian, England.

[7] Paleozoic fossils of Canada, vol. 2, p. 15, fig. 6, 1874; Oriskany, Gaspe, Canada. This species has a crenulated hinge line in the pedicle valve and belongs to the subgenus Eodevonaria Breger.

[8] Buffalo Soc. Nat. Sci. Bull., vol. 1, p. 250, pl. 9, figs. 5, 14, 18, 19, 31, 1874; Lower to Middle Devonian, Para, Brazil.

[9] Oehlert, D. P., Soc. géol. France Bull., 3d ser., vol. 5, p. 599, pl. 10, figs. 13-13a, 1877.

[10] De Koninck, L. G., Recherches sur les animaux fossiles: Monographie des genres Productus et Chonetes, 1847.

[11] Schnur, J., Brachiopoden der Eifel: Palaeontographica, vol. 3, pl. 21, fig. 6, 1853.

[12] Oehlert, D. P., Chonetes devoniens de l'ouest de la France: Soc. géol. France Bull., 3d ser., vol. 11, p. 119, pl. 14, fig. 2, 1883. Kayser, Emanuel, Paläont. Inst. Univ. Wien, Bd. 12, Heft 1, pp. 28, 34, 1898 (cf. Roemer, F. A., Neues Jahrb., 1863, p. 521), Schnur, J., Palaeontographica, vol. 3, pl. 21, figs. 5a, 5c, 1853.

to warrant a union of the two. *Chonetes sarcinulatus* has 100 or more striæ; the shell has the size and wide form of *Chonetes novascoticus* and is depressed-convex, without definitely demarcated ears, median sinus, or median rib. Although recognizing the strong possibility that *Chonetes novascoticus* may be identical with these European Eo-Devonian shells, it seems preferable for the present to retain the name *Chonetes novascoticus* Hall, 1860, especially considering the uncertainty enshrouding Schlotheim's types of *Chonetes sarcinulatus*.[1]

Equally apparent is the similarity and possible identity of *Chonetes novascoticus* with some Gotland late Silurian shells that have passed under the name *Chonetes lata* Von Buch[2] or *Chonetes striatella* Dalman var. *lata*. Gagel[3] has lately revived Von Buch's long unused *Chonetes lata* for a large, depressed species from Baltic late Silurian drift bowlders. These shells have more than 125 striæ and seem identifiable with *Chonetes novascoticus*, but whether Von Buch's originals conform with this type is questionable. Von Buch's contemporaries, Sowerby[4] and De Koninck,[5] as also Davidson,[6] regarded the "species" *Chonetes lata* as having a maximum of less than 100 striæ and as representing only a larger, wider extreme of *Chonetes striatella* Dalman. "*Chonetes lata*," as figured by Sowerby and by Davidson from the English Upper Ludlow and Tilestones, differs from *Chonetes novascoticus* not only in the less profuse striation but also in having the spines curved in the opposite direction.

Clarke has identified with *Chonetes novascoticus* Hall a very coarsely ribbed Chonetes occurring in the Silurian along Rio Trombetas, in the State of Para, Brazil.[7] This Brazilian species is somewhat more coarsely ribbed than *C. novascoticus* but agrees better with the Waldron form, especially in its small size and in the persistent presence of a median rib. This form is closely allied with *Chonetes zephyrus* Barrande, from the Bohemian middle Silurian, étage E 2, which has medium-fine radial sculpture and a median riblet and is rather flat.

CHONETES BASTINI Williams.

Plate VIII, figure 25.

1886. cf. "Chonetes allied to *C. cornuta* but much larger and with finer ridges, Clinton." Shaler, N. S., Preliminary report on the geology of the Cobscook Bay district, Maine: Am. Jour. Sci., 3d ser., vol. 32, p. 56, 1886.

1913. *Chonetes bastini*. Williams, U. S. Nat. Mus. Proc., vol. 45, p. 337, pl. 30, figs. 6, 7, 10. Pembroke formation, Leighton Cove, etc., town of Pembroke, Washington County, Maine.

A broad, finely lineate form of Chonetes was reported by N. S. Shaler from Leighton's Cove as allied to *C. cornuta* but much larger and with finer ridges. In the collections made some of the specimens closely resemble *Chonetes novascoticus*. The more characteristic form is, however, more finely lineate and broader than the typical representative of *C. novascoticus* from the Arisaig rocks. To this finely lineate form the specific name *bastini* was applied.

The species is similar in form to *Chonetes striatella* Dalman but differs in its finer and more numerous surface lines and in the number of its spines. Full-grown specimens are frequently 20 millimeters wide and generally not quite 10 millimeters long. The pedicle valve is gently convex; beak low; spines on the cardinal margin from 12 to 16 and the radiating lines over 100 and occasionally as many as 200 at the margin. A short median septum is generally present under the beak of the pedicle valve. The brachial valve is slightly concave. There is no enlarged median rib on the pedicle valve, but occasionally a narrow median furrow crosses the shell at this point.

The shell differs from *Chonetes novascoticus* Hall in its greater transverse extension; ordinarily it is twice as wide as long.

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[1] The American shell identified by Norwood and Pratten (Jour. Acad. Nat. Sci. Philadelphia, vol. 3, p. 28, 1854) as *Chonetes sarcinulatus* Schlotheim is probably one of the forms of *Chonetes coronatus* occurring at the Devils Bake Oven, Ill., in beds of Hamilton age.

[2] Von Buch, L., Ueber die Silicification organischer Körper, nebst einigen anderen Bemerkungen über wenig bekannte Versteinerungen: K. Akad. Wiss. Berlin Abh. (for 1828), pp. 53, 70, pl. 3, figs. 1, 3, 5–9, 14, 15, 1831.

[3] Gagel, C., Die Brachiopoden der cambrischen und silurischen Geschiebe im Diluvium der Provinzen Ost- und West-Preussen: Beitr. Naturh. Preuss., No. 6, 1890.

[4] Sowerby, J. de C., in Murchison, R. I., Silurian system, pp. 603, 610, pl. 3, figs. 10b, 12c; pl. 5, fig. 13, 1839.

[5] De Koninck, L. G., Monographie des genres Productus et Chonetes, p. 200, pl. 20, fig. 5, Liège, 1847.

[6] Davidson, Thomas, Monograph of the British fossil Brachiopoda, pt. 7, The Silurian Brachiopoda, p. 331, pl. 49, figs. 23, 24 (not 25 or 26), 1870.

[7] Clarke, J. M., Mus. Naccional, vol. 10, p. 24, pl. 50, fig. 25, Rio de Janeiro, 1899 (author's English ed., p. 12, 1900).

Locality: Pembroke formation, Leighton Cove, Long Cove, and in many other localities in the town of Pembroke, Maine.

U. S. National Museum, catalogue Nos. 58960, 58961, and 59926.

CHONETES NOVASCOTICUS Hall var. CANADENSIS Billings.

Plate IX, figures 20, 21; Plate X, figures 30, 31; Plate XI, figure 16.

1874. *Chonetes canadensis*. Billings, Paleozoic fossils, vol. 2, pt. 1, p. 17, figs. 17.
Lower Devonian: Perce, Bay de Chaleurs, Quebec.

1883. *Chonetes canadensis*. Ells, Canada Geol. Survey Rept. Progress for 1880–1882, p. 9DD.
Gaspe upper limestones (Oriskany): Perce Rock, Gaspe, Quebec.

1885. *Chonetes canadensis*. Ells, idem, 1882–1884, p. 24E.
Gaspe Oriskany [whether limestone or sandstone is not stated]: Hills in the rear of Gaspe Village, Quebec.

1907. *Chonetes impensus*. Clarke, New York State Mus. Bull. 107, p. 263, fig.
Lower Devonic [Moose River sandstone]: Moosehead, 7 miles north of Kineo, Somerset County, Maine.

Chonetes canadensis Billings was described as a large, nearly flat Chonetes; transversely extended, semicircular or semielliptical in outline, and covered with radiating striæ, of which there are 10 to 15 in the width of two lines (12 to 18 in 5 millimeters). A large Chonetes presenting these characters is common at Detroit, Maine. It is represented in its different expressions by the five specimens figured, which have the following measurements:

Dimensions of specimens of Chonetes canadensis.

Specimen No.	Plate.	Figure.	Length (millimeters).	Width (millimeters).	Radial lines in 5 millimeters.
765	IX	21	24.5	44.5	14–15–18+
635	X	30	18.75	39.5	[a] 12–15–16+
767	IX	20	18	28	14–16−
641	X	31	21	37.5	15–24−
763	XI	16	24.5	44	14–15–17−

[a] No. 635 has about 170 lines at the margin. Note the median rib on this specimen (a brachial valve) and the radial lines curving inward. Both these features seem to be due to an injury to the shell. The same features appear in *Chonetes impensus* Clarke.

These specimens represent a very variable species, if, indeed, they are cospecific. Specimen No. 635 (Pl. XX, fig. 30) is a slightly convex brachial valve; specimen No. 641 (Pl. X, fig. 31) is a slightly concave brachial valve; the other three specimens are pedicle valves of slight but varying convexity. No two of the five specimens have quite the same expression. They answer fairly well, however, to Billings's description of *C. canadensis* and are included under that species as a variety of *C. novascoticus*. The Maine forms are larger than any of Billings's specimens, the largest of which were 12 by 20, 12 by 22, and 14 by 24 millimeters. Specimens Nos. 765, 767, and 763 seem to be only large individuals of *Chonetes novascoticus*, and the general resemblance of the Canadian form to Hall's species leads to the conclusion that it is a variety. That *C. canadensis* is only a large varietal modification of *C. novascoticus* has already been suggested.[1]

Locality: Moose River sandstone, Detroit, Maine. This type of shell does not occur in the Chapman sandstone.

U. S. National Museum, catalogue No. 59708.

CHONETES VICINUS var. DEFLECTUS Hall.

Plate III, figure 8.

1843. *Leptæna vicina*. Castelnau, Essai sur le système silurien de l'Amérique septentrionale, p. 39, pl. 14, fig. 9.
Formation (?): Ontario County, N. Y.

1843. *Strophomena mucronata*. Hall, Geology of New York, Rept. Fourth Dist., pp. 180–181, fig. 3.
Marcellus shale: Avon, Indian reservation, Erie County, N. Y.

[1] Williams, H. S., and Gregory, H. E., Contributions to the geology of Maine: U. S. Geol. Survey Bull. 165, pp. 84, 85, 1900.

1854. *Chonetes armata.* Norwood and Pratton, Acad. Nat. Sci. Philadelphia Jour., vol. 3, p. 28.
Hamilton limestone: Bake Oven, Ill.

1857. *Chonetes laticosta.* Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 119.
Corniferous limestone: A few miles southeast of Buffalo, N. Y.
Hamilton shales: Canandaigua, N. Y.
Hamilton limestone: Devils Bake Oven, Jackson County, Ill. (associated with *Chonetes coronatus* and *C. pusilla*).[1]

1857. *Chonetes gibbosa.* Hall, idem, p. 145.
Hamilton group: York, Livingston County, N. Y.

1857. *Chonetes deflecta.* Hall, idem, p. 149.
Hamilton group shales: Canandaigua Lake, N. Y.

1857. *Chonetes pusilla.* Hall, idem, p. 149.
Hamilton limestone: Devils Bake Oven, Ill.

1867. *Chonetes mucronata* (pars). Hall, Paleontology of New York, vol. 4, p. 124, pl. 20, fig. 2, pl. 21, fig. 1.
Marcellus shale: Avon, Livingston County; Crooked Creek, near Darien, Genesee County; and Alden, Erie County, N. Y.

1867. *Chonetes laticosta.* Hall, idem, p. 125, pl. 20, figs. 1a–1d.
Corniferous limestone: Manchester, Ontario County; in Erie County on the Indian reservation southeast of Buffalo; and at Williamsville and Clarence Hollow, N. Y.
Hamilton: Pratts Falls and other localities in Onondaga and Madison counties, N. Y.

1867. *Chonetes deflecta.* Hall, idem, p. 126, pl. 2, figs. 7, 8.
Hamilton group shales: Canandaigua Lake, Ludlowville and Kidders Ferry on Cayuga Lake, Moscow, York, Covington, and other places in western New York.

1867. *Chonetes pusilla.* Hall, idem, p. 128, pl. 21, fig. 6.
Hamilton limestones: Bake Oven, Ill.

1868. *Chonetes pusillus.* Meek, Chicago Acad. Sci. Trans., vol. 1, p. 93, pl. 13, fig. 2.
Middle Devonian: Fort Resolution, Great Slave Lake, British America.

1874. *Chonetes mucronata.* Nicholson, Paleontology of the Province of Ontario, p. 74.
Corniferous limestone: Ramas Farm, near Port Colborne, Ontario.

1874. *Chonetes laticosta.* Billings, Paleozoic fossils, vol. 2, pt. L, p. 20.
Gaspe limestone No. 8: Little Gaspe, Grande Greve, and Indian Cove, Gaspe, Quebec.

1878. *Chonetes mucronatus.* Ashburner, Pennsylvania Second Geol. Survey Rept. F, p. 223.
Upper Hamilton sandstone: Aughwick Valley and end of Jacks Mountain, Huntingdon County, Pa.

1883. *Chonetes mucronatus.* I. C. White, Pennsylvania Second Geol. Survey Rept. G7, pp. 76, 230.
Marcellus shale: Little Fishing Creek, Hemlock Township, Columbia County, Pa.

1883. *Chonetes mucronata.* Hall, New York State Geologist Second Ann. Rept., pt. 47, figs. 6, 7.
Marcellus shale: West Avon, Livingston County, N. Y.

1883. *Chonetes deflecta.* Hall, idem, pl. 47, fig. 28.
Hamilton group: Western New York.

1883. *Chonetes laticosta.* Ells, Canada Geol. Survey Rept. Progress for 1880–1882, p. 13DD.
Upper Gaspe limestones (Oriskany): Indian Cove, Grande Greve, and Little Gaspe; Gaspe Bay, Quebec.

1884. *Chonetes deflecta.* Walcott, U. S. Geol. Survey Mon. 8, p. 124, pl. 2, fig. 8.
Lower part of Nevada limestone (Lower Devonian): Combs Peak, west slope of County Peak, and lower beds at Lone Mountain, 18 miles northwest of Eureka, Nev.
Upper Devonian: Rescue Hill, Eureka district, Nev.

1884. *Chonetes mucronata* (?). Walcott, idem, p. 124.
Upper part of Nevada limestone (Upper Devonian): Foothills east of Sentinel Mountain and the Sugar Loaf, Eureka district, Nev.

1884. *Chonetes macrostriata* (pars). Walcott, idem, p. 126, pl. 13, fig. 14b (not figs. 14, 14a, 14c; not pl. 2, fig. 13).
Lower Devonian limestone: Combs Peak; south spur of Atrypa Peak; on the divide of Rescue and Berry canyons; and midway of Grays Canyon, Eureka district, Nev.; also at north end of Ravens Nest, Pinon Range, Nev.

1885. *Chonetes mucronata.* Claypole, Pennsylvania Second Geol. Survey Rept. F2, p. xiii.
Hamilton (upper shales): Perry County, Pa.

1889. *Chonetes mucronatus.* Claypole, Pennsylvania Second Geol. Survey Rept. O3, p. 157.
Upper Hamilton shale: Brickfield, 1 mile southwest of New Bloomfield, Perry County, Pa.

1889. *Chonetes mucronata.* Simpson, idem, pp. 212–213, 216.
Hamilton formation: Marshalls Creek, Monroe County, Pa.

1889. *Chonetes* allied to *mucronata.* Schuchert, New York State Geologist Eighth Ann. Rept., p. 52.
Oriskany: Cayuga, Canada West.

1892. *Chonetes mucronata.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, pl. 16, figs. 6, 7.
Marcellus shale: West Avon, Livingston County, N. Y.

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[1] In the detailed section of the Devils Bake Oven given by Weller, in 1897, no two of these three species are recorded as associated together.

1892. *Chonetes deflecta.* Hall and Clarke, idem, pl. 16, fig. 28.
Hamilton group: Western New York.
1894. *Chonetes mucronatus.* Prosser, U. S. Geol. Survey Bull. 120, pp. 4, 19, 20, 21, 28, 35, 37.
Marcellus shale: Near Scott Street Bridge, Stroudsburg, Pa.
Hamilton group: Lehigh Valley Railroad cut north of Bowmans, Carbon County, Pa.; roadside, half a mile north of Marshalls Falls post office, and in Marshalls Creek at the falls, Monroe County, Pa.; Sawkill Creek, above the falls, Pike County, Pa.; and Rose Point, Orange County, N. Y.
1894. *Chonetes deflecta.* Prosser, idem, pp. 5, 8, 21.
Hamilton group: Gravel Place, Brodhead Creek, and Marshalls Falls, Monroe County, Pa.
1897. *Chonetes mucronatus.* Schuchert, U. S. Geol. Survey Bull. 87, p. 176.
Oriskany and Hamilton: New York; Cayuga, Ontario; Gaspe, Quebec; Eureka district, Nev.
1897. *Chonetes pusillus.* Schuchert, idem, p. 177.
Hamilton: Bake Oven, Ill.; Fort Resolution, Great Slave Lake, British America.
1897. *Chonetes vicinus.* Schuchert, idem, p. 180.
Hamilton: Ontario County, N. Y.; Columbus, Ohio.
Wisconsin: Eureka district, Nev.
1897. *Stropheodonta macrostriata* (pars). Schuchert, idem, p. 424.
Lower Devonian: Eureka district, Nev.
1897. *Chonetes laticosta.* Weller, Jour. Geology, vol. 5, No. 6, pp. 626, 627.
Lower part of Upper Helderberg group,[1] Devils Bake Oven, near Grand Tower, Jackson County, Ill. (zones 1, 2, 4).
1897. *Chonetes mucronatus.* Weller, idem, pp. 628–630.
Corniferous limestone: Devils Bake Oven, near Grand Tower, Jackson County, Ill. (zones 6, 7, 11, 13).
1897. *Chonetes deflecta.* Weller, idem, pp. 630, 631.
Corniferous-Hamilton transition: Devils Bake Oven, near Grand Tower, Jackson County, Ill. (zones 15, 16, 23).
1897. *Chonetes pusillus.* Weller,[2] idem, pp. 631, 634.
Corniferous-Hamilton transition: Devils Bake Oven, near Grand Tower, Jackson County, Ill. (zone 23).
1897. *Chonetes pusillus.* Schuchert, U. S. Geol. Survey Bull. 87, p. 178.
Hamilton: Bake Oven, Ill.; Fort Resolution, Great Slave Lake, British America.
1898. *Chonetes mucronatus* (?). Bownocker, Denison Univ. Sci. Lab. Bull., vol. 11, pl. 6.
Corniferous limestone: Deer Creek, Columbus, Marble Cliff, Marion, Sandusky, Kellys Island, White House, and Bellefontaine, Ohio.
1899. *Chonetes mucronatus.* Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), p. 353.
Marcellus black shale: Near Clarkesville, Albany County, N. Y.
1899. *Chonetes deflecta.* Prosser, idem, p. 353.
Hamilton sandy shales: Near Clarkesville, Albany County, N. Y.
1899. *Chonetes mucronatus.* Schuchert, Am. Jour. Sci., 4th ser., vol. 7, p. 431.
Oriskany chert: Camden, Benton County, Tenn.
1900. *Chonetes mucronatus.* Schuchert, Geol. Soc. America Bull., vol. 11, pp. 293, 321, 325.
Oriskany: Camden, Tenn.; Cayuga, Canada.
1901. *Chonetes mucronatus.* Clarke, New York State Mus. Bull. 49, pp. 115, 129, 132, 134.
Stafford limestone lenticle: Western New York.
Marcellus shale below the Stafford limestone: Livonia salt shaft and Lancaster, N. Y.
1901. *Chonetes deflectus* and cf. *deflectus.* Clarke, idem, p. 136.
Calcareous lenses in Marcellus shale: Livonia salt shaft, Livonia, N. Y.
1901. *Chonetes mucronatus.* Wood, New York State Mus. Bull. 49, pp. 142–144, 146–152, 158.
Stafford limestone and Marcellus shale below Stafford limestone: Lancaster, Erie County, N. Y. (in all the zones).
1902. *Chonetes vicinus.* Monroe, Wisconsin Nat. Hist. Soc. Bull., vol. 2, No. 1, p. 65.
Hamilton group: East Bethany, Genesee County, N. Y.
1904. *Chonetes robustus.* Raymond, Am. Jour. Sci., 4th ser., vol. 17, p. 289, pl. 17, figs. 1, 2.
Hamilton (Moscow) shales: Monteth Point, Canandaigua Lake, N. Y.
1904. *Chonetes mucronatus.* Raymond, idem, p. 289, pl. 15, rows 4 and 5.
Moscow (Hamilton) shales: Monteth Point, Canandaigua Lake, N. Y.
1907. *Chonetes billingsi.* Clarke, New York State Mus. Bull. 107, p. 266, figs. on p. 267.
Lower Devonic: Grande Greve, Quebec.
Middle Devonic: Gaspe Basin, Quebec.

Shell small; convexo-concave; outline transversely quadrate or semicircular. Pedicle valve strongly convex, a valve 7.2 millimeters long and 12 millimeters wide being 1.6 millimeters thick. Greatest convexity in the middle; profile arcuate from beak to front; ears flattened. Commonly the proportion of width and length is about as 4 to 3. The hinge line is equal to

[1] Probably equivalent to the "zone of *Spirifer hercyniæ*" or Grande Greve and York River beds of Gaspe and Moose River sandstone of Maine.
[2] Weller reiterates here that "*Chonetes deflecta* and *Chonetes pusilla* * * * are apparently variations of a single species."

the greatest width, the sides are subparallel, straight, and curve into the front margin, which is widely and shallowly arcuate. A median septum on the interior extends from the beak about one-quarter the length; the brachial valve is strongly concave.

The surface is marked by very coarse flexuous ribs, of which there are commonly about 15 near the beak; they increase at first chiefly by implantation, and in front by both implantation and bifurcation. These ribs number about 28 or 30 at the front margin of a shell 7 millimeters long. In the umbonal region the ribs are wider than the interspaces and there are 9 to 11 ribs in 5 millimeters; in front the interspaces are as wide as or slightly wider than the ribs. No spines were observed on the specimens, but the general expression of the shells places them evidently in the genus Chonetes.

Locality: Moose River sandstone, Little Brassua Lake, Somerset County, Maine (locality 1061 B[1]). It is associated with *Leptostrophia blainvillii* Billings (=*L. perplana* Conrad), a crushed Spirifer not unlike *Spirifer murchisoni* Castelnau, and a bivalve. In the Chapman fauna no Chonetes of this coarsely marked type is known to occur.

U. S. National Museum, catalogue No. 59709.

Remarks.—The *Chonetes vicinus* type represents in America, as does the *Chonetes plebeia* Schnur in Europe, an expression of Chonetes which differs from the ordinary smaller forms of Chonetes in its greater gibbosity and more particularly in the coarseness and sparsity of its radial lines, which amount, in fact, to ribs, or riblets rather than lines. Species of Chonetes of this expression have been given various names, but appear to constitute a species-group or gens to which the name *Chonetes vicinus* of Castelnau is applicable. *Chonetes vicinus* usually manifests itself in the following modifications, the characters of which are fluctuating and not fixed:

1. Variety *a*, or *mucronatus* type; ribs simple, rigid, 20 to 24, occasionally up to 30.
2. Variety *b*, or *laticosta* type; ribs flexuous, increasing rather freely in number by implantation and by bifurcation, 12 to 25.
3. Variety *c*, or *deflecta* type; ribs as in the *laticosta* type, but 26 to 30 and rarely up to 34 in number.
4. Variety *d*, or *gibbosa* type; ribs as in the *laticosta* and *deflecta* types, but the shells are large and gibbous and with a minimum of 30 to 40 ribs.

Chonetes vicinus and its European equivalent, *Chonetes plebeia*, are valuable horizon markers. *Chonetes plebeia* appears to be unknown in the Taunusian or zone of *Spirifer primævus*, but it becomes conspicuous in the overlying Lower Coblenzian or zone of *Spirifer hercyniæ*, and continues into the Upper Coblenzian and Meso-Devonian. In North America the *Chonetes vicinus* type is conspicuous in the zone of *Spirifer hercyniæ* (*C. gaspensis*, etc.), represented by the Moose River, Grande Greve, and York River beds, and continues into the Onondaga and Meso-Devonian, the *gibbosa* type continuing on from the Upper Hamilton into the Ithaca shale member of the Portage formation of the Neo-Devonian. In the Oriskany, as in the Taunusian of Europe, the *Chonetes vicinus* type is not definitely known, and in the Helderberg there is no indication of its occurrence.

Subgenus EODEVONARIA Breger.

For the Chonetes having denticulate hinge margin Mr. Breger[1] proposed the name Eodevonaria, taking for the type some specimens of *Chonetes arcuatus* Hall from the Moose River sandstone. To this subgenus six previously known species conform, namely, (1) *Chonetes arcuatus* Hall, from the "Corniferous" of Ohio, Indiana, New Jersey, and New York; specimens from the Moose River sandstone at Little Brassua Lake, Somerset County, Maine, are also referred to this species; (2) *Chonetes dilatus* F. Roemer, Lower and Middle (?) Devonian; (3) *Chonetes melonicus* Billings, Grande Greve limestone of Little Gaspe, Quebec; (4) *Chonetes acutiradiata* Hall, "Corniferous" limestone of Williamsville, Erie County, N. Y.; (5) *Chonetes extensus* Kayser, Lower Coblenzian of the Rhenish Devonian; and (6) *Chonetes arcei* A. Ulrich, Lower Devonian of Bolivia, Argentina, and South Africa. It is evident, therefore, that the subgenus is characteristic of the Lower Devonian over a wide geographic range. Stratigraphically it is nowhere known to pass below the Oriskany nor to range upward into distinctly Meso-Devonian faunas. Chonetes of the type of Eodevonaria do not occur in the Chapman sandstone,

[1] Breger, C. L., On Eodevonaria, a new subgenus of Chonetes: Am. Jour. Sci., 4th ser., vol. 22, p. 534, 1906.

but the species *Eodevonaria arcuatus* occurs in the Moose River sandstone of central Maine. *Chonetes melonicus* Billings is reported by Clarke from the upper beds of the Grande Greve limestone. Clarke found no crenulations in the specimens of *Chonetes hudsonicus* from Becraft Mountain, but observed them as a distinct feature of the shells from the Gaspe (York River) sandstones of Gaspe, which he called *C. hudsonicus* metatype *gaspensis*. *C. hudsonicus* metatype *gaspensis* has also been recognized in the *Spirifer arenosus* fauna at St. Helens and Cote St. Paul, near Montreal.[1]

Chonetes (Eodevonaria) arcuatus Hall.

Plate III, figures 6, 9, 11.

1857. *Chonetes arcuata*. Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 116.
Corniferous limestone: New York.
1867. *Chonetes arcuata*. Hall, Paleontology of New York, vol. 4, p. 119, pl. 20, fig. 7.
Corniferous limestone: Near Williamsville and Clarence Hollow, Erie County, N. Y.
1883. *Chonetes arcuata*. Hall, New York State Geologist Second Ann. Rept., pl. 47, figs. 15, 35, 36.
Corniferous limestone: Near Williamsville, Erie County, N. Y.
1892. *Chonetes arcuata*. Hall, Paleontology of New York, vol. 8, pt. 1, pl. 16, figs. 15, 35, 36.
Corniferous limestone: Near Williamsville, Erie County, N. Y.
1897. *Chonetes arcuatus*. Schuchert, U. S. Geol. Survey Bull. 87, p. 172.
Corniferous limestone: Williamsville, Clarence Hollow, etc., New York, Columbus, Ohio.
1900. *Chonetes arcuatus*. Kindle, Indiana Dept. Geology and Nat. Res. Twenty-fifth Ann. Rept., p. 601, pl. 4, figs. 6, 6a.
Jeffersonville ("Corniferous") limestone: Paris Crossing, Ind.
1903. *Chonetes arcuatus*. Weller, Paleontology of New Jersey, vol. 3, pp. 103, 105, 367, 373, pl. 51, figs. 18, 21.
Corniferous limestone: Road along Delaware River, 1½ miles southwest of Peters Valley, N. J.
Newfoundland grit: West of Greenwood Lake, N. J.
1906. *Chonetes (Eodevonaria) arcuatus*. Breger, Am. Jour. Sci., 4th ser., vol. 22, p. 534.
Upper Helderberg group: Ohio, Indiana, New Jersey, and New York.
Moose River sandstone: Little Brassua Lake, Somerset County, Maine.

Shell small to medium-sized, convexo-concave, very gibbous. Ratio of length and breadth varying from 9.10 to 7.10; greatest width along the hinge line; the sides of the shell are straight for some distance below the hinge and curve into the front margin, which is semicircular; the pedicle valve is very gibbous, the depth being equal to about a third of the length. The shell is inflated in the middle, which includes the greatest convexity; the umbo is gibbous and the beak protrudes over the hinge line. The ears are somewhat flattened and small. They are demarcated on the interior by a ridge (a crural ribbon?) which curves about and includes the inflated portion of the shell. A faint narrow median sinus occurs occasionally in the pedicle valve. On the interior of the valve a thin median septum extends one-third to one-half the length from the beak. Brachial valve not seen.

The surface is marked by straight, slightly flexuous radial lines which increase frequently by bifurcation. On specimens 10.5 millimeters long there are from 72 to 84 lines at the margin and from 19 to 24 in the space of 5 millimeters on the front part of the shell. The lines also cover the ears. In some internal molds the radial lines are sharply expressed, nearly as well developed as on the surface; in other specimens the ornamentation is preserved only in spots, and the internal mold is for the greater part radially pustulose. On all internal molds the ornamentation on the umbo near the beak is obsolescent. The hinge is denticulate in all three of the internal molds of the pedicle valve in which the hinge is visible.

Dimensions of specimens of Chonetes (Eodevonaria) arcuatus.

No.	Length (millimeters).	Width (millimeters).	Depth (millimeters).	Radial lines.
5052.1	10.5	11.5	3	24 in 5 millimeters; 84 around the margin.
5052.2	10.5	15	3	
5052.4	10.5	12	4	19 in 5 millimeters; 72 around the margin.

[1] Williams, H. S., On the fossil faunas of St. Helen's breccia: Roy. Soc. Canada Trans., 3d ser., vol. 3, pp. 217-239, 1909-10. *C. hudsonicus* metatype *gaspensis* has also been recognized in the *Spirifer arenosus* fauna at St. Helens and Cote St. Paul, near Montreal.

The species is easily recognized by its inflated gibbosity, medium fine radial sculpture, denticulations on the hinge, and slight difference between length and width. The Maine specimens correspond with forms of *C. arcuatus* figured by Weller[1] from the "Corniferous" limestone of New Jersey.

Locality: Little Brassua Lake, Somerset County, Maine. No representative of this species or of Eodevonaria has been discovered in the Chapman fauna proper.

U. S. National Museum, catalogue No. 59710.

Comparisons.—In its superficial characters *Chonetes* (*Eodevonaria*) *arcuatus* resembles fossils identified by authors and apparently also by Hall with the *Chonetes hemisphericus* of Hall (*? Strophemena gibbosa* Conrad, 1841); but the present species has a denticulated hinge, a character which is usually regarded as of generic value among the strophomenoids and leptænoids. This denticulated hinge occurs in *C. melonicus* Billings and also in *C. acutiradiatus* Hall, which is closely allied to *C. hemisphericus* Hall, but in the last-named species this character, so far as known, does not occur. The types of *Chonetes hemisphericus* are much more coarsely lined and are larger shells than the Maine fossils under discussion. Hall says that *Chonetes arcuatus* "is distinguished from *C. hemisphericus* by being a little less prominent on the umbo, and by the shallow sinus, as well as the more numerous and much finer striæ. The cast does not preserve the marks of the striæ so conspicuously, while the surface is more abundantly pitted without being sensibly arranged in distinct lines."[2]

The Jewett collection in Cornell University, which was largely used in the preparation of Hall's works on New York paleontology, contains specimens of *C. hemisphericus* and *C. arcuatus* that controvert these statements. A large *Chonetes arcuatus* in that collection is more gibbous on the umbo than *C. hemisphericus*, and the same may be said of a specimen figured by Weller[3] compared with average specimens of *C. hemisphericus*. Many specimens of *C. hemisphericus* also have a shallow sinus, which is commonly wanting in *C. arcuatus* from New York, New Jersey, and Maine. *C. hemisphericus* in one of its forms has very fine radial lines. *C. arcuatus* is also occasionally regularly striate on the interior, but *C. hemisphericus* is occasionally obscurely papillose on the interior. The Jewett collection contains a small, finely striate form of *C. hemisphericus*, with less gibbous umbones than usual, from the Onondaga ("Corniferous") limestone of Erie County, N. Y. On one of these specimens, which is hardly distinguishable from the Maine form, there are indications of what may prove to be denticulations on the hinge. If a denticulated hinge line could be proved in *C. hemisphericus*, there need be no hesitancy in uniting *C. arcuatus* with it. There is some doubt, however, as to whether these finely striate specimens ought to be identified with *C. hemisphericus*, for the types of that fossil preserved in the American Museum of Natural History in New York are a coarsely striate large species.

The large forms of *Chonetes macrostriatus* Walcott very much resemble *C. arcuatus* in size, contour, and outline, and in the method of preservation of the ornamentation; but Walcott's species has fewer and coarser ribs. According to Schuchert,[4] who places Walcott's species in Stropheodonta, a denticulated hinge is present; but whether this denticulated hinge occurs in the real Chonetes figured by Walcott[5] on his Plate XIII or on the different shell shown on his Plate II is unknown at present. If *Chonetes macrostriatus* Walcott really has a denticulated hinge, its association will be with *C. arcuatus* rather than with *C. vicinus* var. In the European fauna an equivalent of *C. arcuatus* is found in the species *Chonetes dilatata* F. Roemer, a shell of wide distribution in the Lower Devonian of Germany, Belgium, and England. This European form has a denticulated hinge and can be distinguished from the American species only with difficulty. The large individuals of *C. dilatata* have, according to De Koninck, as many as 160 to 170 striæ at the margin. The large American forms have perhaps half that number and the ribs are coarser. The more finely striate American types are smaller shells and more finely striate on the umbones.

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[1] Weller, Stuart, Paleontology of New Jersey, vol. 3, 1903, pp. 103, 105, 367, 373, pl. 51, figs. 18, 21.

[2] Paleontology of New York, vol. 4, p. 120, 1867.

[3] Paleontology of New Jersey, vol. 3, pl. 51, fig. 21, 1903.

[4] Schuchert, Charles, A synopsis of American fossil Brachiopoda: U. S. Geol. Survey Bull. 87, p. 424, 1897.

[5] Walcott, C. D., Paleontology of the Eureka district [Nevada]: U. S. Geol. Survey Mon. 8, p. 126, 1884.

Genus CHONOSTROPHIA Hall and Clarke.

The genus Chonostrophia was proposed by Hall and Clarke[1] for brachiopods having the general characters of Chonetes but with reversed convexity of the valves at maturity, displaying what is known as "resupinate curvature." *Chonetes reversa* Whitfield, an American Onondaga ("Corniferous") species, was taken as the type.

A single species, *C. helderbergiæ* Hall, is reported from the Helderberg group in New York. With this exception the genus Chonostrophia is confined to the Oriskany and Onondaga ("Corniferous") faunas of North and South America, where it is common and widespread. In Europe, Africa, and Australasia, Chonostrophia is not known to occur. The genus is also unknown in the Chapman sandstone fauna, though it is present in the Moose River sandstone.

CHONOSTROPHIA COMPLANATA (Hall).

Plate X, figure 4.

cf.? 1846. *Orthis tenuis.* Morris and Sharpe, Geol. Soc. London Quart. Jour., vol. 2, p. 275, pl. 10, fig. 4; pl. 11, fig. 4.
Lower Devonian; Falkland Islands.

1857. *Chonetes complanata.* Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 56.
Oriskany sandstone: Albany and Schoharie counties, N. Y.

1859. *Chonetes complanata.* Hall, Paleontology of New York, vol. 3, p. 418, pl. 93, fig. 1.
Oriskany sandstone: Albany and Schoharie counties, N. Y.

1874. *Chonetes dawsoni.* Billings, Paleozoic fossils, vol. 2, pt. 1, p. 18, fig. 8.
Gaspe limestone [Grand Greve]: Split Rock, (Perce), Quebec.
Gaspe sandstone [York River]: Gaspe, Quebec.

1876. *Chonetes complanata.* Barrett, Lyceum Nat. Hist. New York City Annals, vol. 11, p. 296.
"Trilobite beds" [basal Oriskany or Helderberg transition]: Bennett's quarry, Port Jervis, N. Y.

1877. *Chonetes complanata.* Barrett, Am. Jour. Sci., 3d ser., vol. 13, p. 386.
Trilobite beds; Bennett's quarry, near Port Jervis, N. Y.

1883. *Chonetes complanata.* Hall, New York State Geologist Second Ann. Rept., pl. 47, figs. 13, 29.
Oriskany sandstone: Albany County, N. Y.

1883. *Chonetes dawsoni.* Ells, Canada Geol. Survey Rept. of Progress for 1880–1882, p. 9DD.
Upper Gaspe Limestone (Oriskany): Perce Rock, Quebec.

1889. *Chonetes complanata.* Schuchert, New York State Geologist Eighth Ann. Rept., p. 52.
Oriskany: Cumberland, Md.; New York; Cayuga, Canada West.

1889. *Chonetes complanata.* Lesley, Pennsylvania Second Geol. Survey Rept., pt. 4, p. 125.
Stormsville shale, upper part of Lower Helderberg group ["Trilobite beds"]: Delaware River, Pennsylvania (near Port Jervis, N. Y.).

1892. *Chonostrophia complanata.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, p. 311, pl. 16, figs. 13, 29.
Oriskany sandstone: Albany County, N. Y.

1892. Chonostrophia sp. nov. Clarke, Am. Jour. Sci., 3d ser., vol. 44, p. 413.
Lower Oriskany: Becraft Mountain, Columbia County, N. Y.

1892. *Chonostrophia dawsoni.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, p. 311.
Oriskany: Gaspe, Canada.

1897. *Chonostrophia complanata.* Schuchert, U. S. Geol. Survey Bull. 87, p. 180.
Oriskany: Albany and Schoharie counties, N. Y.; Cayuga, Ontario; Cumberland, Md.; ?Bolivia.

1897. *Chonostrophia dawsoni.* Schuchert, idem, p. 180.
Lower Devonian: Gaspe and Perce, Quebec.

1897. Chonostrophia sp. Kayser, Deutsch. geol. Gesell. Zeitschr., vol. 49, p. 301, pl. 10, fig. 1.
Lower-Middle Devonian: Cerro del Fuerte, Argentine.

1900. *Chonostrophia complanata.* Schuchert, Geol. Soc. America Bull., vol. 11, pp. 313, 324.
Monterey (Oriskany) sandstone: Cumberland, Md.
Oriskany: Oneida and North Cayuga townships, Ontario.

1900. *Chonostrophia complanata.* Clarke, New York State Mus. Mem., vol. 3, No. 3, p. 50, pl. 7, figs. 7–13.
Oriskany: Becraft Mountain, Columbia County; half a mile southeast of Rondout Creek near Kingston, N. Y.

1901. *Chonostrophia jervensis.* Schuchert, Am. Geologist, vol. 28, p. 250, figs. c, d.
Becraft limestone ["Trilobite beds"]: Port Jervis, N. Y.

1903. *Chonostrophia jervensis.* Weller, Paleontology of New Jersey, vol. 3, pp. 94, 95, 326, pl. 42, figs. 1, 2.
"Trilobite beds" (lowest Oriskany): Near Nearpass Quarry and at Peters Valley, N. J.

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[1] Hall, James, and Clarke, J. M., Paleontology of New York, vol. 8, pt. 1, p. 310, 1892.

1903. *Chonostrophia complanata.* Weller, idem, pp. 100, 101, 348, pl. 46, fig. 12.
Spirifer murchisoni zone for upper member of the Oriskany: 1½ miles north of Layton, three-fourths of a mile west of Layton, and at Peters Valley, N. J.

1903. *Chonostrophia complanata.* Van Ingen and Clarke, New York State Mus. Bull. 69, pp. 1203, 1206.
Oriskany siliceous limestone: Glenerie and Rondout, N. Y.

1905. *Chonostrophia complanata.* Clarke, New York State Mus. Bull. 80, pp. 143, 145.
Grand Greve limestone: North side of Gaspe Bay and at Perce Rock, Gaspe, Quebec.

1905. *Chonostrophia dawsoni.* Clarke, idem, p. 145.
Gaspe sandstone [York River beds]: Gaspe Bay, Quebec.

1905. *Chonostrophia jervisensis.* Shimer, idem, pp. 185, 188, 199, 226, 227, 228, 232, 234, 243, 263.
Upper New Scotland limestone ["Trilobite beds"], lower and upper Oriskany: Trilobite Mountain, Orange County, N. Y.

1905. *Chonostrophia complanata.* Shimer, idem, pp. 189, 263.
Upper Oriskany: [1] Trilobite Mountain, Orange County, N. Y.

1905. *Chonetes (Chonostrophia) complanata.* Harris, Guide to the geology of Union Springs, p. 4, pl. 12, fig. 4.
Oriskany sandstone: Yawger's Woods, Union Springs, N. Y.

A couple of internal molds of pedicle valves from the Moose River sandstone of Somerset County, Maine, are referred to this characteristic species. The specimens show the pedicle valve slightly concave except over the muscular area and beak, where it is slightly convex. Over the center of this convex area there is an internal median septum extending about half the length of the shell, and on each side there is an obscure ridge (an impressed line in the internal mold) extending forward from the teeth, which are very strong and sharp. The cardinal area is of low or medium height, inclined at an acute angle. The bases of three or four spines are preserved along the hinge on one side of the middle. There are traces of very fine radial lines on the surface, but the molds are for the most part smooth. Length 8.5 millimeters; width 13 millimeters.

Locality: Moose River sandstone, Detroit; Somerset County, Maine (locality 1100 A).

U. S. National Museum, catalogue No. 59711.

Comparisons.—The species called *Chonetes dawsoni* Billings is apparently the same form as *C. complanata* Hall, as Clarke [2] pointed out; at least no reliable distinction has been observed. The ventral valve varies from convex on the umbonal and visceral regions, and faintly concave in front to flat on the visceral region and strongly concave in front. The radial lines are also variable but are always fine, though not so fine and uniform as in *Chonostrophia helderbergia* Hall and Clarke. In *Chonostrophia complanata* Hall, as recorded by Clarke from Becraft Mountain, N. Y., in *Chonostrophia dawsoni* Billings, and in the Maine form the median septum extends only about half the length of the valve. In Hall's typical *C. complanata*, from the Oriskany sandstone (quartzite) of Schoharie and Albany counties, and in the same form from the coarse sands of the Oriskany in Yawger's Woods, at the head of Cayuga Lake, N. Y., the septum is frequently as much as two-thirds the length. These shells from the sandstones are larger than the others and their sides are more nearly parallel, but it is believed that these are not constant distinctions.

Chonostrophia jervensis Schuchert, from the *Dalmanites dentatus* zone,[3] near Port Jervis, N. Y., is apparently only a small or young form of *Chonostrophia complanata* Hall or *C. dawsoni* Billings. Another Chonostrophia, *C. montrealensis*, described by Schuchert,[4] has between the coarser lines one, two, or three finer threadlike lines; the species is small and strongly resupinate. It is reported from the upper (Helderbergian) fauna at St. Helens Island, near Montreal. The only remaining species of Chonostrophia, *C. reversa* Whitfield (the type of the genus), is from the "Corniferous" limestone of Ohio and is a small reversed Chonetes having several fine radial lines grouped between each pair of coarse lines. The finer lines are closer and more numerous than in *C. montrealensis* Schuchert, which otherwise bears a very close relationship to Whitfield's species. The form of *Chonostrophia reversa* found at Union Springs, N. Y.,

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[1] On p. 263 given also from upper New Scotland and lower Oriskany, evidently in error for *C. jervisensis*.

[2] Clarke, J. M., New York State Mus. Mem., vol. 3, No. 3, p. 50, pl. 7, figs. 7-13, 1900.

[3] Schuchert, Charles, Am. Geologist, vol. 28, p. 250, figs. c, d, 1901. This horizon is at the top of the Port Ewen limestone or base of the Oriskany, and is included by some authors in the Helderberg and by others in the Oriskany.

[4] Idem, p. 250, figs. a, b.

in the Onondaga ("Corniferous") limestone, is slightly different from the typical form of the species as it occurs in Ohio. In the Ohio specimen, as figured by Hall and Clarke, fine radial lines lie between the coarser ones, but in this respect the specimens from Union Springs approach Schuchert's *C. montrealensis*. *Chonetes manitobiensis* Whiteaves has been mentioned as having a convex brachial valve and a compressed pedicle valve and may possibly prove to be an additional species of Chonostrophia. Before leaving the Chonostrophias attention must be called to the *Orthis tenuis* of Morris and Sharpe, from the Falkland Islands, described in 1846. The original description[1] is as follows: "Nearly semicircular; both valves flat and covered with fine bifurcating striæ, increasing to about 200 at the margin and crossed by a few concentric lines. Hinge area of the width of the shell, linear. The cast is scarcely thicker than a sheet of paper and faintly marked by the striæ. Width 1½ inches, length seven-eighths of an inch. Nearly allied to the *Orthis expansa* and *O. grandis* of the Lower Silurian rocks." This shell is apparently chonetoid, though no spines have been observed on it. The typical forms indicate a shell of the appearance of *Chonostrophia dawsoni* Billings or *C. complanata* Hall. *Strophomena expansa* Sowerby, one of the two shells with which *Orthis tenuis* was compared, is perplanoid, and the similar form, *Strophomena grandis* Sowerby, is distinctly resupinate. It is therefore probable that the species is resupinate, in which case it might be referred to Chonostrophia. Schuchert[2] regards *Orthis tenuis* as similar to *Chonostrophia complanata* Hall. It should be borne in mind, however, that no indication of spines in *Orthis tenuis* has yet been recorded. If spines are discovered in this species it will have to be referred to Chonostrophia and the name *Chonostrophia tenuis* will have priority over *C. dawsoni* and *C. complanata*.

Family ORTHIDÆ Woodward.

Genus DALMANELLA Hall and Clarke.

DALMANELLA PLANOCONVEXA (Hall).

Plate VI, figure 17; Plate VII, figures 10, 11, 13, 14, 16–18, 20–22, 24–30.

1859. *Orthis planoconvexa*. Hall, Paleontology of New York, vol. 3, p. 168, pl. 12, figs. 1–6.
Lower Helderberg shaly limestone [New Scotland]: Albany County, N. Y.; Cumberland, Md.
Oriskany: Cumberland, Md.

1874. *Orthis lucia*. Billings, Paleozoic fossils, vol. 2, pt. 1, p. 35, pl. 3, fig. 4.
Gaspe limestone No. 8 [Grande Greve limestone]: Indian Cove, Gaspe Bay, Quebec.

1876. *Orthis planoconvexa*. Barrett, Lyceum Nat. Hist. New York City Annals, vol. 11, p. 296.
"Trilobite beds": Bennett's quarry, Port Jervis, N. Y.

1882. *Orthis planoconvexa*. White, Pennsylvania Second Geol. Survey Rept. G6, p. 132.
Uppermost Stormville shales ["Trilobite beds"]: Eastern Pike and Monroe counties, Pa., and William Nearpass quarry section in New Jersey.

1883. *Orthis lucia*. Ells, Canada Geol. Survey Rept. Progress for 1880–1882, p. 13DD.
Gaspe upper limestones (Oriskany): Indian Cove, Grande Greve, and Little Gaspe, Gaspe Bay, Quebec.

1889. *Orthis planoconvexa*. Schuchert, New York State Geologist Eighth Ann. Rept., p. 52.
Oriskany: Cumberland, Md.

1892. *Dalmanella planoconvexa*. Hall and Clarke, Paleontology of New York, vol. 8, pt. 1, pp. 207, 224.
Lower Helderberg (no localities given).

1892. *Rhipidomella lucia*. Hall and Clarke, idem, p. 225.
Devonian (no locality given).

1897. *Dalmanella planiconvexa*. Schuchert, U. S. Geol. Survey Bull. 87, p. 202.
Lower Helderberg and Oriskany: Albany County, N. Y.; Cumberland, Md.

1897. *Rhipidomella lucia*. Schuchert, idem, p. 349.
Oriskany: Indian Cove, Gaspe, Quebec.

1899. *Orthis (Dalmanella) planoconvexa*. Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), pp. 340, 350.
New Scotland shaly limestone: Countryman Hill and near Clarksville (Oniskethau Creek), Albany County, N. Y.
?Becraft limestone: Oniskethau Creek.

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[1] Geol. Soc. London Quart. Jour., vol. 2, p. 275, pl. 11, fig. 4, 1846.
[2] Schuchert, Charles, A synopsis of American fossil Brachiopoda: U. S. Geol. Survey Bull. 87, p. 293, 1897.

1900. *Orthis (Dalmanella) planiconvexa.* Schuchert, Geol. Soc. America Bull., vol. 11, pp. 282, 306, 314.
New Scotland-Becraft: New York-Maryland-Virginia district; ?Tennessee.
"Trilobite beds" (Becraft): Trilobite Ridge, near Port Jervis, N. Y.
Monterey sandstone (Oriskany): Cumberland, Md.

1900. *Orthis (Dalmanella?) lucia.* Schuchert, idem, p. 329.
Gaspe limestone No. 8: Quebec.

1900. *Dalmanella planoconvexa.* Clarke, New York State Mus. Mem., vol. 3, No. 3, p. 73.
Kingston (Port Ewen) shaly limestone: West Shore Railroad near Kingston, N. Y., one-half mile southeast of Rondout Creek.

1901. *Orthis (Dalmanella) planoconvexa.* Prosser, New York State Geologist Eighteenth Annual Rept. (for 1898), pp. 58, 61.
New Scotland shaly limestone: High Point, Altamont, Knox, Helderberg Mountains, Albany County, N. Y.

1903. *Dalmanella planoconvexa.* Van Ingen and Clark, New York State Mus. Bull. 69, pp. 1203, 1206.
Upper Port Ewen beds: Near Rondout, N. Y.
Oriskany: Glenerie, N. Y.

1905. *Dalmanella lucia.* Clarke, New York State Mus. Bull. 80, p. 144.
Grande Greve limestones: North shore of Gaspe Bay, Quebec.

1905. *Dalmanella planiconvexa.* Williams and Kindle, U. S. Geol. Survey Bull. 244, p. 47.
Coarse sandstone (Lower Helderberg): East fork of Powell River (above the flouring mill; station 1376 A[2], p. 28); and Southern Railway near Big Stone Gap (station 1376 B[2], p. 28); Bland County, Va.
Coarse sandstone (Oriskany): Rear of Alabama Row, White Sulphur Springs, W. Va. (1380 A[2], p. 34); Jackson River below Covington, Alleghany County, Va. (1382 B[2], p. 39).

1907. *Dalmanella drevermanni.* Clarke, New York State Mus. Bull. 107, p. 286 (pars) not fig.
Lower Devonic [Chapman sandstone]: Edmunds Hill, Chapman Plantation, Aroostook County, Maine.

Orthids of medium to small size, convexo-planoid; radial lines fasciculate. Outline circular or subcircular; ratio of length to width commonly 8:9; varying from 4:5 to nearly equal, greatest width at or just back of the middle. Hinge line very short; cardinal outline sometimes slightly concave each side of the beak. The pedicle valve is gibbous over the umbones as far as the middle, sloping to the front and sides; beak curved inward. Teeth supported by dental lamellæ which curve around and include the musculature. Musculature half the length of the shell or a little more, indistinctly limited in front; ovoid in outline, widest near the middle. It is commonly about twice as long as wide, with a low, blunt ridge extending down the middle. The musculature of the pedicle valve is somewhat similar to that of Schizophoria (cf. *S. impressa* or *S. multistriata*). The internal mold of the shell is mainly smooth except for some obscure radial vascular markings and a narrow striate fringe at the margin.

The brachial valve is nearly or quite flat and is commonly marked by a broad, faint, undefined sinus. On the interior the muscular impression is quadrate or subcircular, indistinct in front, and limited posteriorly by the thick cardinal process and by two short diverging ridges (the crural processes ?). A low broad median ridge divides the musculature. This ridge is highest and widest at the posterior edge of the musculature and is continued anteriorly into a faint, low rounded ridge which extends nearly to the front margin, where it is commonly obscure. Posteriorly this ridge becomes more prominent and merges into the cardinal process. Cardinal process bluntly toothlike; in the Maine forms it is divided into two parts by a sharp, narrow impressed line on the inner side. In internal molds the cardinal process leaves a prominent oval hole at the apex of the valve. The internal mold is unornamented except by a narrow striate fringe about the margin. The surface of the shell is covered with coarse threadlike radial lines which increase by bifurcation and implantation and are distinctly though not very conspicuously fasciculate. In well-preserved specimens these lines are crossed by very obscure concentric lines of growth. The radial lines curve strongly upward near the posterior margin. It is extremely difficult to count the number of radial lines accurately, owing to the constant addition of finer ones alongside the coarser. The shell structure is minutely punctate. Some of the punctæ are arranged in distinct radial rows, but in other parts of the shell they are compactly crowded. The species may be recognized by its planoconvexity, very convex pedicle valve, thick shell, fasciculate coarse radial lines, and very low cardinal area. The radial lines are finer and more numerous than in the Ordovician *Dalmanella testudinaria*, which the species otherwise closely resembles.

Locality: Chapman sandstone, west side of Edmunds Hill (very common), Edmunds Hill (occasional), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59712, 59713.

Remarks on Dalmanella planoconvexa.—This species occurs in both the Helderberg and the Oriskany fauna. In the higher faunas of St. Helens Island, near Montreal, occurs an Orthis which Schuchert regarded as "much like the Oriskanian variety of *D. planoconvexa.*" This would imply that the Helderberg and Oriskany representatives of this species are varietally distinct, but no such distinction has been emphasized or even noted elsewhere in previous literature on the species.

A very closely allied "species" from the Grande Greve limestone of Indian Cove, Gaspe, is the *Orthis lucia* of Billings. This form differs from *D. planoconvexa* (Hall) in having no cardinal area, and it is possibly the Oriskany variety of Hall's species referred to by Schuchert. The cardinal area of *Dalmanella planoconvexa* is extremely narrow; it is observable only in the better-preserved specimens from Maryland and New York and can not be seen in the Maine specimens. As an Orthis with no cardinal area whatever would be anomalous, we are inclined to think that the shells of *Orthis lucia* of Billings, like those from Maine here described, represent a condition of preservation of *D. planoconvexa* (Hall), in which the very narrow cardinal area of Hall's species, observable at best only in superlatively preserved specimens, is hardly discernible, and that Billings's specific name has probably no standing, even as the name of a variety. Hall and Clarke and Schuchert evidently regard *O. lucia* Billings as not only specifically but also generically distinct from *D. planoconvexa*, for they refer Billings's species to the genus Rhipidomella. The only basis for this reference is the assumption that the gibbous valve described by Billings is the ventral valve; but this is a doubtful assumption, and the Maine material, which appears to correspond with Billings's descriptions, is a Dalmanella, not a Rhipidomella.

Specific and stratigraphic relations.—In European Silurian-Devonian faunas *Orthis orbicularis* Sowerby, from the Ludlow beds of England, Ireland, and Esthonia,[1] has been regarded as a close ally of *D. planoconvexa,* but this European shell is a distinct form, having the brachial valve more convex and the musculature shorter than in the American forms, and Sowerby's types also lack the fasciculation of the radial lines.

In the Devonian of Turkey, Germany, northwestern France, and Spain [2] there occurs an Orthis which is with difficulty distinguishable from *D. planoconvexa* Hall. This European species was originally identified by De Verneuil [3] with Sowerby's *Orthis orbicularis.* Subsequently it was discovered that Sowerby's species was different, but as the English form has been regarded by some as a variety of *O. elegantula,* which it really is not, De Verneuil decided to retain the name *O. orbicularis* for the Lower Devonian continental species. This decision has been adopted by Kayser and others. In this European shell the pedicle valve appears to be more ventricose than in the American species, and is less subcarinate and more broadly inflated.

DALMANELLA cf. D. CIRCULARIS Sowerby.

Plate VII, figure 9.

The following synonymy includes some of the more important references to Sowerby's species:

1842. *Orthis circularis.* Sowerby, Geol. Soc. London Trans., 2d ser., vol. 6, p. 409, pl. 38, fig. 12.
Rhenish Lower Devonian: Daun, in the Eifel, Germany.

1845. *Orthis orbicularis* (not Sowerby). De Verneuil, Soc. géol. France Bull., 2d ser., vol. 2, p. 478, pl. 15, fig. 9.
Eo-Devonian limestone: Ferrones and Pelapaya, Asturias, Spain.

1853. *Orthis circularis.* Schnur, Palaeontographica, vol. 3, p. 218, pl. 39, fig. 1 (? pl. 38, figs. 5a, 5b).
Graywacke (Lower Coblenzian): Daun and Daleiden, in the Eifel, Germany.

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[1] See *Orthis lunata* in Davidson, Thomas, Monograph of British fossil Brachiopoda, pt. 7, Silurian, p. 215, pl. 28, figs. 1-5, 1870.

[2] See *Orthis orbicularis* in Kayser, Emanuel, Die Fauna der ältesten Devon-Ablagerungen des Harzes: Abh. Geol. Specialkarte Preuss., etc., Bd. 2, Heft 4, 1878, p. 187, pl. 28, figs. 11-13; pl. 34, fig. 7.

[3] Soc. géol. France Bull., 2d ser., vol. 2, p. 81, pl. 15, fig. 9, 1845.

1854. *Leptæna orbicularis* (?). Wirtgen,[1] Naturhist. Ver. preuss. Rheinlände Verh., vol. 11, p. 374.
Lowest graywacke [Taunusian?] Bonsbeuren, near Bertrich, Rhenish Prussia.

1857. *Orthis circularis.* Krantz, idem, vol. 14, p. 155.
[Eo-]Devonian: Menzenberg, Daun, and Daleiden, Prussia.

1871. *Orthis circularis.* Kayser, Deutsch. geol. Gesell. Zeitschr., vol. 23, p. 603, footnote.
[Lower Eo-]Devonian: Daun and Stadtfeld, in the Eifel, Germany; Ferrones and vicinity, Asturias, Spain; Nehou, La Manche, France.

1871. *Orthis circularis.* Quenstedt, Petrefakten Deutschlands, Brachiopoden, pp. 569, 573, pl. 56, figs. 8, 9, 13, 14 (not 20–22).
Graywacke [Lower Coblenzian]: Daun, Daleiden, Laubach, Kemmenau, Germany.

1876. *Orthis circularis.* Ribbentrop, Naturhist. Ver. preuss. Rheinlände Corr.-Bl., vol. 33, p. 103.
Taunusian to Hundsruckian [Eo-Devonian]: Between Nerother Head, Oberstadtfeld, and Salm, in the Eifel, Germany.

1881. Orthis cf. *O. circularis.* Kayser, K. preuss. Geol. Landesanstalt Jahrb. (for 1880), p. 263.
Taunus quartzite: Sauerbrunnen and ?Neuhütte, near Birkenfeld, Prussia.

1881. *Orthis circularis.* Dewalque, Soc. géol. Belgique Bull., vol. 8, p. 159.
Ahrien (Lower Coblenzian): Niederstadtfeld, in the Eifel, Germany.

1882. *Orthis circularis.* Follmann, Naturhist. Ver. preuss. Rheinlände Verh., vol. 39, pp. 153, 171, 178.
Lower graywacke: Bonsbeuren, near Bertrich, Germany.
Upper graywacke, Chondrites beds, and higher: Near Olkenbach, southern Eifel, Germany.

1883. Orthis aff. *O. arcuata.* Kayser, K. preuss. geol. Landesanstalt Jahrb. (for 1882), p. 131.
Taunusian: Saltern Railway cut, 4 to 5 miles south of Torquay, South Devonshire, England.

1885. *Orthis circularis.* Gosselet, Soc. géol. Nord Annales, vol. 13, pp. 334–338.
Taunusian: Anor; woods of the Harscamp hospital back of Montigny-sur-Meuse; Virrus Woods, northeast of Nouzon; 148.56-kilometer post on the railroad near Nouzon; Neufmanil Woods; Grand Duchy of Luxembourg.

1887. *Orthis circularis.* Béclard, Soc. belge géologie, paléontologie et hydrologie Bull., vol. 1, 1887, p. 87, pl. 4, figs. 13, 14.
Coblenzian [Taunusian]: St. Michel, near St. Hubert, Belgium.

1891. *Orthis circularis.* Follmann, Naturhist. Ver. preuss. Rheinlände Verh., vol. 45, p. 141.
Lower Spirifer sandstone (Lower Coblenzian): Vallendar, Ehrenbreitenstein, Pfaffendorf, Bienhornthal, Laubach-Königbach.
Middle Spirifer sandstone (Coblenz or Ems quartzite): Bienhornthal, Oberlahnstein (?), Muhlthal, and Konigsstuhl.
Upper Spirifer sandstone (lower part of Chondrites beds): Vallendar Valley; all localities in the Coblenz district, Germany.

1899. *Orthis circularis.* Collins, Roy. Geol. Soc. Cornwall Trans., vol. 12, pp. 233, 239.
Siegen, or probably Lower Coblenzian: Fowey, Cornwall, England.

1902. *Orthis circularis.* Drevermann, Palaeontographica, vol. 49, p. 109, pl. 14, figs. 1–3.
Siegen graywacke: Seifen.
Lower Coblenzian: Oberstadtfeld, near Daun, in the Eifel, Germany.

1906. *Orthis circularis.* Green and Sherborn, Geol. Mag., dec. 5, vol. 3, p. 35.
Taunusian: Polyne quarry, Cornwall, England.

cf. 1907. *Dalmanella drevermanni.* Clarke, New York State Mus. Bull. 107, p. 286, fig.
Lower Devonic [Chapman sandstone]: Edmunds Hill, Chapman, Maine.

1907. *Orthis circularis.* Ussher, Geology of the country around Plymouth and Liskeard, Devon-Cornwall (Geol. Survey England and Wales, Explan. Sheet 348), p. 33.
Meadfoot group shales [Taunusian]: Quarry north of Polyne farm, Looe district, Cornwall, England.

1909. *Orthis circularis.* Ussher and others, Geology of the country around Bodmin and St. Austell, Cornwall (idem, sheet 347), p. 25.
Meatfoot group [Lower Coblenzian]: Fowey, Cornwall, England.

A small brachial valve found in the Chapman sandstone at Edmunds Hill closely resembles the species from the Rhenish Lower Devonian described by Sowerby under the name *Orthis circularis.* The close similarity of the species to *Dalmanella planoconvexa* Hall was observed by Drevermann. Clarke apparently refers to the same species, as well as to *Dalmanella planoconvexa,* in applying the new name *Dalmanella drevermanni* to Chapman sandstone specimens from the same locality as the present material. The dorsal valve figured by Clarke and described as *D. drevermanni* appears to be the same species as our Dalmanella cf. *D. circularis* Sowerby.

[1] Wirtgen's material, in the museum of the Prussian Rheinland Natural History Society, is identified with Sowerby's species by Follmann, 1882.

The shell is subcircular in outline; length 10.5 millimeters, width 11.5 millimeters, greatest width just above the middle. The dorsal valve is nearly flat, depressed convex without evident sinus; marked by strong dichotomous radial lines which are not fasciculate. A few fragments of the pedicle valve also show distinctly nonfasciculate radial sculpture; in curvature and in internal structure they agree with *D. planoconvexa.* As for internal structure, Drevermann's figures of *D. circularis* and the figures of *D. planoconvexa* in the present work might have been made from the same specimens.

Most of the specimens of Dalmanella of this general type from the Edmunds Hill locality we have identified with *D. planoconvexa* (Hall). The shells referred to Sowerby's species differ from *D. planoconvexa* in lacking the dorsal sinus and in having the radial lines nonfasciculate though strongly dichotomizing.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59714.

Genera SCENIDIUM Hall and MYSTROPHORA Kayser.

The genus Skenidium (now spelled Scenidium)[1] was founded by Hall[2] in the year 1860 to include orthoid shells having a wide hinge line with angular extremities, a high cardinal area in the convex pedicle valve, and a fairly well developed though lower area in the depressed brachial valve, and on the interior of the brachial valve a thick median septum. The septum extends in some forms the entire length of the valve and downward as far as the pedicle valve; in the umbonal region a spoonlike bowl on each side is formed by a ridge or septum curving round from near the base of the crura to the median septum. The structure is somewhat similar to the spondylium of the pentameroids but differs in several respects, chief among which is that in Scenidium the median septum is continued through this pseudospondylium to the tip of the beak, forming "spondylia" on each side of the median septum, whereas in the superficially similar Clitambonites and in all the true pentameroids the spondylium is simple and the septum when present extends only to the front edge of the simple spoon and not to the tip of the beak. In Scenidium there are also in the pedicle valve no such septal structures as are usually developed in the pentameroids. The genus Scenidium is rather well marked interiorly and of typical low, Cyrtina-like aspect on the exterior.

In 1871 Kayser,[3] apparently unaware of Hall's genus Scenidium, erected the genus Mystrophora for small low Cyrtina-like orthids with the same internal structure as Scenidium—a small median septum in the depressed brachial valve and a spoonlike bowl on each side in the umbonal region, with the cardinal process weakly developed. The type of Mystrophora was Quenstedt's *Orthis areola*, from the Eifelian, Middle Devonian, and Kayser included in his genus also *Orthis lewisi* Davidson,[4] from the Wenlock of Great Britain and Gotland.

Hall and Clarke[5] in 1892 regarded Mystrophora as a complete synonym of Scenidium. They noted not a single point of distinction between Mystrophora and Scenidium and since then Scenidium has been supposed to include Mystrophora. Winchell and Schuchert remove these shells altogether from the orthids and place them near Clitambonites in the group of Pentameraceæ, presumably because of the presence of the pseudospondylium and the superficial resemblance to Clitambonites, which is commonly regarded as pentamenerid.

The genus Mystrophora is not, however, identical with Scenidium, for whereas all the Ordovician and Silurian species of Scenidium have impunctate shells, *Orthis* (*Mystrophora*) *areola* is strongly punctate. Kayser[6] in his description of Quenstedt's species *O.* (*M.*) *areola* says: "Schalenstrucktur perforirt," and he figures the punctate shell structure. In Mystrophora the delthyrium is entirely open, not partly closed as in several species of Scenidium. The surface

[1] Oehlert, D. P., Soc. études sci. Angers Bull., 1887 (p. 4 of separate). Hall and Clarke, Paleontology of New York, pt. 1, p. 241, 1892. Winchell and Schuchert, Minnesota Geol. Survey, vol. 3, p. 381, 1893.
[2] New York State Cab. Nat. Hist. Thirteenth Ann. Rept., p. 70, figs. 1-5, 1860; type *Orthis insigne* Hall, Lower Helderberg.
[3] Kayser, Emanuel, Die Brachiopoden des mittel und ober Devon der Eifel: Deutsch. geol. Gesell. Zeitschr., 1871, p. 612, pl. 13, fig. 5.
[4] Davidson, Thomas, British Silurian Brachiopoda, p. 208, pl. 26, figs. 4-9, 1869.
[5] Op. cit.
[6] Op. cit., p. 612, middle of page, pl. 13, fig. 5i.

is finely or coarsely ribbed, with the riblets increasing by bifurcation or frequent implantation, as distinguished from the simple plications on the surface of typical Scenidium.

Mystrophora does not belong in the family Pentameridæ, for not only is its spondylium-like structure entirely distinct from that of the pentamerids, but the shell structure is punctate and the muscular scars are strongly impressed and occupy the bottom of the valve. Mystrophora and the closely allied but distinct genus Scenidium Hall should therefore be retained among the orthids, where they were originally placed by Hall, Davidson, Kayser, Oehlert, and Clarke.

In specimens of *Mystrophora elevata* from Maine the spoonlike bowls each side of the median septum are distinctly preserved in the internal mold, but they do not appear to be so well developed as in the typical forms of Scenidium and Mystrophora. The median septum, too, though well developed, thick, and deep, does not attain the extreme development observable in these genera. It is possible that more and better material may show less deviation from the typical Mystrophora, but our specimens, even as they are, may safely be referred to Kayser's genus. The shell structure is punctate. The species closely resembles Dalmanella, with which it was originally identified, and serves to show the very close relationship between Mystrophora and Dalmanella. *Scenidium devonicum* Walcott[1] from the Lower Devonian of Nevada is placed in the genus Dalmanella by Schuchert,[2] but should probably be included in Mystrophora. It is also probable that a closer study will tend to remove several other doubtful species now referred to the impunctate genus Scenidium and some cyrtinaform Dalmanellas into the punctate genus Mystrophora.

The name Mystrophorus was used by Forst in 1856 for a genus of Hymenoptera prior to Kayser's proposal of the name Mystrophora in 1871. This should not, however, invalidate Mystrophora.

Dalmanella (Mystrophora) elevata sp. nov.

Plate VI, figures 1, 2, 3, 6, 9; Plate VII, figures 12, 19, 23; Plate VIII, figures 17–23.

The pedicle valve is elongate, semielliptical, with a broad, straight hinge line, rather sharp cardinal extremities, and obtusely acuminate umbo. The valve is subcarinately gibbous. The greatest height is equal to one-third the length and is situated over the beak, from which the surface slopes to the front and lateral margins. The tip of the beak is hardly at all incurved. The cardinal area of the pedicle valve is very high, almost equal to the height of the valve. It is only slightly arching and is inclined at an angle of 60° to the plane of the margin. Delthyrium open; angle 45° or less. The musculature of the pedicle valve is pentagonal-cordate in outline. It extends forward to the middle of the shell, or slightly beyond, and is surrounded by a raised ridge or platform. It is divided into two elongately trigonal scars, which are not subdivided. Surface of the pedicle valve unknown, but marked, apparently, by rather coarse radial lines.

The brachial valves, which are regarded as belonging to this species, are quadrately subcircular. The hinge line is broad and straight and is about two-thirds the width of the shell. The posterior margin reclines from the beak at an angle of 145° to 150°. The cardinal extremities, if preserved, are sharp and obtusely angular. The proportion of length to width of the brachial valve varies from 6 : 7 to 7 : 9; the greatest width is at or slightly in front of the middle. The cardinal area extends the width of the hinge line, or about two-thirds the width of the shell, and is well developed, though less conspicuous than that of the opposite valve. The brachial valve as a whole is depressed convex; a specimen 13 millimeters long and 14.5 millimeters wide has a depth of 1.25 millimeters. The valve is marked by a distinct rounded sinus of undefined limits. On the interior of the brachial valve the thick crural bases extend in front of the deep dental sockets. A thick median septum reaches one-third the length of the valve and ends posteriorly in the cardinal process, which appears to have been simple and to have had an impressed line down its center. In front of the median septum there is on each side a large, circular, indistinctly bipartite adductor scar extending a trifle in advance of the

[1] Walcott, C. D., Paleontology of the Eureka district [Nevada]: U. S. Geol. Survey Mon. 8, 1884, p. 116, pl. 13, fig. 4.
[2] Schuchert, Charles, Synopsis of American fossil Brachiopoda: U. S. Geol. Survey Bull. 87, p. 200, 1897.

midlength of the valve. Behind this muscular scar there is on each side, in the internal mold, a troughlike depression curving around from the base of the crura to the median septum. This represented, in the original shell, a low, curving ridge which inclosed a spoonlike basin in the umbonal region on each side of the median septum, as in Scenidium and Mystrophora, but apparently not quite so well developed as in typical forms of those genera. The shell is coarsely punctate; the punctæ are closely crowded and do not appear to be arranged in any radial, concentric, quincunx, or other regular order.

The ornamentation on the brachial valve consists of very coarse, nonfasciculate, radial lines or riblets, which increase by bifurcation, rarely by implantation. These are crossed in the best-preserved specimens by concentric lines which are weakly developed on the crests of the radial lines, but which impart to the interspaces a strongly crenulate aspect. About 50 radial riblets or lines may be counted at the margin of an average specimen.

The distinguishing features of the species are the high cardinal area in both pedicle and brachial valves, the wide hinge line and subangular cardinal extremities, the coarse surface lines or riblets, the depressed convex brachial valve with broad undefined sinus, and, on the interior, a large spondylium with the median septum continuing through it and dividing it in two.

Locality: Edmunds Hill (locality 1099 C²), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59715.

Comparisons.—This species resembles *Scenidium devonicum* Walcott[1] in the outline and convexity of the pedicle valve, but that species is a minute form, much smaller than our species, and has coarser ornamentation. The wide, straight hinge line and elongate outline recall also *Orthis* (*Rhipidomella*) *eminens* Hall,[2] but that fossil has the musculature of Rhipidomella, and its pedicle valve is more depressed than in *Dalmanella elevata.*

Orthostrophia canadensis Clarke[3] bears a close resemblance to our *Dalmanella* (*Mystrophora*) *elevata*, but it has a much smaller musculature in both valves, and the fold or carination in the pedicle valve is much better developed than in the Chapman fossil.

Dalmanella penouile Clarke,[4] from the so-called Middle Devonian of the Gaspe basin, Quebec, has a wide posterior margin and high cardinal area, like the Chapman fossils under consideration, and the outline and ornamentation are approximately similar in the two, but the Gaspe form is described as having a short hinge line.

Order TELOTREMATA Beecher.

Family RHYNCHONELLIDÆ Gray.

Genus STENOSCISMA Conrad (CAMAROTŒCHIA of authors, in part).

The species *Stenoscisma formosa* Hall is the genotype of the genus Stenoscisma of Conrad, 1839,[5] and of Hall, 1867.[6] The discovery, in the Chapman specimens of the species, of dental plates in the pedicle valve, and of a forked or Y-shaped septum in the brachial valve, together with the absence of a cardinal process, shows that they are identical with the mass of Paleozoic rhynchonelloids referred by authors to the genus Camarotœchia Hall and Clarke.[7] The genotype of Camarotœchia, *C. congregata* (Conrad), displays crenulated or corrugated dental sockets, which are also observable in a few other species, chiefly from the Middle and Upper Devonian (*C. contracta* (Hall), *C. eximia* (Hall), *C. orbicularis* (Hall), *C. prolifica* (Hall), *Rhynchonella allegania* (Williams), etc.). This character has not yet been observed in the Maine speci-

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[1] Walcott, C. D., U. S. Geol. Survey Mon. 8, p. 116, pl. 13, fig. 4, 1884; Lower Devonian, Eureka district, Nev.

[2] See Schuchert, Charles, U. S. Geol. Survey Bull. 87, p. 348, 1897, for references to this species. It is described from the New Scotland limestone of the Helderberg group in New York and is reported from the Helderbergian Square Lake limestone of Square Lake, Maine, as well as from the limestone containing Becraft fossils at St. Helens Island, near Montreal, Canada.

[3] New York State Mus. Bull. 107, p. 285, figs., 1907. The species is described from the St. Albans beds of the Grand Cove and Cape Rosier Cove, Quebec, and reported from Square Lake, Maine.

[4] Idem, pp. 285-286, figs.

[5] New York Geol. Survey Third Ann. Rept., pp. 58, 59, 1839.

[6] Paleontology of New York, vol. 4, pp. 334, 335, 1867.

[7] Idem, vol. 8, pt. 2, p. 189, 1893.

mens of *Stenoscisma formosa*, nor indeed in the bulk of species referred to Camarotœchia. If it should really prove to be absent in Stenoscisma, then Camarotœchia may stand as a valid genus distinguishable from Stenoscisma in that it has the dental sockets crenulated.

Owing to the uncertainty previously attendant upon the use of the name Stenoscisma of Conrad, Schuchert[1] has proposed that Stenoscisma be abandoned altogether and has referred *S. formosa* to the genus Rhynchotrema Hall, 1860. In Rhynchotrema, however, there is a cardinal process present throughout life,[2] and the genus also lacks dental lamellæ. Nearly a dozen species known to belong to Rhynchotrema are exclusively Ordovician. I am therefore of the opinion that the generic name Stenoscisma is appropriately applied to the species described by Hall as its type species and here follow the usage proposed by Hall and Clarke in 1893.[3]

STENOSCISMA FORMOSA Hall.

Plate VI, figures 4, 5, 7, 10, 14, 21, 22, 25, 26.

1839. Stenoscisma="*Terebratula schlotheimii* (von Buch)." Conrad, New York Geol. Survey Third Ann. Rept., pp. 58–59. See Paleontology of New York, vol. 8, pt. 2, p. 187.
"Silurian:" New York.

1857. *Rhynchonella formosa*. Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 76, figs. 1–5.
Shaly limestone of the Lower Helderberg and in the Upper Pentamerus limestone: Albany and Schoharie counties, N. Y.

1859. *Rhynchonella formosa*. Hall, Paleontology of New York, vol. 3, p. 236, pl. 35, fig. 6.
Shaly limestone of the Lower Helderberg group, and in the Upper Pentamerus limestone: Helderberg Mountains, Schoharie, Hudson, Catskill, Carlisle, Cherry Valley, and other places in New York.

1867. *Stenoscisma formosa*. Hall, idem, vol. 4, p. 334.
Lower Helderberg: New York.

1874. *Rhynchonella dryope*. Billings, Paleozoic fossils, vol. 2, pt. 1, p. 37, pl. 3, figs. 1a–c.
Gaspe limestone No. 8: Grande Grevè, Gaspe Bay, Quebec.

1878. *Rhynchonella formosa*. Ashburner, Pennsylvania Second Geol. Survey Rept. F, p. 241.
Basal 50 feet of Lewistown limestone: Aughwick Valley, Huntingdon County, Pa.

1881. *Rhynchonella formosa*. Platt, Pennsylvania Second Geol. Survey Rept. I, p. 41.
Lower 50 feet of Lewistown limestone: Huntingdon County, Pa.

1883. *Rhynchonella dryope*. Ells, Canada Geol. Survey Rept. Progress for 1880–1882, p. 13DD.
Upper Gaspe limestones (Oriskany): Indian Cove, Grande Greve, and Little Gaspe, Gaspe Bay.

?1883. *Rhynchonella formosa*. White, Pennsylvania Second Geol. Survey Rept. G7, pp. 89, 98, 101, 261, 311, 313.
Bastard limestone: Mauser quarry, Montour Township, Columbia County, Pa.
Between Bastard and Stromatopora limestones: D. Derr's quarry, Limestone Ridge, Liberty Township, and A. F. Russell quarry, near Mahoning Creek, Valley Township, Montour County, Pa.
Stromatopora limestone: Quarry opposite Lime Ridge station, Columbia County, Pa.

1885. *Rhynchonella formosa*. White, Pennsylvania Second Geol. Survey Rept. T3, pp. 126, 172.
Bastard limestone: Lincoln Township.
Near base of Lewistown limestone: Aughwick Valley. Both localities in Huntingdon County, Pa.

1886. *Rhynchonella formosa*. Darton, Am. Jour. Sci., 3d ser., vol. 31, pp. 212, 214.
Lower Helderberg: Cornwall station, Orange County, N. Y.

not 1886. *Rhynchonella formosa*. Shaler, Am. Jour. Sci., 3d ser., vol. 32, p. 55.
Lower Helderberg siliceous limestone: Half a mile south of Balls Mills, Whiting Bay, Maine.

1890. *Rhynchonella formosa*. Deeks, Canadian Rec. Sci., vol. 4, No. 2, p. 108.
Lower Helderberg: St. Helens Island, Montreal.

1893. *Stenocisma formosa*. Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, p. 187, pl. 56, figs 41–45.
Lower Helderberg group: Albany County, N. Y.

1896. *Rhynchonella formosa*. Ami, Canada Geol. Survey Ann. Rept., new ser., vol. 7, p. 156J.
Lower Helderberg: St. Helens Island, Montreal.

?1897. *Rhynchotrema formosum*. Schuchert, U. S. Geol. Survey Bull. 87, p. 369.
Lower Helderberg: Schoharie and Albany counties, N. Y.; Lake Temiscouata, New Brunswick; Arisaig, Nova Scotia.

1899. *Stenochisma formosa*. Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), pp. 340, 351.
New Scotland shaly limestone: Countryman Hill and Oniskethau Creek sections, Albany County, N. Y.

1900. *Camarotœchia dryope*. Clarke, New York State Mus. Mem., vol. 3, no. 3, p. 41, pl. 5, figs. 20, 21.
Oriskany siliceous limestone: Becraft Mountain, Columbia County, N. Y.

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[1] Schuchert, Charles, Synopsis of American fossil Brachiopoda: U. S. Geol. Survey Bull. 87, p. 413, 1897.
[2] Winchell, N. H., and Schuchert, Charles, Geol. and Nat. Hist. Survey Minnesota, vol. 3, pt. 1 (Paleontology), p. 458, 1895.
[3] Hall, James, and Clarke, J. M., Paleontology of New York, vol. 8, pt. 2, p. 187, 1893.

1901. *Stenochisma formosa.* Prosser, New York State Geologist Eighteenth Ann. Rept. (for 1898), p. 61.
New Scotland shaly limestone: Knox, Albany County, N. Y.

?1903. *Rhynchonella (Rhynchotrema) formosa.* Schuchert, U. S. Nat. Mus. Proc., vol. 26, pp. 418–423.
Manlius shaly limestone: Baltimore & Ohio Railroad quarries, Kayser, Mineral County, W. Va.; Devils Backbone, near Cumberland, Md.

1903. *Rhynchotrema formosum.* Weller, Paleontology of New Jersey, vol. 3, pp. 92, 94, 95, 309, 328, pl. 36, figs. 5–12; pl. 42, figs. 5–8.
Becraft limestone: Near Nearpass quarry, N. J.
"Trilobite beds:" Near Nearpass quarry and three-fourths of a mile southwest of Wallpack Center, N. J.

1903. *Rhynchotrema formosum.* Van Ingen and Clark, New York State Mus. Bull. 69, pp. 1188, 1191, 1193.
Basal Coeymans limestone, upper New Scotland limestone, middle Becraft limestone: Becraft Mountain, Columbia County, N. Y.

?1903. *Rhynchotrema formosum.* Van Ingen and Clark, idem, p. 1203 (error for *Rhynchospira formosa?*).
Oriskany siliceous limestone: Glenerie, N. Y.

1905. *Camarotœchia dryope.* Clarke, New York State Mus. Bull. 80, p. 146.
Grande Greve limestone: North shore of Gaspe Bay, Quebec.

1905. *Stenochisma formosa.* Shimer, idem, pp. 185, 227, 245, 265.
Upper New Scotland and "Trilobite beds" (lower Oriskany): Trilobite Ridge, Orange County, N. Y.

1905. *Rhynchotrema formosum.* Williams and Kindle, U. S. Geol. Survey Bull. 244, p. 28.
"Oriskany" sandy and cherty beds: Southern Railway, near Bigstone Gap, Wise County, Va.

Biconvex, highly gibbous, subglobular rhynchonellids of medium size, with less than 24 coarse ribs. Pedicle valve ventricose, less so than the brachial; beak strongly incurved at nearly right angles to the plane of the margin. In longitudinal profile the shell is flat for two-thirds of the length of the front; surface elevated, abruptly deflected to the postero-lateral margins, less abruptly deflected in front. A mesial sinus is deeply depressed in front, flat at the bottom, but is obsolescent in the region over the musculature. The mesial profile of the sinus is evenly arcuate longitudinally. The musculature extends not quite half the length of the shell. It is elongate trigonal, strongly elevated in front, and surrounded by a border elevated above the interior surface of the valve. The adductor scars are oval or circular, sunken, rather small, and continued posteriorly into an elongate cicatrix (the pedicle muscular scar), which extends along the middle of the musculature to the posterior end. Small dental lamellæ are distinctly preserved in the better specimens. These lamellæ are short, bound the musculature posteriorly, diverge at an acute angle of about 55° to 70°, and in well-preserved internal molds leave a very thin, knifelike extension of the rock matrix projecting toward the beak. They are well developed in younger individuals but tend toward obsolescence at maturity. The delthyrial characters are obscure and uncertain. The delthyrium seems to have been an open fissure in the posterior margin with cardinal area entirely absent. The tip of the beak is invariably broken in the Maine specimens, but whether this indicates a circular pedicle opening at the apex or accidental fracture can not be definitely stated.

The brachial valve is broadly, rather uniformly, and very highly inflated, its depth being equal to half the length or more. There is a pronounced fold in front, where it is strongly raised above the general surface by the elevation of the outer slopes of the outermost ribs (on the fold). The anterior margin of the valve is insinuate in the region of the fold. On the interior of the brachial valve there is a distinct median septum which extends nearly a quarter the length of the shell. Its detailed features are not preserved, though it appears to fork posteriorly. The average size of the specimens is about 15 millimeters in length by about 15.5 millimeters in width.

The surface is covered by 16 to 22 strong rounded ribs, becoming subangular in front. Three or four ribs are in the sinus and four or five on the fold. They extend to the beak. Most specimens have only six ribs on each side of the fold and sinus and thus agree very well with the form of *Stenoscisma formosa* from Gaspe, called *Rhynchonella dryope* by Billings. This form occurs at Becraft Mountain, according to Clarke, and according to Weller, in the New Scotland-Becraft beds and in the *Dalmanites dentatus* zone of New Jersey. Billings's species was supposed to differ from *Stenoscisma formosa* in having slightly stronger ribs, but in the forms here discussed this character possesses little or no diagnostic value, for it is determined largely by conditions of preservation.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine. The recording of the form of the species known as *Stenoscisma dryope* (Billings) from the Oriskany of New York and Quebec suggests that the fossil may be also expected in the Moose River sandstone fauna of northern Maine.

U. S. National Museum, catalogue No. 59716.

Comparisons.—This species is referred by Schuchert to the genus Rhynchotrema and has therefore commonly come to be known among American geologists as *Rhynchotrema formosum.* In 1900, in discussing the evolution of the rhynchonelloids of the Maine Devonian, I suggested[1] then that this species probably could not belong to the genus Rhynchotrema. The genus Rhynchotrema (type species, *Rhynchonella capax*) includes the following species:

Rhynchonella (*Rhynchotrema*) *capax* (Conrad), Lorraine.
inæquivalve (Castelnau), Trenton.
laticostatum Winchell and Schuchert, Trenton.
ainsliei Winchell, Trenton.
ottawaense (Billings), Trenton.
perlamellosum Whitfield, Lorraine.
subtrigonalis Hall, Trenton.
dentatum Hall, Trenton and Lorraine.

None of the members of this group of species pass above the Ordovician in the geologic column, and the *Rhynchonella formosum* in the Helderberg is the only species referred to the genus above the Ordovician. As I said in 1900, "The genus is thus characteristically Ordovician in age, and the propriety of referring the Lower Helderberg species to the genus calls for careful examination." The impropriety of Rhynchotrema as a generic receptacle for *Stenoscisma formosa* has already been referred to in the discussion of Conrad's genus.

Stenoscisma formosa Hall (young).

Plate VI, figures 25, 26.

A small rhynchonelloid was found at Edmunds Hill in the same strata with the larger mature specimens of *Stenoscisma formosa* above described and is regarded as the young of that species. The specimen, which is only 6.8 millimeters long, 6.8 millimeters wide, and 3.1 millimeters thick, preserves important internal characteristics which are less clearly defined on the larger specimens.

Shell small, depressed, biconvex; outline trigonal, widest in front of the middle. Pedicle valve depressed convex, hardly appreciably less convex than the brachial valve; apex acuminate, subtending a right angle. A sinus is beginning to appear at the margin. This sinus is deeply excavated; its bottom is flat and marked by three plications. On each side there are five or six plications. The brachial valve is strongly convex, but hardly appreciably more elevated than the pedicle valve. The outline is rounded, and the length is 0.9 millimeter less than that of the pedicle valve. On the surface a strongly elevated fold is beginning to appear on the front margin, where there are four plications on the incipient fold and four or five more on each side. The plications are very strong and reach nearly to the apex. The specimen is an internal mold.

In the pedicle valve two prominent dental plates extend one-fifth the length. In the brachial valve a sharp median septum extends about half the length of the shell or a trifle less. Posteriorly the septum is forked, and each of the two divisions supports a crural process. The latter extend anteriorly and toward the pedicle valve and diverge only very slightly. There is no cardinal process.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

[1] Williams, H. S., and Gregory, H. E., Contributions to the geology of Maine: U. S. Geol. Survey Bull. 165, p. 58, 1900.

Genus RHYNCHONELLA De Waldheim, 1809.

(Rhynchonellidæ incertæ sedis.)

RHYNCHONELLA cf. R. MAINENSIS Billings.

Plate VI, figure 12.

cf. 1869. *Rhynchonella mainensis.* Billings, Portland Soc. Nat. Hist. Proc., vol. 1, pt. 2, p. 110, pl. 3, fig. 4.
Limestone of Square Lake [of Helderberg age]: Square Lake, Aroostook County, Maine.

cf. 1900. *Rhynchonella mainensis.* Billings, quoted in Williams and Gregory: U. S. Geol. Survey Bull. 165, p. 69, pls. 1, 2.
Limestone of Square Lake [of Helderberg age]: Square Lake, Aroostook County, Maine.

A few specimens of obscure rhynchonellids from the Chapman sandstone are referred with some hesitancy to Billings's species *R. mainensis*, from the Helderbergian Square Lake limestone of Maine. The brachial valve figured shows the presence of a very small, thin raised line representing the cardinal process. There is no trace of median septum and the dental sockets are minute and do not exhibit crenulations. The surface is marked by about 21 low, rounded plications, six or seven of which are slightly raised to form a fold. The resemblance to the variable form called *R. mainensis* by Billings is external, as little is known of the internal character of that species. The internal characters recall some features of the genus Pugnax and remove it from the genus Stenoscisma. The shells lack, however, the external expression usually associated with Pugnax and conform superficially with Stenoscisma.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59717.

Genus EATONIA Hall, 1857.

The term Eatonia may be applied to certain rhynchonellids of characteristic surface expression, distinguished primarily by having the anterolateral portions of the pedicle valve concave. The two valves are very unequal. The brachial valve is convex; the pedicle valve is depressed on the umbone, concave in front and near the middle; sinus and fold are present and generally prominent. The internal features are of doubtful constancy among the different species. The internal features are a median septum in the brachial valve (a constant feature) and a distinct cardinal process which is bifurcate and rests on the short median septum. In the pedicle valve there are no dental lamellæ except in *Rhynchonella palumbina* Barrande and *R.* (*Atrypa*) *magæra* Barrande, and the musculature is large and deeply impressed. The margin is denticulate internally.

The shells may be easily recognized by the marginal recurvature in the pedicle valve. The surface sculpture is very variable, but is chiefly of three or possibly four kinds, and serves to divide Eatonia into three groups, as follows:

Subdivisions of genus Eatonia.[1]

By C. L. BREGER.

A. Group of *Eatonia peculiaris* Conrad. Surface covered with fine threadlike striations.

1. *Eatonia peculiaris* Conrad (genotype). New Scotland limestone, of the Helderberg group, but chiefly in the Oriskany sandstone: New York, New Jersey, Pennsylvania, Maryland, Virginia, and equivalent beds in New Brunswick, Quebec, Maine, and Ontario.
2. *Eatonia singularis* Vanuxem. Helderberg group, horizon of the New Scotland limestone and higher: New York, New Jersey, and equivalent beds in Tennessee and Missouri.
3. *Eatonia pumila* Hall. Oriskany sandstone: New York and West Virginia.
4. *Eatonia peregrinus* Drevermann, Palaeontographica, 1902, p. 105, pl. 12, figs. 17–19. Lower Coblenzian graywacke: Oberstadtfeld, in the Eifel, Germany.

[1] For references to the literature and range of the American species, see Schuchert, Charles, Synopsis of American fossil Brachiopoda: U. S. Geol. Survey Bull. 87, 1897; Lower Devonic aspect of the Lower Helderberg and Oriskany formations: Geol .Soc. America Bull., vol. 11, pp. 241–332, 1900.

A[1]. Subgroup of *Eatonia thetis* (Barrande). Surface smooth, devoid of radial striations or ribs; resembles decorticated specimens of group A.

1. *Atrypa thetis* Barrande, Syst. silur. Bohême, pls. 86, 133. Étage F^2 (Konieprussian; Eo-Devonian); Konieprus, Bohemia. Also recorded from étages G^1, G^3 (Meso-Devonian), E^2 (Lower Ludlow-Aymestrian; Silurian), and E^1 (Wenlockian; Silurian).
2. *Atrypa harpya* Barrande, idem, pl. 88. Étage E^2 (Lower Ludlow-Aymestrian; Silurian): Dlaua-Hora, Bohemia.
3. *Atrypa magæra* Barrande, idem, pl. 86. Étage E^2 (Lower Ludlow-Aymestrian; Silurian): Dlaua-Hora and Hinter Kopanina, Bohemia.

B. Group of *Eatonia medialis* Vanuxem. Surface covered with broad plications.

1. *Eatonia medialis* Vanuxem. Coeymans limestone to Onondaga ("Corniferous") limestone, chiefly horizon of New Scotland limestone: Canada, New York, New Jersey, Pennsylvania, Maryland, and Maine.
2. *Eatonia eminens* Hall. New Scotland limestone, of the Helderberg group, and equivalent beds: New York and Tennessee.
3. *Eatonia whitfieldi* Hall. Oriskany sandstone: Maryland.
4. *Eatonia sinuata* Hall. Oriskany sandstone: Maryland.
5. *Rhynchonella eucharis* Barrande, Syst. silur. Bohême, pls. 26, 31.
6. *Rhynchonella palumbina* Barrande, idem, pl. 113.
7. *Rhynchonella velox* Barrande, idem, pl. 33.
8. *Rhynchonella prosperina* Barrande, idem, pl. 30.
9. *Rhynchonella corvina* Barrande, idem, pl. 29.
10. *Atrypa matercula* Barrande, idem, pls. 34, 113, 135.
11. *Atrypa alecto* Barrande, idem, pl. 34.
12. *Atrypa? disjuncta* Barrande, idem, pl. 35.
    Nos. 5–12 from étage F^2 (Konieprussian; Eo-Devonian): Koniepruss, Bohemia.
13. *Rhynchonella nympha* Barrande, idem, pls. 29, 93, 122. Same formation and locality; also recorded from étages E^2 to G^1, inclusive.
15. *Rhynchonella famula* Barrande, idem, pl. 35. Étage E^2: Bohemia.
14. *Rhynchonella minerva* Barrande, idem, pl. 32. Étage E^2 (Lower Ludlow-Aymestrian): Dlaua-Hora, Bohemia.
16. *Rhynchonella famula* var. *modica* Barrande, idem, pls. 35, 140. Étage E^2, Bohemia.
17. *Rhynchonella coronata* Kayser, Deutsch. geol. Gesell., 1871, p. 512, pl. 9, fig. 5. Crinoid beds of the Eifelian (Meso-Devonian): Prum, in the Eifel, Germany.

?18. *Rhynchonella gainesi* Nettelroth. Jeffersonville ("Corniferous") limestone and Sellersburg limestone (of Hamilton age): Kentucky and Indiana. This species seems to have a median septum and an Eatonia-like convexity. If the Konieprussian *Rhynchonella præcox* of Barrande (op. cit. pl. 29) possesses a septum, it too may be placed in this group. Both species resemble Pugnax superficially. In fact, a median septum is known to be developed in *Pugnax pugnus* from Ithaca, N. Y., and therefore it may be necessary to remove that species from Pugnax and place it elsewhere, perhaps in Eatonia.

?19. *Rhynchonella rudis* Hall. New Scotland limestone, of Helderberg group: New York.

20. *Rhynchonella planiconvexa* Hall. New Scotland limestone, of Helderberg group: New York.

C. Group of *Rhynchonella henrici* Barrande. Surface covered with a large number of narrow, low riblets, somewhat as in Wilsonia and Uncinulus.

1. *Eatonia coulteri* Miller and Gurley. Beds of Oriskany age: Illinois.
2. *Rhynchonella obsolescens* Barrande, op. cit., pl. 113. Étage F^2: Koniepruss, Bohemia.
3. *Rhynchonella henrici* Barrande, idem, pls. 25, 37, 130, 131. Étage F^2: Koniepruss and Mnienian, Bohemia. Taunusian and Lower Coblenzian: Germany and Belgium.
4. *Rhynchonella henrici* var. *vellerosa* Barrande, idem, pls. 130, 131.
5. *Rhynchonella henrici* var. *excavata* Barrande, idem.
6. *Rhynchonella henrici* var. *laminaris* Barrande, idem.
7. *Rhynchonella henrici* var. *excisa* Barrande, idem.
8. *Rhynchonella henrici* var. *extenuata* Barrande, idem.
    Nos. 4 to 8 from étage F^2, Koniepruss and Mnienian, Bohemia.

To group C may probably be added the following:

Eatonia eifeliensis Drevermann, op. cit. Lower Coblenzian: Eifel district, Germany.
Rhynchonella sanctamichaelis, Kayser, op. cit. Hauptquarzit: Germany.
Rhynchonella pila Schnur, Palaeontographica, vol. 3, 1853, pl. 26, fig. 1. Eifelian (Meso-Devonian): Germany.
Rhynchonella primipilaris Schlotheim; see Schnur, idem, fig. 3. Eifelian: Germany, Belgium, France, Great Britain.

The species named below, previously referred to Eatonia by authors, do not belong to the genus.

Eatonia variabilis Whiteaves, Contributions to Canadian Paleontology, vol. 1, p. 233, pl. 29, figs. 6–9. Late Meso-Devonian: Hay River, Canada.

Eatonia goodlandensis Kindle and Breger, Indiana Dept. Geol. and Nat. Res. Twenty-eighth Ann. Rept., 1904, p. 439, pl. 8, figs. 10–12. Eo-Silurian: Goodland, Ind. (A species of Mimulus.)

Atrypa assula Barrande is regarded by Schuchert[1] as a probable equivalent of *Eatonia peculiaris*. Neither Barrande's nor Whiteaves's species is rhynchonelloid.

Eatonia singularis (Vanuxem).

Plate VI, figures 8, 18.

1842. *Atrypa singularis*. Vanuxem, Geology of New York, Rept. third district, p. 120, fig. 3.
Catskill shaly limestone: Third district, New York.
1859. *Eatonia singularis*. Hall, Paleontology of New York, vol. 3, p. 243, pl. 38, figs. 14–20.
Shaly limestone of the Lower Helderberg group: Helderberg Mountains, Schoharie, Carlisle, Hudson, Catskill, and other places in New York.
1876. *Eatonia singularis*. Barrett, Lyceum Nat. Hist. New York City Annals, vol. 11, p. 295.
Delthyris shaly limestone: Bennett's quarry, Port Jervis, N. Y.
1882. *Eatonia singularia*. I. C. White, Pennsylvania Second Geol. Survey Rept. G6, p. 134.
Stormville limestone: Pike County, Pa.
1882. *Eatonia singularis*. Stevenson, Pennsylvania Second Geol. Survey Rept. I2, pp. 104, 134.
Basal Oriskany: Near Hyndman, Bedford County, Pa.
Lower Helderberg chert beds: Up Beaverdam Run road on Pine Ridge in King Township, Bedford County, Pa.
1889. *Eatonia singularis*. Lesley, Dictionary of fossils, Pennsylvania Second Geol. Survey Rept. P4, vol. 1, p. 213, figs.
Lower Helderberg chert beds: Perry County, Pa.
1893. *Eatonia singularis*. Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, p. 206, pl. 61, figs. 13–16.
Lower Helderberg group (shaly limestone): Albany County, N. Y.
1897. *Eatonia singularis*. Schuchert, U. S. Geol. Survey Bull. 87, p. 220.
Lower Helderberg: Schoharie, N. Y.
1900. *Eatonia singularis*. Schuchert, Geol. Soc. America Bull., vol. 11, p. 284.
Lower Helderberg: Maryland and Virginia; Tennessee; New York; Gaspe, Quebec; and Nova Scotia.
New Scotland beds: New York.
1901. *Eatonia singularis*. Prosser, New York State Geologist Eighteenth Ann. Rept., p. 58.
New Scotland shaly limestone: Altamont, N. Y.
1903. *Eatonia singularis*. Schuchert, U. S. Nat. Mus. Proc., vol. 26, p. 422.
New Scotland limestone: Twenty-first Bridge, Baltimore & Ohio Railroad, near Keyser, Mineral County, W. Va.
Lower New Scotland cherty limestone: Western Maryland.
1903. *Eatonia singularis*. Weller, New Jersey Geol. Survey, Paleontology, vol. 3, pp. 89, 311, pl. 36, figs. 24–27.
New Scotland cherty limestone and higher shaly beds: One-half mile below Hainesville, N. J.
1903. *Eatonia singularis*. Van Ingen and Clark, New York State Mus. Bull. 69, pp. 1203, 1207.
Oriskany (sandy and cherty beds): Glenerie, N. Y.
1905. *Eatonia singularis*. Shimer, New York State Mus. Bull. 80.
Lower New Scotland shales: Trilobite Mountain, N. Y. (pp. 222, 223, 224, 245, 264).
Port Ewen (arenaceous limestone): Trilobite Mountain, N. Y. (pp. 134, 234, 245, 264).

A single specimen from the Chapman sandstone of Edmunds Hill agrees in essential particulars with the typical forms of the species from New York. The specimen has both valves in conjunction and is partly exfoliated. Outline cordate; umbones broadly obtuse, margins evenly rounded, slightly insinuate in front; length less than the width, greatest width at anterior third. Length, 18 millimeters; width, 21 millimeters; depth, 12 millimeters. Pedicle valve depressed convex over the umbo; in the middle and anteriorly the surface is concave from the margin inward. A deep, broad sinus begins at or near the middle, becomes more and more prominent anteriorly, and produces on the front margin a lingual extension which is at nearly right angles with the plane of the margin. The sinus is deeply but not abruptly excavated; its margin is indefinite. On the interior of the pedicle valve the musculature is strongly pronounced; the cicatrix is deeply excavated in the shell posteriorly, while anteriorly it seems to be a little elevated; it is rather elongately oval in outline and extends about half the length. Dental and delthyrial structure not observed. The brachial valve is strongly convex, the greatest elevation of the general surface being at the anterior third. Posteriorly the surface declines toward the beak. A fold is feebly developed near the beak but near the middle becomes more pronounced and is very highly elevated near the front margin. In the present specimen the lateral margins are closed, but the shell is gaping in front between the

[1] Geol. Soc. America Bull., vol. 11, p. 264, 1900.

front edge of the fold and that of the sinus. This gaping may be due to fracture. On the interior of the brachial valve a broad septum was observed. Its detailed structure is not apparent. The surface is marked by fine, even radial lines, which are low, rounded, and closely set. There are four lines in the space of 1 millimeter. They cover both fold and sinus and in front of the sinus two of them become thickened. On the fold there is a sunken area near the front edge bounded by two riblets, one on each side. The ornamentation does not show very distinctly in the figures on Plate VI.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59718.

Comparisons.—*Eatonia singularis* differs from *E. peculiaris* in having the fold on the brachial valve extending to the umbo; in the latter it does not extend back of the middle. In the Maine specimen the fold extends apparently to the umbo, but is obsolescent posteriorly. The outline is broadly cordate, as in typical *E. singularis*, while in typical *E. peculiaris* the outline is more elongate and the shell is proportionally narrower, though this is not a persistent distinction.

Stratigraphic value of Eatonia.—The genus Eatonia in the North American faunas attains a profuse development in the Helderberg and Oriskany, both in species and in individuals, and in plasticity of each of the species. In Europe Eatonia attains its greatest development in species and individuals in beds referred by most authors to the Lower and Middle Devonian. The time range of the genus Eatonia is from late Silurian to Middle Devonian.

In the American faunas typical Eatonias were for a long time unknown above the Oriskany, but the genus is by no means rare in the "Corniferous" of Illinois.[1] This occurrence in Illinois is interesting in connection with the fact that from the beds of Oriskany age in Illinois there has been described *Eatonia coulteri* of Miller and Gurley, the only known North American equivalent of the European group of *E. henrici* (Barrande), which is widespread in the Taunusian and Lower Coblenzian. This occurrence of European types in the Mississippi Valley in the Lower Devonian and their absence in New York recall a similar contrast shown by the Middle and Upper Devonian faunas of Manitoba, where *Stringocephalus burtuni* and other species occur, respectively, with their European associates, these species being either unknown or very rare in New York and other parts of eastern America.

The extension of Eatonia stratigraphically downward into the typical Silurian is shown in the Moydart formation of Arisaig, Nova Scotia,[2] and in the Silurian of the Baltic Province, on the island of Gotland, where two species are reported by Lindström.[3]

In regard to the stratigraphic position of the Konieprus group, or étage F^2 of the Bohemian series, in which Eatonia is prominent, much has been written, particularly concerning its relation to the Helderberg of North America. Schuchert has suggested the "similarity" of many species of the Konieprussian with American Helderbergian fossils. The Konieprus beds are now generally correlated with the Lower Devonian of Europe and North America. The fact that the étage F^2 of Barrande is not homogeneous has been recognized by many geologists, but seems to have been passed over with no further attention. The upper part of the Konieprus group contains many brachiopods and other fossils along with goniatites, which give to it the aspect of a fauna near the American Onondaga ("Corniferous") or even the Marcellus. Étage F^1, the Tentaculite limestone, with the dominant *Spirifer inchoans* Barrande, underlies the Konieprus group. Its fauna resembles that of the American Manlius ("Tentaculite") limestone with *Spirifer vanuxemi* Hall. The Konieprus limestones of étage F^2 are known to bridge several time, stratigraphic, and faunal gaps, including several successive coral-reef horizons, and it is becoming apparent that some of the fossils formerly supposed to represent approximately the same horizon may belong to several different successive faunas, which in the American succession range from the Helderberg through part, at least, of the Onondaga or "Corniferous" and

[1] Weller, Stuart, Jour. Geology, vol. 5, p. 627, 1897.
[2] Am. Jour. Sci., 4th ser., vol. 28, p. 162, 1909.
[3] Lindström, G., Ueber die Schichtenfolge der Silur auf der Insel Gotland: Neues Jahrb., 1888, vol. 1, pp. 147-164.

possibly to the Marcellus. Bohemian species of étage F^2 and closely related species which have been recognized in Europe outside of Bohemia occur chiefly in the Lower Coblenzian and the Taunusian.

Genus BEACHIA Hall and Clarke, 1893.

BEACHIA CHAPMANI sp. nov.

Plate XXV, figure 27.

A large specimen of a brachial valve of a distinctly rensselaeroid type is referred to the genus Beachia, chiefly because of its close resemblance in outer form to full-grown specimens of *Beachia suessana,* although it is evidently distinct from that species. The form is elongate ovoid, widest behind, with a broad, nearly straight posterior margin. The specimen is 40 millimeters long, 37 millimeters wide (the greatest width is at two-fifths the distance from beak to front), and 5 millimeters high (at one-fourth the distance from beak to front). The shell is broad shouldered, the lateral margins converging, convex throughout, and marked by fine radial lines which extend nearly to the beak on the sculpture cast.[1]

This shell has the outline and convexity of *Beachia suessana,* but the radial surface lines are finer and more persistent than in that species. The specimen is also larger than typical specimens of *Beachia amplexa* Clarke and *Megalanteris thunii* Clarke, from Grande Greve and Perce Rock; in the large size it is particularly comparable with the latter species. The Chapman specimen, however, has finer radial surface markings and the mid part of the shell is more strongly produced anteriorly. The difference between the genera Beachia Hall and Megalanteris Oehlert is based on details of the structure of the brachidium,[2] and although specific differences may be defined, it is difficult to determine, in the absence of the evidence of internal characters, to which of these two genera particular specimens may properly be assigned. Clarke emphasizes these difficulties in discussing his species *Beachia amplexa* in the monograph on the early Devonian history of New York and eastern North America.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59719.

Genus MEGALANTERIS Oehlert, 1887.

MEGALANTERIS? sp.

Plate VI, figure 15; Plate VII, figure 15.

Two small, smooth pedicle valves of slight convexity and very obtuse umbones express in their outline and surface curvature a general likeness to the form of *Megalanteris ovalis.* Outline rounded, oval, or suboval; slightly wider than long. Posterior margin subtending an angle of 145° or more, abruptly inflected to the hinge, producing a narrow pseudo-area; greatest width near the middle or somewhat posterior. Outline compares closely with *Megalanteris ovalis.* Shells convex, not inflated; greatest elevation at posterior third or fourth equals one-sixth to one-seventh the length. On the interior two short, nearly parallel dental lamellæ; musculature not impressed in the valve; vascular markings radial, not flexuous, nor evidently branching, apparent in front of the region where the musculature is presumed to be. The internal molds are entirely devoid of traces of surface ornamentation, but the specimens indicate a smooth shell of the Cryptonella-Meristella surface expression. The present specimens differ from the Meristellas in having the umbone very obtuse, in their depressed convexity, in their absence of fold or sinus, and in their lack of any impressions of the musculature on internal molds.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59720.

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[1] The term "sculpture cast" is used to designate an internal mold which shows surface markings. Sculpture casts, showing characters of both the interior and the exterior of the shell are produced when the shell is dissolved out in the rock, leaving at first two distinct impressions, the internal mold and the external mold; by the tectonic compression of the rock these two impressions are squeezed against and modify each other.

[2] New York State Mus. Mem. 9, p. 166, 1908.

Genus **RENSSELAERIA** Hall, 1859.

Rensselaeria mainensis Williams.

Plate VI, figure 11; Plate XI, figures 1–15.

1900. *Rensselaeria mainensis.* Williams, U. S. Geol. Survey Bull. 165, pp. 79, 80.
Chapman sandstone (Eo-Devonian): Presque Isle Stream, Edmunds Hill, and Mars Hill (localities 1099 A, B, C), Chapman, Aroostook County, Maine.
1907 (April). *Rensselaeria mainensis.* Williams, U. S. Nat. Mus. Proc., vol. 32, pp. 267–269, 2 figs.
Chapman sandstone (Eo-Devonian): Presque Isle Stream, etc., Maine.
1907 (May). *Rensselaeria atlantica.* Clarke, New York State Mus. Bull. 107, pp. 243–247, figs.
Presque Isle Stream and Edmunds Hill, Chapman, Aroostook County, Maine.

Shells rensselaeroid, of medium to large size; biconvex, the pedicle valve more convex than the brachial; surface multicostate; beak elevated in the pedicle valve, showing the well-developed cardinal area. Pedicle valve elongate ovate; greatest width at the shoulders, posterior to the middle. Length a trifle greater than the width, generally in the proportion 9 : 8 but varying from 12 : 11 to 6 : 5, except in some specimens, probably fractured and incomplete in front, in which the width is a little greater than the length. The beak is pointed, strongly incurved, and elevated but not curving over nor appressed against the brachial valve. The posterior margin is obtusely angular, inclosing an angle of 115° to 140°. The posterior edge of the shell extends in a straight line from the beak for some distance till it curves into the broad, rounded shoulders. The lateral margins are curved near the shoulders and are subparallel, so that the greatest width of the shell is indefinitely posterior to the middle—in some specimens just back of the middle, in others one-fourth the distance from beak to front. Below the shoulders the lateral margins converge more or less rapidly and merge into the front margin, which is strongly curved parabolically and not demarcable from the lateral margins.

The pedicle valve is gibbous throughout. The longitudinal profile is unsymmetrical; the maximum height is from one-fifth to nearly two-fifths the length from the beak and is equal to about one-third the length of the shell.

The umbo is tumid and the beak strongly incurved. From the umbo the surface slopes down to the sides rather flatly, giving the shell a subcarinate appearance in transverse section. In front the slope is more rounded.

A large pedicle valve has a length of more than 40 millimeters (length in this shell is measured in a straight line from the tip of the beak to the front of the margin), but the common length at Presque Isle Stream, where the species is most abundant and varied, is from 24 to 32 millimeters. The smallest specimen seen had a length of 10 millimeters. The width similarly varies from 9 to 43 millimeters; the typical specimens have a width of 26 to 31 millimeters.

The cardinal area is, for a rensselaeroid, unusually well developed. It is triangular, large, and extends very nearly the whole width of the shell, producing a wide, straight hinge line, the height of which is one-sixth to one-third as great as the width. The general plane of the cardinal area is at an angle of approximately 180° to the plane of the margin; rarely a few degrees more, more commonly a few degrees less. The area is, however, rarely plane but is more commonly curved or arched, especially just under the beak, and is strongly striate horizontally. The delthyrium is large and triangular, the sides including an angle of about 60° or, rarely, a little more, with sides commonly slightly curved, the convex sides of the curves facing each other. The delthyrium is open, as can be seen in a couple of specimens at hand and as is further indicated by the fact that the sand filling of the internal mold is always continuous through the delthyrium with the external rock matrix, which it could not have been if any deltidium intervened between the interior of the shell and the exterior. No true deltidial plates have been observed, but structures simulating them seem to be produced by the protrusion outward through the delthyrium of the callous deposition, in the senile stage, of shelly matter on the interior.

The pedicle valve is extraordinarily thickened on the interior by a ponderous deposit of prismatic calcareous material in the region of the umbones. The prisms are well developed and normal to the surface. In the larger shells, about 35 millimeters long, this deposit is 6 millimeters in thickness. In most specimens of adult size, also, the umbonal portion of the shell is greatly thickened, particularly in the umbonal lateral slopes, but to a less degree than in the large adult shell. On the interior of the larger pedicle valves there was apparently no cavity in front of the cardinal area; all this space appears to have been filled to the hinge line by calcareous shell substance, so that internal molds and sculpture casts do not show any indication of cardinal area. The front of the shell is rather thin and is marked by pronounced radial plications. Dental lamellæ support the teeth. These lamellæ are parallel and very short, reaching only to the posterior margin of the diductor scar. They are fairly prominent and sharply elevated in shells in which there is little shelly deposition about the umbo; but in the larger, greatly thickened shells the cavity on the outer side of the dental lamellæ is entirely filled in, so that the lamellæ hardly project above the base of the shell and, in internal molds, do not leave the characteristic incision. In such clean internal molds of thickened pedicle valves traces of the dental lamellæ may be seen as curved blunt incisions surrounding the pedicle and visceral (?) cavity back of the muscular scars. In these old shells, also, the muscular scars and pedicle cavity occupied deep excavations, showing, in internal molds, as prominently elevated tracts, the lateral boundaries of which are the inside edges of the old dental lamellæ. The muscular scars are distinct in the pedicle valves of shells where there has been no thickening deposition; in the larger and thicker shells they are very prominent and give a characteristic appearance to the fossil. The diductor cicatrix is elongate, about twice as long as wide, and extends nearly to the middle of the valve—that is, to the mid length along the periphery, not in a straight line from the front margin to the tip of the beak. The sides are distinct and in unthickened shells are marked by a faint elevated line which is the continuation of the dental lamellæ. In the thickened shells the musculature is very deeply excavated and produces, in internal molds, an elongate, elevated tonguelike ridge. Anteriorly the muscular scars become obsolescent. The adductor scar is rarely discernible but is very elongate, spindle shaped, and not divided. It begins in front of a narrow spearhead-like median ridge which divides the posterior portion of the diductor scar in two. Posteriorly, the diductor scar ends about halfway between its front margin and the tip of the beak; and the umbonal portion of the shell is marked by a deep trihedral pedicle cavity. This large pedicle cavity is bounded on the side by the dental lamellæ; as has been indicated, the dental lamellæ end above and do not reach the diductor scar.

The brachial valve is convex throughout, including the shoulders, but less convex than the pedicle valve. In outline it is rounded trigonal to subcircular; the width is equal to or slightly greater than the length, greatest width posterior. Hinge line straight; posterior margin varies from nearly horizontal to very obtusely angular and curves into the broad, rounded shoulders; lateral and front margins curved into a semicircle. The longitudinal profile is an unsymmetrical curve deepest at one-third the distance from the hinge and in uncrushed specimens equal to two-ninths to one-third the length of the valve. The umbonal portion is tumid and includes about a quarter of a circle. The slope for the anterior two-thirds is low convex. The transverse profile is rounded or slightly subcarinate.

The dimensions, in millimeters, of some of the specimens are as follows:

Length..	27	21.5	29	24	23	26	24
Width..	27.5	26	29	27.5	25	28.5	29

The dental sockets are obscure. The crural bases are narrow and cylindrical and rest on and merge into the cardinal process. The cardinal process is massive and has a convexly rounded, broad, platform-like surface for attachment of the diductor muscles. This attaching surface is obscurely bilobed, though there is commonly no sharp distinction of divisions. Beneath this bilobed cardinal process, and forming a base for it, are two broad calluses separated by a strong median groove, which is continued as a tubular tunnel under the cardinal process. It is probable also that the two calluses may have been connected and united above by a platform-like bridge, forming an undivided hinge platform under the median portion of which extended the visceral canal or tunnel. This tunnel is preserved in a few internal molds as a sandy connecting dissepiment extending from a point behind the muscular scars to the tip of the beak; underneath (in molds) is a broad, deep cavity left by the dissolving away of the calluses and massive cardinal process. This sandy dissepiment is marked by a groove indicating a continuation of the dorsal median septum. The hinge platform consists, therefore, of two thick, broad calluses supporting a massive cardinal process which is indistinctly bilobed. Between the calluses there is a deep groove which extends as a tunnel under the cardinal process and which may possibly be canopied by a platform uniting the two calluses.

The musculature of the brachial valve is characteristic. The two adductors are distinct and in older shells become conspicuous. They are elongate-oval or subreniform, extend from the base of the calluses to about the middle of the shell, and together inclose a subcircular area. Posteriorly the two adductors are broadly separated by a strong ridge which in good specimens is seen to be tripartite. This ridge, which is an elevated continuation of the visceral canal between the calluses, is about one-fourth or one-third the width of the musculature, but does not extend more than half its length. The median division of this ridge is an elevated, very fine, sharp line (a thin median septum) and is continued into the visceral canal to the tip of the beak. In some well-preserved specimens the median line or septum extends three-fifths the length of the shell; in other specimens it ends near the middle of the musculature and in front of the middle the two adductor scars are separated by a sharp impressed groove instead of by the elevated line. The posterior margin of the adductors is conspicuous by the abrupt beginning of the calluses of the hinge plate. The scars are here broadly separated by the thick median ridge. Anteriorly the margin of the musculature is obscure and the scars closely approach each other. In most well-preserved old specimens the scars are distinctly wrinkled transversely, and in two specimens about 16 strong transverse wrinkles were present.

The shell structure is strongly fibrous, the fibers extending forward from the outer surface to the inner at a very oblique angle. In the thickened umbone of the pedicle valve the fibers are sometimes nearly normal to the surface and are segregated into coarse prisms, which are transversely striate. No punctæ have been observed under a hand glass magnifying more than 4 diameters, and if they exist at all in these early terebratulid shells they must be extremely minute. The shells may be recognized by their multicostate ornamentation. The ribs in mature specimens vary from 48 to 75 in number, but are most commonly between 60 and 65. On the surface they are well rounded, separated by narrower furrows and very prominent from beak to front. On internal molds the impressions of the ribs are well preserved forward and laterally but obsolescent in the muscular areas and posterior third of the shells; on these internal molds the ribs are strongly elevated and rounded, and the interspaces are a little wider than on the surface. The ribs are generally simple, but in a few specimens they increase by bifurcation. No indication of concentric lines has been observed and only occasional varices of growth. In very young shells, from 6 to 10 millimeters in length, the number of ribs is between 19 and 34, and the ribs are as strongly marked, relatively, as in adults. The number of ribs increases to the larger number present in older shells chiefly by the addition of new costæ on the lateral margins, rarely by bifurcation of one or two ribs.

Locality: Chapman sandstone at Edmunds Hill, Presque Isle Stream, and 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59721 to 59726.

Comparisons.—The species may be distinguished from the common American Rensselaerias by its strong plications, cardinal area, elevated beak, and open delthyrium. Among American species *Lissopleura equivalvis*,[1] from the Helderberg group (Coeymans and New Scotland limestones) of New York, is superficially very similar. That species, however, has an acute umbone; its greatest width is in front of the middle; its brachial median septum is much stronger; it has strong, fine concentric markings; its radial ribs are flatter topped; and it never attains the size of mature specimens of *Rensselaeria mainensis*. Internally the shells are quite different. Some

[1] *Rhynchonella equivalvis* Hall, 1857; see Paleontology of New York, vol. 3, p. 224, pl. 29, figs. 2–3, 1859. Also *Lissopleura equivalvis* Whitfield, Am. Mus. Nat. Hist., Bull., vol. 8, p. 232, figs. 1-5, 1896.

rather small specimens of exteriors of the Maine species might be mistaken for *Lissopleura equivalvis*, but the two species are distinct internally. Very small specimens of *R. mainensis* might also be mistaken for *R. mutabilis*, for they have the same outline and the same number of ribs, but the ribs in the Maine Rensselaeria are much stronger than in *R. mutabilis* and the longitudinal profile is different.

Among European shells *Terebratula strigiceps* Roemer (=*Rensselaeria stringiceps* auct.), from the Lower Devonian, presents the nearest approach in superficial character to *R. mainensis.* It seems, however, that this name has been given by different writers to very different shells. The English shell, so called by Davidson,[1] resembles a pentamerid of the Conchidium group, and the Upper Devonian species from Asia identified by Huddleston [2] with Roemer's species, is an entirely distinct shell of uncertain affinities.

The Maine species may be distinguished from the typical German form of *R. stringiceps* [3] by the elevated beak, exposing the characteristic cardinal area, the weaker septum in the brachial valve, the broader, less elongate outline with the greatest width posteriorly, and the larger number of ribs (40–44 in the European fossil). *R. stringiceps* is regarded by Schuchert [4] as a pentamerid.

Rensselaeria mainensis also resembles *Megalanteris* ("*Beachia*") *ovalis* in internal feature, although exteriorly the two are decidedly distinct. There is a remarkable identity in the character of the muscular imprint and the hinge plate. Internal molds of *R. mainensis* show at the beak of the brachial valve two widely separated deep circular holes (imprints of the crural bases) and the massive cardinal process extending up into the pedicle valve musculature, almost exactly as in specimens of *Megalanteris ovalis*. The musculature is also very similar in size, outline, markings, strength of impression, and septal characters, and the calluses and hinge plate are also similar. Although the brachidium is unknown, the present shell may be safely regarded as terebratulid, but whether it has the simple Centronella-Rensselaeria loop of "Beachia" or the more complex loop supposed to characterize Megalanteris can not be stated.

It is a remarkable fact that though truly terebratulid shells are almost without exception punctate—sometimes so strongly so that the punctæ are almost visible to the naked eye, as in Cryptonella—no indications of punctæ have been observed in the present shells under a strong hand magnifying glass. *Scaphiocœlia boliviensis* Whitfield, a large plicated shell with some affinities to *R. mainensis* but with concave brachial valve, is likewise strongly fibrous, no punctæ having been observed under a hand magnifying glass. The same is true of the Helderberg *Lissopleura equivalvis* and *Rensselaeria mutabilis.* It is possible that punctæ may exist in these shells, but if so they are extremely minute. Among the more recent Terebratulidæ the coarsest punctæ are one four-hundredth of an inch in diameter (in the Cretaceous *Megerlia lima*) and the finest are one two-thousandth of an inch in diameter (*Terebratula bullata*, Jurassic).[5] Punctæ of the latter size, especially if scattered, would not, it is believed, be visible under the ordinary hand magnifying glass. That some of the early plicate terebratulids were punctate is certain, for punctæ have been observed by Oehlert in his Eo-Devonian *Centronella bergeroni*,[6] and *Rensselaeria ovoides* from the Oriskany is also punctate. Hall and Clarke regard the entire genus Rensselaeria as punctate.

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[1] *Rensselaeria stringiceps* var.? Davidson, British Devonian Brachiopoda, p. 10, pl. 4, figs. 5, 6, 7, 1864; Middle (?) Devonian, Hagginton Hall near Ilfracombe, England.

[2] McMahon, C. A., and Huddleston, W. H., Fossils from the Hindu Khoosh, pt. 2, Paleontology: Geol. Mag., decade 4, vol. 9, No. 2, p. 56, pl. 3, fig. 9, 1902.

[3] Kayser, Emanuel, Lehrbuch der geologischen Formationskunde, p. 100, fig. 3, 1891. This is the usual figure of this species appearing in the text books. The Sandbergers, in their work on the fossils of the Rhenish series in Nassau, figure the internal molds (pl. 33, figs. 14, 14a). Their figure 14a agrees well with *Rensselaeria mainensis*, but their figure 14 shows the distinctness of the German species.

[4] Geol. Soc. America Bull., vol. 11, p. 258, 1900. More recently (in his paper on the Brazilian Devonian, Jour. Geology, vol. 14, pp. 722–746, 1906) Schuchert remarks of *Rensselaeria* (?) *crassicosta:* "These shells look more like *Plethorhyncha speciosa.*"

[5] Carpenter, William, On the ultimate structure of the shells of Brachiopoda, in Davidson, Thomas, British fossil Brachiopoda, Introduction, p. 28, pls. 5, 6, etc., 1853.

[6] Soc. Études sci. d'Angers Bull., separate, p. 1, fig. 9, 1885.

Family TEREBRATULIDÆ Gray.

Subfamily TEREBRATULINÆ Dall.

Genus EUNELLA Hall and Clarke.

EUNELLA ELLSI (Clarke).

Plate VI, figure 23.

1907. *Cryptonella* (?) *ellsi*. Clarke, New York State Mus. Bull. 107, p. 237, figs.
Lower Devonic: Grande Greve, Quebec.

The specimen shows a narrow umbonal region, the posterior margins diverging from the beak at an angle slightly less than 60°, continuing thus for about four-sevenths the length of the shell, then curving rather abruptly into the anterior margin, which includes a semicircular arc of 180°. The greatest width of the shell is anterior, between three-fifths and two-thirds the length of the beak. The length is 20.5 millimeters; width 14 millimeters. The longitudinal and transverse profiles are symmetrically arcuate; the greatest depth of the valve, 4.3 millimeters (in internal mold), is over the center. The surface is evenly rounded. The beak is very slightly recurved, marked by a fairly large circular foramen arching over a small delthyrium. As seen in longitudinal profile, the lateral margin of the valve is rather strongly sigmoidal.

The solitary internal mold of the pedicle valve figured from Edmunds Hill represents a shell of the common smooth Terebratula or Meristella expression, which was originally placed in Meristella. It is probably not a Meristella, for there is no medial insinuation of the outline nor, more important still, are there any recognizable muscular impressions or pronounced dental lamellæ, such as occur in Meristella and its spire-bearing allies. The absence of muscular impressions can not be due to imperfect preservation, for the mold is clearly and perfectly preserved, showing radiating vascular markings and the impression of what was a low, short, narrow median ridge or crest under the beak. The dental lamellæ are very weakly developed, being hardly discernible, are subparallel to the posterior margin, and do not appear to have been extended over the base of the valve.

The features preserved indicate a terebratulid having a narrow, elongate, triangular-ovate outline, with acute posterior margin (60° or less), somewhat like the Onondaga ("Corniferous") *Eunella sullivanti* Hall.[1] The Chapman fossil differs from *Eunella sullivanti* in having a completely rounded, semicircular front margin, lacking the anterior truncation of Hall's Onondaga species. It also somewhat resembles *Centronella glansfagea*,[2] a species hitherto regarded as diagnostic of the Onondaga ("Corniferous"), which occurs in the coarse Oriskany sandstone at Union Springs, Cayuga County, N. Y. Compared with *C. glansfagea*, the Chapman shell is more acute, having an umbonal angle of less than 60°, and the circular foramen was apparently larger. In these features *Eunella ellsi* approaches *E. sullivanti*, but the well-developed sinus or flattening in the front margin of *E. sullivanti* is not developed in the Chapman species.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Plantation, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59726.

Superfamily SPIRIFERACEA Waagen.

Family SPIRIFERIDÆ King.

Genus CYRTINA Davidson, 1858.

CYRTINA ROSTRATA (Hall).

Plate V, figure 14.

1841. *Spirifer cuspidata*. Phillips,[3] Paleozoic fossils of Cornwall, Devon, etc., p. 72, pl. 29, fig. 124 B.
Middle Devonian: Barton, South Devon.

1857. *Cyrtia rostrata*. Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 64.
Oriskany sandstone: Cumberland, Md.

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[1] See Hall, James, and Clarke, J. M., Paleontology of New York, vol. 8, pt. 2, pl. 80, fig. 25, 1893.
[2] Idem, pl. 79, fig. 3.
[3] Erroneously identified with the Carboniferous *Spirifer* (*Syringothyris*) *cuspidatus* Sowerby.

1859. *Cyrtia rostrata.* Hall, Paleontology of New York, vol. 3, p. 429, pl. 96, figs. 1–6; pl. 98, fig. 8.
Oriskany sandstone: Albany County, N. Y.; Cumberland, Md.
1861. *Cyrtina rostrata.* Billings, Canadian Jour., vol. 6, p. 263.
Corniferous limestone: Lot 45, Cayuga, Ontario.
1863. Cyrtia like *C. rostrata.* Billings and Logan, Geology of Canada, p. 428.
Corniferous limestone: Famine River, Quebec.
1864. *Cyrtina heteroclita* var. *multicostata.* Davidson, British fossil Brachiopoda (Devonian), vol. 3, pt. 6, p. 49, pl. 9, figs. 11–14.
Devonian: Barton and Lummaton, near Torquay, Devonshire.
1876. *Cyrtina rostrata.* Barrett, Lyceum Nat. Hist. New York City Annals, vol. 11, p. 296.
"Trilobite beds": Bennett's quarry, Port Jervis, N. Y.
1877. *Cyrtia rostrata.* Barrett, Am. Jour. Sci., 3d ser., vol. 13, p. 387.
Trilobite beds: Bennett's quarry, Port Jervis, N. Y.
1882. *Cyrtina heteroclita* var. *multiplicata.* Barrois, Soc. géol. Nord Mém., vol. 2, p. 260, pl. 10, figs. 8 c d.
Moniello limestone (*Calceola sandalina* beds): Luanco, Asturias, Spain.
Candas limestone (with *Spirifer disjunctus*): Candas, Asturias, Spain.
1885. *Cyrtina demarlii* (not Bouchard). Maurer, Grossherzogl. hess. geol. Landesanstalt Darmstadt Abh., vol. 1, Heft 2, p. 164, pl. 7, fig. 6.
Lower Devonian limestone: Waldgirmes, near Giessen, Germany.
1887. *Cyrtina demarlii* (not Bouchard). Tschernyschew, Com. géol. (Russe) Mém., vol. 3, No. 3, p. 80, pl. 9, fig. 1.
Middle or Upper Devonian: Wolchow, western Urals, European Russia.
1889. *Cyrtina rostrata.* Schuchert, New York State Geologist Eighth Ann. Rept., p. 53.
Oriskany: Cumberland, Md.; New York; Cayuga, Canada West.
1892. *Cyrtina rostrata.* Clarke, Am. Jour. Sci., 3d ser., vol. 44, p. 414.
Oriskany siliceous limestone: Becraft Mountain, Columbia County, N. Y.
1893. *Cyrtina heteroclita* var. *multiplicata.* Whidborne, Devonian fauna of the south of England, vol. 2, pt. 3, p. 112, pl. 12, figs 13–13a.
Cuboides zone: Lummaton and Woolborough, Devonshire, England.
1895. *Cyrtina rostrata.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pl. 25, figs. 1–8; pl. 28, fig. 6.
Oriskany sandstone: Albany County, N. Y.; Cumberland, Md.
1897. *Cyrtina rostrata.* Schuchert, U. S. Geol. Survey Bull. 87, p. 199.
Oriskany and Corniferous: Albany County, N. Y.; Cumberland, Md.; Cayuga, Ontario.
1900. *Cyrtina rostrata.* Schuchert, Geol. Soc. America Bull., vol. 11, pp. 304, 306, 308, 314, 324.
"Trilobite beds": Trilobite Ridge, Port Jervis, N. Y.
Oriskany: Becraft Mountain, N. Y.; Oneida and North Cayuga townships, Canada West; Cumberland, Md.
1900. *Cyrtina varia.* Clarke, New York State Mus. Mem., vol. 3, No. 3, p. 49 (pars), pl. 6, figs. 15–22.
Oriskany siliceous limestone: Becraft Mountain, Columbia County, N. Y.
1903. *Cyrtina rostrata.* Schuchert, U. S. Nat. Mus. Proc., vol. 26, p. 422.
Becraft limestone: Cherry Run, W. Va.
1903. *Cyrtina rostrata.* Weller, Paleontology of New Jersey, vol. 3, pp. 94, 95, 330, pl. 45, figs. 19–22.
Dalmanites dentatus (or lowest) zone of Oriskany ("Trilobite beds"): Trilobite Ridge, Nearpass section; and Wallpack Ridge at Peters Valley, N. J.
1903. *Cyrtina varia.* Weller, idem, pp. 98, 99, 100, 355, pl. 48, figs. 13–16.
Orbiculoidea jervensis (or middle) zone of Oriskany: Second wagon road across Wallpack Ridge, about 5 miles from New York State line.
Spirifer murchisoni (or upper) zone of Oriskany: Werden farm, Nearpass section; and from three-fourths of a mile west of Layton, N. J.
1903. *Cyrtina rostrata.* Van Ingen and Clarke, New York State Mus. Bull. 69, pp. 1203, 1207.
Oriskany siliceous limestone: Glenerie, N. Y.
1905. *Cyrtina rostrata.* Clarke, New York State Mus. Bull. 80, p. 145.
Grande Greve limestones: North shore of Gaspe Bay, Quebec.
1905. *Cyrtina rostrata.* Shimer, idem, pp. 185, 227, 253, 263.
Dalmanites dentatus (or lowest) zone of Oriskany: Trilobite Ridge, Orange County, N. Y.
1905. *Cyrtina rostrata.* Williams and Kindle, U. S. Geol. Survey Bull. 244, p. 48.
Lewistown limestone: One-half mile north of Covington (1382A′, p. 40).
Coarse sandstone (Oriskany): One-half mile west of Clifton Forge (1384A, p. 43); both in Alleghany County, Va.

Width more than twice the length; outline (of brachial valve) broadly trapezoidal to triangular; greatest width at or just in front of the hinge. Pedicle valve pyramidal; cardinal area as high as or higher than the length of the valve, about normal to the plane of the margin, and very slightly arcuate, not retrorse; apex pointed. Median septum extending not more than halfway to the front. Plications strongly elevated on the internal mold as well as on the surface; seven or eight each side of the middle, the end ones rather weak. Fold and sinus prominent, simple, not distinctly grooved or "mesicostulate." Surface marked by numerous imbricating lamellæ, and under a lens there may be observed in places extremely fine fiber-like radiating lines.

Locality: Chapman sandstone, west side of Edmunds Hill and Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59727, 59728.

Comparisons.—The term *C. rostrata* Hall may be applied to a series of shells having in common the following characters: Form transversely elongate; surface plications strong; ribs rather abundant, strong, and not prominently increasing in width toward the middle; fold strongly elevated and sinus strongly impressed. The ribs are also prominent on the internal molds as well as externally in both the pedicle and the brachial valves. The transverse elongation makes the width two or more times the length, giving the brachial valves a pennate appearance. This transverse elongation is less conspicuous in the pedicle valve than in the brachial valve.

Such transversely elongated Cyrtinas with a large number of strong, narrow ribs have been found, without any known exception, to have the cardinal area high, slightly arcuate or plane, approximately normal to the margin or occasionally retrorse, but never strongly arched, and the umbo in the pedicle valve not gibbous.

From *C. hamiltonensis* the shells may be distinguished by the wide form and prominent erect area; and though both have commonly the same number of plications (six to eight, nine, or ten each side of the middle), *C. hamiltonensis* frequently has less than six, while in *C. rostrata* there are never less than six and the prevailing number is about eight or nine. The plications are also a little stronger in *C. rostrata* than in *C. hamiltonensis*.

In the European *C. heteroclita* the normal ornamentation is of the *C. dalmani* type, with ribs more or less low, increasing markedly in width toward the middle, rather few in number, and having the outline not transversely elongate.

A wide, strongly plicate Cyrtina, of almost typical *C. rostrata* aspect, occurs in the Hamilton at Delphi, N. Y.,[1] along with normal and variant *Cyrtina hamiltonensis* and *C. hamiltonensis* var. *recta*. A couple of similar specimens have been observed in a large suite of variants of *C. heteroclita* in my collection from Gerolstein, in the Eifel. These indicate the extension of the *rostrata* type of *Cyrtina* into the Meso-Devonian in New York and in the Eifel as well as in Devonshire, Spain, and Russia. The European Meso-Devonian and Neo-Devonian forms from the Eifelian of Torquay and from the Cuboides zone at Lummaton, are commonly known as *Cyrtina heteroclita* var. *multiplicata* Davidson. The retrorse cardinal area is a conspicuous feature in some British specimens, but is also occasionally present in *C. rostrata* in the Oriskany of Maryland and apparently in one of the Gerolstein specimens. The area is not retrorse in the Chapman forms.

The *Cyrtina varia* of Clarke has the form of *C. rostrata*, but the name may be used in varietal rank and applied to those specimens in which there is a median groove extending along the fold of the brachial valve, and a narrow rib or flattening in the bottom of the sinus in the pedicle valve. Such "mesicostulate" forms of *C. rostrata* have not been observed or recorded above the Oriskany, although one Gerolstein specimen shows (only, however, at the extreme front margin) a little groove in the fold. The variety *varia* Clarke bears a relation to *C. rostrata* similar to that of var. *demarlii* Bouchard[2] to *C. heteroclita*.

In large lots of *C. hamiltonensis* and *C. heteroclita* may be found occasional specimens of the *C. rostrata* type with the rather large number of strong ribs and the outline transversely elongate. Such specimens, whether from the Oriskany of Maryland, the Hamilton of New York, the Stringocephalus zone of the Eifel, or the Cuboides zone of Devonshire, have the cardinal area high, erect, rarely retrorse, and never strongly overhanging.

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[1] Collections of Cornell University Museum; No. 1457 on specimens, No. 1454 on labels.

[2] See Davidson, Thomas, British Devonian Brachiopoda, p. 50, pl. 9, figs. 15-17, 1864. Whidborne, G. F., Devonian fauna of the South of England, vol. 2, pt. 3, p. 113, pl. 12, fig. 10, 1893.

In the Helderberg, Oriskany, and Onondaga ("Corniferous") faunas *C. rostrata* maintains a characteristic form, distinct from the other Cyrtinas occurring in the same formations, thus justifying the use of a separate name of specific rank for the specimens of this type in this series of rocks. In these formations *C. rostrata* is an important and in the Oriskany by far the dominant type of Cyrtina, and the common variants are variants from the *C. rostrata* type. Some paleontologists would unite *C. rostrata* and *C. hamiltonensis*, because in the Middle Devonian *C. rostrata* occurs as a variant of *C. hamiltonensis* and not as a distinct species, but inasmuch as *C. rostrata* in its typical early occurrence in the Helderberg to Onondaga ("Corniferous") is a species very distinct from the other Cyrtinas occurring in these formations, where it is a persistent and more or less constant type, I am disposed to consider *C. rostrata* as a separate species, distinct from *C. hamiltonensis* and *C. heteroclita*, and to believe that in the great variability of the latter species there occasionally branches off a form recalling the characters of the earlier type *C. rostrata*.

C. dalmani differs from the type of *Cyrtina hamiltonensis* in having the lateral plications fewer in number and increasing rapidly in width and strength toward the middle. *C. rostrata* differs from *C. hamiltonensis*, *C. dalmani*, and *C. heteroclita* in being very wide and pennate and in having the maximum number of plications, which are stronger than in *C. heteroclita*.

In Europe the name *Cyrtina heteroclita* De France, 1824, is given to a great variety of Cyrtinas, the dominant expression of which is apparently that of the *C. dalmani* type, with plications rather few in number, increasing markedly in strength and width toward the middle; median fold simple, not wider than the two bounding ribs on either side; outline of the brachial valve quadrangular or semicircular, not transversely elongated. A better knowledge of De France's original types is necessary before the synonymy of the *C. heteroclita-hamiltonensis* forms can be unraveled.

Cyrtina heteroclita var. alpha var. nov.

Plate V, figure 15.

This variety is distinguished by its well-defined obscurity or absence of radial ribbing. The surface is either actually smooth without ribs, or the ribs are present as extremely indistinct undulations. The internal molds are practically smooth. Fold and sinus are developed but are rather low. The outline is quadrate, not transversely extended. The cardinal area is arched and typically directed more or less posteriorly. The median septum in the pedicle valve is thick and long, extending three-quarters of the way to the front. The shell is normal in outline or only very slightly distorted. Vascular pits are developed in the posterior half on the umbonal slopes beginning alongside the sinus. On the surface, as represented in external mold, there are six or seven very obscure radial undulations; the interior of the pedicle valve is practically without radial ribbing. The width is less than twice the length. The ribs increase slightly in width and in prominence toward the center, though not so markedly as in *Cyrtina dalmani* or in the normal *C. heteroclita* type.

Locality: *Cyrtina heteroclita* var. *alpha* occurs in the Chapman sandstone in the west side of Edmunds Hill, Chapman Township, Aroostook County, Maine. It is found in apparently the same beds with *Cyrtina rostrata*, from which it is easily distinguished by its squarer outline and obscure plications.

U. S. National Museum, catalogue No. 59729.

Comparisons.—This variety in its typical expression is very distinct from *Cyrtina heteroclita*, but a suite of Eifelian specimens from Gerolstein shows a series of nearly all the transitional forms. The same variation toward obsolescent ornamentation is occasionally encountered in *Cyrtina hamiltonensis*, from the Hamilton formation of New York. In the Ithaca shale member of the Portage formation a Cyrtina of this nearly smooth type is a very common form.

A smooth Cyrtina from the Dundee ("Corniferous") limestone of Michigan and the Onondaga limestone of New York has been described by Hall as *Cyrtina biplicata*.[1] It appears

[1] Hall, James, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 165, 1857; Paleontology of New York, vol. 4, p. 266, pl. 27, figs. 5-10, 1867; vol. 8, pt. 2, pl. 28, figs. 7-10, 1895. *Cyrtina biplicata* also occurs in the Eifel at Gerolstein.

to be a species with persistent and distinctive characters, which include a transversely elongated outline, smooth surface, a deep groove each side of the median fold, simple fold and sinus, and absence of plications. *Cyrtina biplicata* differs from the nearly smooth form *C. heteroclita* var. *alpha* in the total and constant absence of ribbing and in its broad outline.

Genus **SPIRIFER** Sowerby, 1815.

SPIRIFER CONCINNUS Hall.

Plate I, figures 6, 7; Plate II, figures 1, 4, 11, 12; Plate III, figure 5; Plate IV, figures 5, 6; Plate V, figures 16, 17.

1857. *Spirifer concinna.* Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 60, figs.
Shaly limestone and upper Pentamerus limestones of the Lower Helderberg; Albany and Schoharie counties, Hudson, etc., N. Y.

1859. *Spirifera concinna.* Hall, Paleontology of New York, vol. 3, pp. 200, 494, pl. 25, fig. 2; pl. 28, fig. 7.
Shaly limestone:[1] Helderberg Mountains and Hudson, N. Y.
Upper Pentamerus limestone; Schoharie and Helderberg Mountains, N. Y.

1876. *Spirifer concinnus.* Barrett, Lyceum Nat. Hist. New York City Annals, vol. 11, p. 296.
"Trilobite beds"; Bennett's quarry, Port Jervis, N. Y.

1882. *Spirifer concinnus.* I. C. White, Pennsylvania Second Geol. Survey Rept. G6, p. 132.
Stormville shaly calcareo-siliceous beds ["Trilobite beds"]: Monroe County, Pa.

1883. *Spirifer concinna.* Hall, New York State Geologist Second Ann. Rept., pl. 55, figs. 1, 2.
Lower Helderberg group: Helderberg Mountains, N. Y.

1890. *Spirifer concinnus.* Deeks, Canadian Rec. Sci., vol. 4, No. 2, p. 108.
Lower Helderberg: St. Helens Island, Montreal.

1893. *Spirifer concinnus.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pp. 24, 27, 38, pl. 30, figs. 1, 2.
Lower Helderberg group: Helderberg Mountains, N. Y.

1896. *Spirifera concinna.* Ami, Canada Geol. Survey Ann. Rept., new ser., vol. 7 (for 1894), p. 155J.
Lower Helderberg limestone: St. Helens Island, Montreal.

1899. *Spirifer concinnus.* Prosser,[2] New York State Geologist Seventeenth Ann. Rept., pp. 341, 351.
Becraft limestone: Countryman Hill and Clarksville-Oniskethau Creek sections, Helderberg Mountains, Albany County, N. Y.

1900. *Spirifer concinnus.* Schuchert, Geol. Soc. America Bull., vol. 11, p. 284.
New Scotland and Becraft limestones: New York, Maryland, and Virginia.

1900. Spirifer cf. *concinnus.* Williams, U. S. Geol. Survey Bull. 165, pp. 79, 80.
Chapman sandstone: Chapman, Aroostook County, Maine.

1901. *Spirifer concinnus.* Prosser, New York State Geologist Eighteenth Ann. Rept. (for 1898), p. 62.
Becraft limestone: Near Gallupville, Albany County, N. Y.

1901. *Spirifer concinnus.* Schuchert, Am. Geologist, vol. 27, p. 249.
Becraft limestone: St. Helens Island, Montreal, Canada.

??1901. Spirifer allied to *S. arenosus.* Schuchert, idem, p. 249.
Becraft (?) or Middle Devonian (?) limestone: St. Helens Island, Montreal, Canada.

1903. *Spirifer concinnus.* Schuchert, U. S. Nat. Mus. Proc., vol. 26, p. 422.
Becraft limestone: Cherry Run, W. Va.

not 1903. *Spirifer concinnus.*[3] Weller, Paleontology of New Jersey, vol. 3, pp. 83, 289, pl. 30, fig. 3.
Uppermost Coeymans: Near Hainesville, N. J.

1903. *Spirifer concinnus.* Grabau, New York State Mus. Bull. 69, pp. 1060, 1067, 1068.
Becraft and Port Ewen beds: Becraft Mountain, Columbia County, N. Y.

1903. *Spirifer concinnus.* Van Ingen and Clark, idem, pp. 1188, 1191, 1193, 1197, 1207.
Lowest Coeymans (?),[4] upper New Scotland, middle and upper Becraft, and lower Port Ewen limestones: Becraft Mountains, Columbia County, N. Y.

cf. 1904. *Spirifer excavatus* (? not Kayser). Drevermann, Palaeontographica, vol. 50, p. 254, figs. 8–10.
Siegen graywacke: Seifen, near Dierdorf, Rhenish Prussia.

1905. *Spirifer concinnus.* Shimer, New York State Mus. Bull. 80, pp. 183, 232, 233, 249, 265 (in part).
Becraft limestone: Trilobite Mountain, N. Y.

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[1] Hall (op. cit., p. 494) reported that among enormous collections of shaly limestone [New Scotland] fossils made in Albany County between 1843 and 1857 only a single specimen of *S. concinnus* was found. At the time the volume cited was written only two specimens were known at the New Scotland horizon, the second specimen being presumably from Hudson, N. Y. This species is abundant and apparently very widespread in the Becraft limestone and upper part of the Helderberg group, of which it is a diagnostic fossil.

[2] Dr. C. E. Smith has identified this species from the New Scotland limestone of the Indian Ladder section of Countryman Hill.

[3] The ribs are too few (only eight on each side) and too coarse for this species. See text, p. 82.

[4] The citation of *Spirifer concinnus* in the Coeymans, especially at its base, is to be taken with some doubt.

1905. *Spirifer concinnus.* Williams and Kindle,[1] U. S. Geol. Survey Bull. 244, p. 39.
Lewistown limestone: Covington, Va. (localities 1382 B′ and 1382 A).
1907. *Spirifer subcuspidatus lateincisus* (not Scupin). Clarke, New York State Mus. Bull. 107, p. 254, figs.
Lower Devonic: Presque Isle Stream, Chapman Plantation, Aroostook County, Maine.

A plicated Spirifer of moderately small size with rounded extremities, nonelongated outline, and 11 or 12 ribs on each side of the sinus and fold. Width less than twice the length, ratio varying from 1¼:1 to 1¾:1, commonly about 1½:1. Hinge line straight, commonly slightly shorter than the greatest width. Hinge extremities rectangular or rounded, rarely acute, never (in the Maine specimens) mucronate. Lateral and front margins arcuate. Pedicle valve gibbous, with a broad, tumid umbo; beak incurved but elevated above the brachial valve. Greatest depth of the pedicle valve over the hinge line. Cardinal area well developed, strongly curved; delthyrium large, acute, its sides subtending an angle of less than 60° but more than 45°. On the interior dental lamellæ extend one-fourth to one-third the length from the beak. They are situated generally[2] nearly under the third sinus, each side of the large median sinus. The muscular scars are not impressed. The brachial valve is nearly equal in convexity to the pedicle valve; greatest depth slightly back of the middle; cardinal area appreciably curved, but much narrower than in the pedicle valve. Cardinal process simple. A median elevated line or very obscure septum extends about half the length of the brachial valve on the interior. Depth (with both valves in conjunction) varying from 0.75 to 1.1 times the length of the brachial valve.

The surface is marked by 11 or 12 strongly elevated, rounded plications each side of the fold and sinus; the sinus in the pedicle valve is angular in the bottom, rather deep, and without any median riblet. It is equal in width to about four lateral ribs. The fold in the brachial valve is strongly arched and broad topped; the surface is generally marked by a median groove which is occasionally indistinct, although in some specimens it is so well developed that it divides the median fold into two strong plications. On only one of the many external molds of the Maine specimens was the finer surface ornamentation discernible. This consisted of concentric lamellæ, strongly recurving on the brachial fold. The largest specimen observed was 17 millimeters long and 26 millimeters wide. The average specimens are about three-fifths that size. The distinguishing features of this species are the small size, the rounded or square shoulders, and the number of plications (11 or 12, rarely as many as 14) on each side of the usually simple sinus and fold.

The specimens figured show some variations, which are noted in the following paragraphs.

Plate I, figure 6. A brachial valve of average size from locality 1099 L, in which the dorsal median septum shows more strongly than usual.

Plate I, figure 7. Another brachial valve from the same locality, showing the groove in the fold common in Maine specimens.

Plate II, figure 1. A pedicle valve from Presque Isle Stream, of very large size but showing the usual outline, ornamentation, and the angular sinus without median riblet.

Plate II, figure 4. A pedicle valve, from St. Helens Island, near Montreal, Canada.

Plate II, figure 11. Cardinal aspect of an internal mold from Presque Isle Stream, with both valves in conjunction, showing the high, curved cardinal area and also the slight inequality in convexity of the two valves.

Plate II, figure 12. Cardinal aspect of another pedicle valve from Presque Isle Stream, showing high curved cardinal area and the dental lamellæ. This is the only specimen in our collection in which the dental lamellæ occupy the first groove on each side of the sinus; usually

[1] These specimens are large (about 24 by 33 millimeters) and show 13 or 14 plications on each side. The ribs are narrow and low and the sinus is not so deeply excavated as in the Maine forms. In one of the specimens (labeled fig. 204, Feb. 3, 1899; 1382 B′) there are two very obscure ribs in the sinus, one on each side. These originate as branches from the ribs bounding the sinus, exactly as in the early stages of *S. arenosus*; but in the present specimen the sinus continues well pronounced, no further ribs are developed, and the two ribs which do appear are so obsolescent as to be discernible with difficulty. This specimen suggests the close phylogenetic relationship to *Spirifer arenosus*, not only because the ribs which bound the sinus send off branch ribs into the sinus, but also because of the large size of the shell, the low and numerous ribs, and the shallower sinus, which are features more or less uncommon in *Spirifer concinnus*.

[2] Their position in the Maine forms is variable. In one or two specimens the lamellæ are under the first lateral sinus.

they are situated at about the third groove on each side of the sinus. Clarke describes and figures his Presque Isle Stream specimens, which he identified with *Spirifer subcuspidatus* var. *lateïncisus* Scupin, as having the lamellæ in the first lateral groove on each side the sinus.

Locality: Chapman sandstone, Edmunds Hill, Presque Isle Stream, and 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59730 to 59734.

Comparison with the typical New York specimens.—There are a few minor points of distinction between the New York and Maine specimens. The former are described by Hall as having 12 to 14 plications on each side; in the Maine specimens there are only 11 or 12. Many New York specimens examined by us from several localities, however, have the same number of ribs as the Maine forms.

In specimens from Becraft Mountain, N. Y., Shimer[1] reports only eight or nine—in one specimen probably ten—plications on each side. The Trilobite Mountain specimens average eight to ten plications on each side, and some very large specimens (27 millimeters long and 31 millimeters wide) having 12 ribs on each side are recorded. Weller's specimens from the Coeymans-New Scotland transition beds have only eight ribs on a side. These figures indicate that average specimens from the Becraft limestone of Becraft Mountain and Trilobite Mountain, N. Y., having an approximate length of 16 millimeters and width of 23 millimeters, have only eight to ten plications on each side of the middle. The Maine specimens, though smaller than these, have commonly 11 or 12 plications on each side. One or two have as many as 13 or possibly 14, and these agree with the species as described by Hall and as generally distributed in the Becraft of New York. The shells called *Spirifer concinnus*, from Trilobite and Becraft Mountains, and possibly New Jersey, may therefore represent a distinct species or more probably are to be identified with *Spirifer cyclopterus*.

The strength of the plications in the New York forms is variable, but commonly they are pronounced, rather than "little elevated," as stated by Hall. The strength of the fold and sinus is also variable in the New York specimens, and the median sinus is generally shallower than in the specimens from Maine. A faint riblet was observed in the median sinus of one or two New York shells, but no such riblet has yet been observed in the Maine specimens, though they have commonly a grooved fold in the brachial valve, a feature very rare in the New York forms. The cardinal extremities in the Maine specimens are rectangular or rounded; the form with salient cardinal extremities occasionally found in New York has not been observed in Maine. In his paper on the Silurian and Lower Devonian faunas of Maryland[2] Schuchert, without description, lists a fossil from the Maryland Oriskany as "*Spirifer concinnoides* nov." As I am unacquainted with the fossil thus designated, no comparisons between the Chapman modifications of *S. concinnus* just described and the Maryland forms can be made at present.

Comparison with related species.—The Chapman forms here called *Spirifer concinnus* are remarkably similar to some shells identified with the *Spirifer excavatus* Kayser,[3] from the lowest Devonian of Germany. Scupin[4] removes from Kayser's species the specimens figured by Kayser in his Plate XXII, figure 7; Plate XXV, figure 26 (=*S. hystericus*); Plate XXII, figure 9, and probably Plate XXIII, figure 6, and restricts the name to shells having only eight or nine plications on each side; he regards Kayser's Plate XXII, figure 11, as the type of the species and figures Kayser's original specimen. In both Kayser's and Scupin's figures of this specimen there are 11 or 12 plications on each side, not eight or nine, as mentioned in Scupin's text. This type is a large specimen; the fold is very deeply divided, the ribs angular, and the interspaces broad. This form is very similar to the Spirifer sp. indet. Weller,[5] from the Kanouse sandstone (so-called "Newfoundland grit") of New Jersey.

These spirifers with angular ribs and very deeply and broadly divided median fold have nothing in common with typical *Spirifer concinnus* and but little in common with the Chapman

[1] New York State Mus. Bull. 80, p. 249, 1905.
[2] U. S. Nat. Mus. Proc., vol. 26, pp. 413-424, 1903.
[3] Consult Kayser, Emanuel, Die fauna der ältesten Devon-Ablagerungen des Harzes, p. 17, pl. 22, figs. 7-9, 11; pl. 23, fig. 6; pl. 25, figs. 22, 25, 26, 1878.
[4] Spiriferen Deutschlands, p. 24, pl. 2, fig. 8, 1900.
[5] Paleontology of New Jersey, vol. 3, p. 376, pl. 52, fig. 4, 1903.

sandstone forms of *Spirifer concinnus*. The latter are more nearly comparable with the smaller shells having rounded ribs, narrower interspaces, and fold not so broadly cleft, represented by the fossils collected by Drevermann from the Siegen graywacke at Seifen and elsewhere in the Rhenish province and described and figured by him as *Spirifer excavatus*.[1] Indeed, Drevermann's figures 8 and 9 look as if they might have been drawn from Chapman specimens; his figure 10 shows fewer ribs. It is difficult with our present knowledge to satisfactorily separate these Siegen graywacke fossils specifically from the Chapman forms, but it may be questioned whether these fossils can be strictly identified with Kayser's Hercynian (Lower Coblenzian) *S. excavatus*, which is larger and has a more broadly cleft fold and angular ribs with wider interspaces.

Although Kayser's forms agree with the Chapman specimens in outline, convexity, and muscular markings, and in having 11 or 12 ribs each side of the fold, which is deeply cleft, the persistently more deeply cleft fold in the brachial valve, as well as some minor characters of the original Hercynian *Spirifer excavatus* of Kayser and Scupin show little direct relationship with the New York typical *Spirifer concinnus*. In Kayser's Hercynian species the ribs are more angular and have wider interspaces than in the Chapman forms of *S. concinnus*. It is also larger and, though it agrees with the Maine shell in the presence of a cleft fold, that character is very persistent and very much better developed in the German species than in the Chapman fossils.

Spirifer carinatus Schnur and *Spirifer nerei* Barrande[2] also closely resemble *Spirifer concinnus* but generally have the fold carinate instead of rounded. In *Spirifer nerei* Barrande the umbones are usually more inflated than in *S. concinnus*. Finally, both *S. carinatus* Schnur and *S. nerei* Barrande are larger than *S. concinnus*—very much larger than the ordinary Chapman forms of that species—and also frequently have one or two more ribs on each side than the maximum of *Spirifer concinnus*.

These Chapman fossils have been identified by Clarke[3] with *Spirifer subcuspidatus* Schnur var. *latëincisus* Scupin.[4] The German species, which occurs in the white sandstone of the Kahleberg and at other points in the Oberharz, in beds of the age of the Coblenz (Ems, or Middle Coblenzian) quartzite, is a larger and wider form than the Chapman *Spirifer concinnus*, and its cardinal extremities are more acute. The height of the cardinal area in the Chapman fossils is less, and the two valves are more nearly equal in convexity. There is, however, a very close similarity between the shells from Aroostook County, Maine, and those from the Harz Mountains, Germany.

Variation of Spirifer concinnus toward Spirifer arenosus.—In the beginning of its career as a species *Spirifer concinnus* seems to have been derived from some such form as *Spirifer cyclopterus*, from which it differs only, aside from a few insignificant points, in having a few more ribs. Toward the end of its career *Spirifer concinnus*, a species with a simple fold and sinus, varies toward *Spirifer arenosus*, a species with a plicose fold and sinus. Hall noted this feature in *S. concinnus* when he stated[5] that in "many specimens there are faint indications of a fold on each side of the mesial sinus and of several similar ones upon the corresponding mesial elevation; this character, however, is not constant in the specimens examined." Such a form is figured by Hall and Clarke.[6]

In some rocks at St. Helens Island, near Montreal, Canada, which contain Helderberg fossils, occurs a Spirifer which has been listed by Donald, Deeks, Ami, and Schuchert as "Spirifer allied to *arenosus*." In the words of Schuchert,[7] "This is apparently the earliest form of *S. arenosus* type." However, it is not that species, since when small it is much like *S. concinnus*, but toward maturity the fold and sinus became plicated. Characteristic representatives of the species *Spirifer arenosus* have been recognized in the breccias of St. Helens Island,[8] proving

[1] Palaeontographica, vol. 50, p. 254, figs. 8-10, 1904.
[2] See Scupin, Hans, Die Spiriferen Deutschlands: Palaeont. Abh. (Dames & Koken, Jena), vol. 8, Heft 3, pp. 26 and 32, 1900, for references, description, and figures of these species.
[3] New York State Mus. Bull. 107, p. 254, figs., 1907.
[4] Scupin, Hans, op. cit., p. 223, pl. 24, figs. 13, 14a-c.
[5] Paleontology of New York, vol. 3, p. 200, 1859.
[6] Idem, vol. 8, pt. 2, pl. 30, 1893.
[7] Am. Geologist, vol. 27, No. 4, p. 249, April, 1901.
[8] Williams, H. S., Roy. Soc. Canada Proc. and Trans., 3d ser., vol. 3, p. 221, 1910.

conclusively that the Oriskany was represented there. The specimen from St. Helens Island figured in the present work (Pl. II, fig. 4) plainly shows the similarity in configuration to *S. concinnus.* "In *S. arenosus* of the Oriskanian, the horizon for this species (*S. arenosus*)," continues Schuchert, "the plication of the fold and sinus is not a recently acquired character, for it appears in the shell when quite small." This is true both in general and particularly in regard to the Maryland specimens; but specimens of *Spirifer arenosus* nearly an inch wide from Union Springs, N. Y., are without plications on the fold. Plicose specimens of *S. concinnus* may be distinguished from small forms of *S. arenosus* chiefly by the more elevated plications and rounded shoulders.[1] The type is similar to *Spirifer grieri* Hall,[2] from the American "Corniferous" limestone, and *Spirifer winterii* Kayser.[3]

SPIRIFER ARENOSUS (Conrad).

Plate II, figures 15, 16, 19, 21; Plate III, figure 1; Plate V, figure 18.

1839. *Delthyris arenosa.* Conrad, New York Geol. Survey Third Ann. Rept., p. 65.
"Helderberg, in sandstone." [Oriskany sandstone: Helderberg Mountains, N. Y.]

1842. *Delthyris arenaria.* Vanuxem, Geology of New York, Rept. Third Dist., p. 123, fig. 1; p. 124, fig. 5.
Oriskany sandstone: Third district. (Madison County westward to Cayuga Lake), N. Y.

1843. *Delthyris arenaria.* Mather, idem, Rept. First Dist., p. 342, fig. 1.
Oriskany sandstone: Hills east and west of Schoharie; various places in the Helderberg Mountains, in the towns of Berne, Knox, and Bethlehem, and southward to Esopus Falls, N. Y.

1843. *Delthyris arenosa.* Hall, idem, Rept. Fourth Dist., p. 148, fig. 1.
Oriskany sandstone: New York.

1858. *Spirifer arenosa.* Rogers, Geology of Pennsylvania, vol. 2, pt. 2, p. 826, fig. 650.
Meridian formation (Oriskany): Pennsylvania.

1859. *Spirifer arenosus.* Hall, Paleontology of New York, vol. 3, p. 425, pl. 98, figs. 1–8; pl. 99, figs. 1–10; pl. 100, figs. 1–8.
Oriskany sandstone: Everywhere in New York, "being one of the most constant if not the most persistent fossil of the rock. In the same rock in Maryland, Virginia, and elsewhere."

1863. *Spirifer arenosa.* Billings, Geology of Canada, p. 960, fig. 465 a, b.
Oriskany (sandstone): North Cayuga, Ontario (p. 361).
Gaspe limestones, division 8: Whitehead, Cape Barry, and Perce Rock, Gaspe (pp. 393, 439).

?1867. *Spirifera unica.* Hall, Paleontology of New York, vol. 4, p. 203, pl. 30, fig. 21; pl. 55, fig. 8.
Corniferous limestone: Clarence Hollow, Erie County, N. Y.

cf. 1868. *Spirifer arenosus.* Dawson, Acadian geology, p. 498 (1891 edition).
"Oriskany" Nictaux iron ore; Nictaux, Nova Scotia.

1874. *Spirifera superba.* Billings, Paleozoic fossils, vol. 2, pt. 1, p. 47, pl. 3A, figs. 3, 3a, 3b (not *S. superbus* Eichwald).
Gaspe limestone No. 8: Indian Cove, Gaspe.

1876. *Spirifer arenosus.* Barrett, Lyceum Nat. Hist. New York City Annals, vol. 11, p. 297.
Oriskany: Bennett's quarry, Port Jervis, N. Y.

1878. *Spirifer arenosus.* Ashburner, Pennsylvania Second Geol. Survey Rept. F, p. 239.
Oriskany (Meridian) coarse sandstone: East Broad Top Railroad cut at Three Springs; on Royer and Sandy ridges near Orbisonia, Huntingdon County, Pa.

1882. *Spirifer arenosus.* I. C. White, Pennsylvania Second Geol. Survey Rept. G6, pp. 124, 247, 248.
Oriskany (Stormville?) limy, cherty shales: One mile south of Carpenter's Point village, Pike County, Pa.

1882. *Spirifera arenosa.* Stevenson, Pennsylvania Second Geol. Survey Rept. T2, pp. 86, 103–104, 132, 149.
Lower Helderberg-Oriskany transition (siliceous limestone): Wills Creek, near Hyndman, Bedford County, Pa.
Oriskany (hard blue-gray grits): Wills Creek, above preceding locality, on Exline road, King Township, and at Bedford Springs, Bedford County, Pa.

1883. *Spirifera arenosa.* Hall, New York State Geologist Second Ann. Rept., pl. 55, figs. 3–7.
Oriskany: Eastern New York and Cumberland, Md.

1883. *Spirifer superba.* Ells, Canada Geol. Survey Rept. Progress for 1880–1882, p. 14DD.
Upper Gaspe limestone (Oriskany): Indian Cove, the Blowhole, Grande Greve, and Little Gaspe, Gaspe Bay, Quebec.

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[1] Williams, H. S., op. cit., pp. 221, 234.

[2] Paleontology of New York, vol. 4, p. 194, pl. 27, fig. 29; pl. 28, figs. 17–23, 1867. See Schuchert, Charles, U. S. Geol. Survey Bull. 87, p. 392, 1897, for additional references.

[3] Deutsch. geol. Gesell. Zeitschr., 1881, p. 331, pl. 19, fig. 1; occurs at Gerolstein, in the Eifel. Compare also *Spirifer bischofi* (A. Roemer's sp.), pars, figured by Drevermann in Palaeontographica, vol. 50, pl. 29, figs. 15–17, 1904. Drevermann's fossils are from the Siegen graywacke of Seifen, etc., in the Westerwald.

1883. *Spirifer arenosa.* I. C. White, Pennsylvania Second Geol. Survey Rept. G7, pp. 86, 297, 305, 310, 329.
Oriskany: Little Fishing Creek, Columbia County (cherty sandstone); Grove Bros. tunnel, Cooper Township, Montour County (chert); Mahoning Township, Montour County (sandy, limy chert); Chillisquaque Creek and Lime Ridge, Liberty Township, Montour County (blackish cherty beds); Delaware Township, Northumberland County (cherty sandstone).

1883. *Spirifera arenosa.* I. C. White, idem, p. 346.
Oriskany: Near milepost 135, Northern Central Railway, Upper Augusta Township (limy, cherty beds), and Lower Mahanoy Township, Northumberland County, Pa.

1884. *Spirifer arenosus.* Ewing, Pennsylvania Second Geol. Survey Rept. T4, p. 431.
Oriskany (coarse sand cemented with lime carbonate): Alexander quarry, between Julian and Unionville, Center County, Pa.

1885. *Spirifera arenosa.* I. C. White, Pennsylvania Second Geol. Survey Rept. T3, pp. 119, 259.
Oriskany sandstone: Mapleton and Huntingdon car works, Oneida Township, Huntingdon County, Pa.

1885. *Spirifera superba* and *arenosa* (?). Ells, Canada Geol. Survey Rept. Progress for 1882–1884, p. 24E
Gaspe limestone No. 8: Grande Greve, Gaspe Bay.

1899. *Spirifera billingsana.* Miller, North American Geology and Paleontology, p. 372 (nom. nov. proposed for *S. superba* Billings, preoccupied).
Gaspe limestone No. 8: Gaspe.

1889. *Spirifera arenosa.* Schuchert, New York State Geologist Eighth Ann. Rept. (for 1888), p. 53.
Oriskany: Cayuga, Ontario; Cumberland, Md.

1889. *Spirifera arenosa.* Simpson, Pennsylvania Second Geol. Survey Rept. O3, pp. 208–209.
Oriskany sandstone: Sandy Ridge and Royers Ridge, Orbisonia, Huntingdon County, Pa.

1892. *Spirifer arenosus.* Clarke, Am. Jour. Sci., 3d ser., vol. 44, p. 413.
Oriskany siliceous limestone: Becraft Mountain, Columbia County, N. Y.

1893. *Spirifer arenosus.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pp. 24, 27, 37, pl. 29, figs. 1–4; pl. 30, figs. 3–8.
Oriskany: Eastern New York; Cumberland, Md.

?1893. *Spirifer unicus.* Hall and Clarke, idem, pl. 30, fig. 8.
Upper Helderberg limestone: Clarence Hollow, Erie County, N. Y.

cf. 1895. *Spirifera arenosa.* Ami, Canada Geol. Survey Ann. Rept., new ser., vol. 6, p. 15Q.
Nictau beds (Oriskany): Nictau, Nova Scotia.

1897. *Spirifer arenosus.* Schuchert, U. S. Geol. Survey Bull. 87, p. 382.
Oriskany and Corniferous: Schoharie, Clarence Hollow, etc., N. Y.; Cumberland, Md.; Virginia; Frankstown, Pa.; Cayuga, Ontario.

1899. *Spirifer arenosus.* Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), p. 341.
Oriskany sandstone: Countryman Hill, Helderberg Mountains, N. Y.

1900. *Spirifer arenosus.* Schuchert, Geol. Soc. America Bull., vol. 11, pp. 315–316.
"Monterey" formation (Oriskany): Cumberland, Md.
"Oriskany": North Branch of Potomac River at Keyser, Mineral County; Moosefield, Hardy County; North Fork of South Branch of Potomac River, Pendleton County, W. Va.; Rock Enon Springs and 6 miles northwest of Winchester, Frederick County, Va.

1900. *Spirifer arenosus.* Clarke, New York State Mus. Mem., vol. 3, No. 3, pp. 46, 74, 77–79.
Oriskany siliceous limestone: Becraft Mountains, N. Y.
Oriskany sandstone: Oriskany Falls, Oneida County, N. Y.; in quartzitic sandstone (?), Livonia salt shaft, Livingston County, N. Y.; in siliceous limestone, Glenerie, N. Y.; in quartzitic limestone, West Mountain, Schoharie, N. Y.

1901. *Spirifer arenosus.* Prosser, New York State Geologist Eighteenth Ann. Rept., p. 59.
Oriskany (dark-gray sandstone): Altamont section, Helderberg Mountains, Albany County, N. Y.

1901. *Spirifer arenosus.* Prosser, Jour. Geology, vol. 9, p. 418.
Oriskany: Alleghany County, Md.

1903. *Spirifer arenosus.* Weller, Paleontology of New Jersey, vol. 3, pp. 100, 101, 353, pl. 48, fig. 5.
Spirifer murchisoni or upper zone of the Oriskany (siliceous limestones): Three-fourths of a mile west of Leighton and at Peters Valley, N. J.

1903. *Spirifer arenosus.* Van Ingen and Clark, New York State Mus. Bull. 69, pp. 1203, 1207.
Oriskany siliceous limestone: Glenerie, N. Y.

1905. *Spirifer arenosus.* Harris, Guide to the Geology of Union Springs, p. 4, pl. 13, figs. 1, 2.
Oriskany sandstone: Yawger's Woods, Union Springs, Cayuga County, N. Y.

1905. *Spirifer arenosus.* Clarke, New York State Mus. Bull. 80, pp. 140, 143, 145, 149.
Grande Greve limestone: North shore of Gaspe Bay.
Perce limestone: Perce Rock, Blowhole, and Barre Brook, Gaspe Bay.

1905. *Spirifer arenosus.* Shimer, idem, pp. 229, 251, 265.
Spirifer murchisoni zone, or upper division of the Oriskany (dense blue limestone): Trilobite Mountain, N. Y.

1905. *Spirifer arenosus.* Williams and Kindle, U. S. Geol. Survey Bull. 244, pp. 32, 34, 39, 43, 48.
Giles formation [in sandstone of Oriskany age] interbedded in chert: Ravine 1½ miles above Hicksville, Bland County, Va. (as Spirifer sp., p. 32); Springs Hotel, W. Va.; Jackson River, below Covington, and one-half mile west of Clifton Forge, Alleghany County, Va.
1905. *Spirifer arenosus.* Clarke, New York State Mus. Bull. 82, p. 41.
Oriskany granular quartzite: Tully quadrangle, N. Y.
Oriskany sandstone: Yawger's Woods, near Union Springs, and at Oriskany Falls, N. Y.
1910. *Spirifer arenosus* (Conrad). H. S. Williams, Roy. Soc. Canada Trans., 3d ser., vol. 3, sec. 4, p. 221.
St. Helens breccias, lot 1 (252.1): St. Helens Island, near Montreal, Canada.

This species, though not present in the Chapman sandstone, is introduced here with illustrations, because its importance as a stratigraphic landmark makes its absence significant in a fauna which has species genetically related to it and with which it is necessary to institute detailed comparison. A full synonymy is also given in order to show its geographic distribution. The Moose River sandstone, in which the species is abundant, is exposed in an adjoining county in Maine and indicates the probable areal continuity of the basins in which the two faunas lived, thus requiring succession in time to explain the difference in fauna.

The species *Spirifer arenosus* is too well known to warrant any detailed description here. It is of interest to note that this, the first species in the American faunas with plicated fold and sinus, has no close equivalent in the European faunas. It is true that the first similarly plicose Spirifers—*S. bischofi* A. Roemer [1] and *S. daleidensis* Steininger [2]—occur in the European Eo-Devonian at a horizon (the Taunusian, Siegen graywacke, or zone of *Spirifer primævus*) supposed to be the equivalent of the Oriskany; but these European species can not be compared very closely with *S. arenosus,* for they have a different outline and convexity and a stronger fold and sinus and can easily be recognized as distinct. The second species named above (*Spirifer daleidensis*) has bifurcating ribs. Some specimens with distant and bifurcating ribs, which appear to be identifiable with *Spirifer daleidensis,* have been observed in the Maryland Oriskany from Hicksville, Bland County, Va.[3] The Kentucky "Corniferous" (?) shells doubtfully identified by Nettelroth,[4] with *Spirifer divaricata* Hall, are similar to if not actually identifiable with *Spirifer daleidensis* Steininger.

Locality: *Spirifer arenosus* occurs in the Moose River sandstone in Somerset County, Maine. All the figured specimens are from Detroit, Maine (locality 1100 A), except that shown in Plate III, figure 1, which is from the Oriskany at Keyser, Mineral County, W. Va.

U. S. National Museum, catalogue Nos. 59735, 59736.

SPIRIFER ARENOSUS var. SIMPLEX nov. var.

Plate III, figures 2–4, 7, 12.

This variety, which does not occur in the Chapman fauna, differs from *Spirifer arenosus* in having in the median sinus a single strong rib with one weaker rib on each side. The shells are of medium size, rather elongate; ratio of length to breadth, 3:5 or 3:4, generally near the latter. Hinge line equals the greatest width of the shell; hinge extremities square or nearly so, slightly auriculate. Cardinal area fairly well developed; curved, not erect. Delthyrium over 60°, nearly 90°. The musculature is deeply impressed in the pedicle valve and is marked by a broad median groove, a continuation of the bottom of the median sinus of the valve. The surface is ornamented with low, flattened or rounded plications, of which there are between 15 and 21 on each side of the fold and sinus. The interspaces between the ribs are very narrow. The plications at the lateral extremities are rather faint. In the bottom of the sinus is a central rib generally broader than any other plication on the surface, and on each side of this central rib is a single narrow rib. Fold and sinus broad, moderately elevated, not sharply demarcated. Brachial valves, associated with the typical pedicle valves in the same

[1] Roemer, A., in Giebel, C. G., Die silurische Fauna des Unterharzes, p. 29, pl. 4, fig. 3, 1858.
[2] Steininger, Johann, Geognostische Beschreibung der Eifel, p. 71, 1853. For further references see Scupin, Hans, Die Spiriferen Deutschlands, pp. 277–279, etc.
[3] U. S. Geol. Survey Bull. 244, p. 32, 1905 (Spirifer sp.).
[4] Nettelroth, Henry, Kentucky fossil shells, p. 113, pl. 12, figs. 5–11, 1889; not pl. 11, figs. 6–11.

beds, generally exhibit a subdivision of the central plication within an inch from the point of the beak, so that from there forward there are four plications on the median fold. In some large specimens a slight linear depression is seen on the mesial plication of the brachial valve near the front; and in several specimens the left-hand division of the median pair of plications on the fold (right-hand one when the specimen is examined with umbo upward) is bifurcate, and at the front the plications are five in number, which makes the inside plication of the first division take prominence in place of the sulcus between the divisions.

The ornamentation characteristic of the variety *simplex* occurs in the young of all *Spirifer arenosus*, but in the variety it is maintained apparently throughout life and certainly in shells having a larger size than specimens of *S. arenosus* which have the normal five plications, or even seven plications, in the sinus.

Spirifer arenosus var. *simplex* may therefore be considered as founded on specimens of *Spirifer arenosus* in which the juvenile ornamentation in the sinus is maintained longer than normal—in other words retarded—and in which the normal adult ornamentation in the sinus of typical *S. arenosus* is not attained.

In very young pedicle valves of *Spirifer arenosus* the sinus is simple and flat in the bottom, and the bounding rib on each side is strong. At about 7 millimeters from the beak each bounding rib dichotomizes; the inner branch is a little lower and weaker than the outer, so that it appears to develop within the sinus. At nearly the same stage that the bounding ribs dichotomize (about 1 millimeter's growth later), the flat bottom of the sinus also dichotomizes, producing two more low ribs within the sinus; and at some distance in front, a narrower riblet is developed [1] between the two median ribs in the sinus. There are now five ribs in the sinus; in older forms each bordering rib again dichotomizes, producing seven ribs in the sinus. The stages of development may be summarized as follows, the letters referring to the accompanying diagram (fig. 2):

1. Median sinus (A) simple, flat-bottomed; each bounding rib (B) strong. Diagram, B (A) B.
2. Each bounding rib dichotomizes, the inner branch being a little weaker. Diagram, B (b^1, A, b^1), B.
3. The flat bottom of the sinus (A) dichotomizes. Diagram, B (b^1, a^1, a^1, b^1), B.
4. A narrow riblet is added between them by the forking of one of the two divisions of (A). Diagram, B (b^1, a^1, a, a^1, b^1), B. (This is the stage figured in Pl. III, fig. 1.)
5. The marginal ribs of the sinus (either B or b^1) again dichotomize. Diagram, B (b^2, b^1, a^1, a, a^1, b^1, b^2), B.

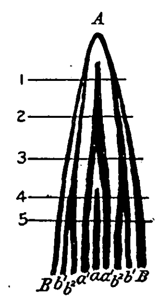

FIGURE 2.—Surface ornamentation of *Spirifer arenosus*.

The development of the plications in the sinus and fold of *Spirifer arenosus* furnishes an admirable illustration of the evolutional laws of retardation and acceleration. Although phases 1 and 2 of the above series are developed rather uniformly with exceedingly rare exceptions, at the same stage in the shell, the phases after 2 are each developed at different successive intervals in different shells, and indeed phase 4 is in many shells not developed at all.

The example of retardation may be explained here in connection with the variety *simplex*. In this variety only the second stage of development of the above table is reached at maturity; the flat bottom of the sinus does not divide but remains simple as a broad, slightly elevated flat rib in the bottom of the sinus. This condition is maintained in the largest specimen observed for a length of 30 millimeters from the beak (Pl. III, fig. 4), and in another specimen (No. 215, not figured) for 27 millimeters. This large size and the abundance of material including smaller sizes indicate that the variety *simplex*, though possessing the ornamentation of the young of typical *S. arenosus*, is not an immature form of the species but a variety. This interpretation is further corroborated by the fact that in normal forms of *S. arenosus*, as illustrated by the only specimen (Pl. III, fig. 1) in the large collection from Keyser examined in this study, the mature stage, or fourth stage, of the diagrammatic classification, is attained at a

[1] This narrow riblet is the result of the dichotomizing of the sinus, generally of the left branch and apparently less frequently of the right branch. The origin of the fifth riblet by the dichotomizing of the left branch in the sinus is visible in the specimen figured in Plate III, figure 1; in Hall's specimens (Paleontology of New York, vol. 3, pl. 100, fig. 4b, pl. 98, fig. 3, 1859); and in a specimen in the Cornell University (Col. E. Jewett) collection, No. 82, from Cumberland, Md. In the specimen shown in Hall's plate 100, figure 8a, and in another Cornell University specimen from Cumberland, Md., the median riblet dichotomizes from the right branch in the sinus.

distance of less than 15 millimeters from the beak. In all the others referred to var. *simplex* only the second stage is reached at full maturity. Comparison with the variety *simplex* shows that *Spirifer concinnus* with the rudimentary plications represents stage 1 of the diagram (fig. 2) so far as development of plications on the fold and sinus is concerned.

Locality: Keyser, Mineral County, W. Va. This variety is the dominant form of *Spirifer arenosus* and is very abundant. Only one normal specimen of *S. arenosus*, with the typical five plications in the sinus, was observed in a large collection from this locality.

U. S. National Museum, catalogue No. 59737.

SPIRIFER CYCLOPTERUS Hall.

Plate I, figures 1, 4, 5, 8, 9, 12, 16, 18, 19, 20; Plate II, figures 3, 5, 6, 7, 8, 10, 13, 14, 20; Plate IV, figures 1, 10.

1857. *Spirifer cycloptera.* Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 58.
Lower Helderberg shaly limestone: Helderberg Mountains, Schoharie, Catskill, Hudson etc., N. Y.

1859. *Spirifer cyclopterus.* Hall, Paleontology of New York, vol. 3, p. 199, pl. 25, fig. 1.
Shaly limestone of Lower Helderberg group: Helderberg Mountains, Schoharie, Catskill, Hudson, etc., N. Y.

1863. *Spirifera cycloptera.* Billings and Logan, Geology of Canada, p. 957, fig. 457.
Lower Helderberg: Canada [locality not given].

?1874. *Spirifera cycloptera.* Billings, Paleozoic fossils, vol. 2, pt. 1, p. 48, pl. 3A, figs. 4b, 4c (not 4 and 4a, which are *S. murchisoni* Castelnau).
Gaspe limestone No. 8: Grande Greve and Indian Cove, Gaspe, and Split Rock, Perce, Quebec.

1876. *Spirifer cyclopterus.* Barrett, Lyceum Nat. Hist. New York City Annals, vol. 11, pp. 295, 296.
Delthyris shaly limestone and Trilobite beds: Bennett's quarry, Port Jervis, N. Y.

1882. *Spirifer cyclopterus.* I. C. White, Pennsylvania Second Geol. Survey Rept. G6, pp. 132, 134.
"Trilobite beds" at top of Stormville shales: Delaware River at Carpenters Point, Pa.
Stormville limestone (lower part of Lower Helderberg): New Jersey and Pennsylvania.

1882. *Spirifera cycloptera.* Stevenson, Pennsylvania Second Geol. Survey Rept. T2, pp. 156, 159.
Lower Helderberg limestone: Imlentown road, east of Lutheran Church, Bedford County, Pa.; Martins Ridge, near Maryland State line, Bedford County, Pa.

1883. *Spirifera cycloptera.* Hall, New York State Geologist Second Ann. Rept., pl. 61, figs. 12–13.
Lower Helderberg: Carlisle, N. Y.

1883. *Spirifera cycloptera.* Ells, Canada Geol. Survey Rept. Progress for 1880–1882, p. 8DD.
Lower Gaspe limestones: Upper part of Griffin Cove River near peaks of Ruisseau de la Grande Carriere, Gaspe, Quebec.

1886. *Spirifer cyclopterus.* Darton, Am. Jour. Sci., 3d ser., vol. 31, pp. 212, 214.
Lower Helderberg: Cornwall Station, Orange County, N. Y.

1890. *Spirifer cyclopterus.* Deeks, Canadian Rec. Sci., vol. 4, No. 2, p. 108.
Lower Helderberg limestone [Becraft fossils]: St. Helens Island, Montreal.

1893. *Spirifer cyclopterus.* Hall, Paleontology of New York, vol. 8, pt. 2, p. 36, pl. 36, figs. 12, 13.
Lower Helderberg: Carlisle, N. Y.

1896. *Spirifera cycloptera.* Ami, Canada Geol. Survey Ann. Rept., new ser., vol. 7, p. 156J.
Lower Helderberg: St. Helens Island, Montreal, Canada.

1897. *Spirifer cyclopterus.* Schuchert, U. S. Geol. Survey Bull. 87, p. 387.
Lower Helderberg and Oriskany: Helderberg Mountains, New York; Gaspe and New Brunswick, Canada.

1898. *Spirifer cyclopterus.* Prosser, New York State Geologist Seventeenth Ann. Rept., pp. 340, 341, 350.
New Scotland shaly limestone: Countryman Hill and Clarksville, N. Y.
Becraft limestone: Countryman Hill; Helderberg Mountains, Albany County, N. Y.

1899. *Spirifer cyclopterus.* Girty, U. S. Geol. Survey Nineteenth Ann. Rept., pt. 3, p. 565.
Lower Helderberg: T. 1 S., R. 8 E., Atoka quadrangle, Indian Territory [Oklahoma].

1900. *Spirifer cyclopterus.* Williams, U. S. Geol. Survey Bull. 169, p. 80.
Chapman sandstone: Chapman, Maine.

1900. *Spirifer cyclopterus.* Schuchert, Geol. Soc. America Bull., vol. 11, pp. 285, 294.
New Scotland and Becraft: New York, Maryland, Virginia, Tennessee, Indian Territory, Maine, New Brunswick.
Oriskany: Localities not cited.

1900. *Spirifer cyclopterus.* Clarke, New York State Mus. Mem., vol. 3, No. 3, p. 73.
Kingston (=Port Ewen) impure schistose limestone; near Kingston, Ulster County, along West Shore Railroad, one-half mile southeast of Rondout Creek, N. Y.

1901. *Spirifer cyclopterus.* Prosser, New York State Geologist Eighteenth Ann. Rept. (for 1898), pp. 54, 58, 61.
New Scotland shaly limestone: Indian Ladder section, Countryman Hill; High Point, Altamont; and Knox, Helderberg Mountains, Albany County, N. Y.

1903. *Spirifer cyclopterus.* Schuchert, U. S. Nat. Mus. Proc., vol. 26, p. 422.
Coeymans limestone: Devils Backbone, near Cumberland, Md.
New Scotland limestone: Bridge 21, Baltimore & Ohio Railroad, near Keyser, Mineral County, W. Va.
Becraft limestone: Cherry Run, W. Va.

1903. *Spirifer cyclopterus.* Weller, Paleontology of New Jersey, vol. 3, pp. 82, 84, 85, 87–90, 287, 314, pl. 30, fig. 2; pl. 38, figs. 1–6.
Basal Coeymans limestone: Top of Nearpass Quarry bluff.
Lower Coeymans limestone: One-half mile northeast of Peters Valley, in the hillside.
Coeymans limestone: Below Flatbrookville.
Lower New Scotland cherty limestone: Back of quarry and limekiln of Mr. Sanford Nearpass.
New Scotland shaly beds: One-half mile northeast of first crossroads over Wallpack Ridge below New York State line, one-half mile below Hainesville, and 1 mile below Peters Valley.
Upper part of New Scotland shaly beds: Nearpass section.
Becraft hard gray cherty limestone: Low ridge, back of Nearpass Quarry Bluff.
All localities in northwestern New Jersey.

cf. 1903. *Spirifer concinnus* (not Hall's species). Weller, idem, pp. 83, 289, pl. 30, fig. 3.
Uppermost Coeymans: Near Hainesville, N. J.

1903. *Spirifer cyclopterus.* Grabau, New York State Mus. Bull. 69, pp. 1056, 1061, 1067.
Coeymans limestone, Becraft limestone, Port Ewen shaly limestone: Becraft Mountain, New York.

1903. *Spirifer cyclopterus.* Hartnagel, idem, p. 1164.
Stromatopora layer [included by Hartnagel in the basal Helderberg]: Hill east of Manlius, N. Y.

1903. *Spirifer concinnus.* Van Ingen and Clark, idem, pp. 1188, 1189, 1191, 1203, 1207.
Basal Coeymans limestone, Coeymans-New Scotland transition shaly limestone, lower and upper New Scotland, and lower and upper Port Ewen beds: Becraft Mountain, Columbia County, N. Y.
Oriskany: Glenerie, Ulster County, N. Y.

1905. *Spirifer cyclopterus.* Williams and Kindle, U. S. Geol. Survey Bull. 244, pp. 28, 33, 48.
"Oriskany" coarse sandstone: East Fork of Powell River, above flouring mill, Wise County, Va.
"Oriskany" sandy and cherty beds: Along Southern Railway northeast of Big Stone Gap, Wise County, Va.
Giles sandstone: 1¼ miles south of Rocky Gap, Bland County, Va.

1905? *Spirifer cyclopterus.* Clarke,[1] New York State Mus. Bull. 80, p. 149.
Grande Greve (Oriskany) limestone: The Blowhole, Gaspe, Canada.

1905. *Spirifer cyclopterus.* Shimer, idem, pp. 181, 182, 189, 207, 208, 212, 220, 224–228, 232, 233, 248–249, 265.
Lower Coeymans, lower and upper New Scotland,[2] lower Oriskany (Trilobite beds), and upper Oriskany (zone of *S. murchisoni*): Trilobite Mountains, N. Y.

1905. *Spirifer cyclopterus.* Clarke and Luther, New York State Mus. Bull. 82, p. 40.
Lower Helderbergian limestone: Jamesville, Onondaga County, N. Y.

1907. *Spirifer cymindis.* Clarke, New York State Mus. Bull. 107, p. 255, figs.
Lower Devonic: Presque Isle Stream, Chapman Plantation, Aroostook County, Maine.

This is a plicated Spirifer of small size, 6 to 9 low plications, square or rounded lateral extremities, and semicircular outline; hinge line straight, a little less than the greatest width of the shell; proportion of length to width varying from 8 or 9 to 12; greatest width just below the posterior margin, rarely at the hinge. Pedicle valve strongly convex, but only slightly more so than the brachial valve; gibbous over umbonal region.

The greatest depth of the pedicle valve is equal to about one-third the length and is situated at two-fifths of the distance from beak to front. Transverse profile low, broadly subcarinate. Umbone tumid, obtuse, strongly arched over the hinge; beak incurved so that the tip is not the most posterior point of the shell. Cardinal area of medium height, curved, nearly in the plane of the edges of the valve. Delthyrium acute; rarely discernible because of the incurved beak. The musculature on the interior is in general distinctly impressed, though obscure in some specimens. It extends from one-third to two-fifths the length of the valve and is divided into two portions by the median sinus. The musculature is longitudinally striated; adductor scars not discernible. The dental lamellæ are well developed, widely separated, slightly divergent; they extend about one-fourth the length of the shell and are situated either in the second groove on each side of the median sinus or on the corresponding inner fold.

[1] Clarke here records Ells's citation of *S. cyclopterus* from this locality and states that it is "probably *S. murchisoni*"; Clarke found *Spirifer murchisoni* here, but apparently he did not find *Spirifer cyclopterus*.

[2] Shimer divides the New Scotland here into lower (45 feet) and upper (125 feet), the division being based upon the rarity of *Spirifer cyclopterus* in the lower and its abundance in the upper member.

The brachial valve is strongly convex, only slightly less so than the pedicle valve. Longitudinal profile deeply arcuate; the greatest depth is at the middle and is equal to about one-third the length of the brachial valve.

Transverse profile carinated by the median fold. The umbonal part of the valve is deeply arched downward to the hinge; rarely does the posterior extremity extend beyond the hinge line. On internal molds of the brachial valve a pair of short, rounded incisions, about a millimeter in length, represent the crural bases adherent to the bottom of the valve. The musculature of the brachial valve is not impressed; the median septum or elevated line in the brachial valve extends about half the length of the shell. On the surface six to eight plications appear each side of the fold and sinus; the prevailing number of plications is seven, or seven with an indistinct eighth plication; in one large shell nine ribs were counted. The extreme lateral extremities are smooth, the outermost plications being obsolescent and the ribs increasing in strength and width toward the middle. The plications are strong, rounded to subangular, interspaces rarely equal to the width of the ribs. The sinus of the pedicle valve is deeply excavated and slightly flat in the bottom; it is equal in width to two or three of the bounding ribs and is extended tonguelike forward and toward the fold of the opposite valve. The median fold is strongly elevated, subcarinate, and equal in width to two or three of the bounding ribs. The finer surface ornamentation consists of extremely fine radiating lines visible only under a hand lens, and crossed and more or less interrupted by stronger or weaker concentric lines of growth. This ornamentation is discernible only on external molds. The shell structure is finely fibrous, impunctate. The inner layer of the shell is thicker than the outer layer and the fibers are radially or prismatically arranged as usual. In the outer thin layer the fibers are concentrically arranged, curving over the ribs, and are parallel to the lines of growth. The largest specimen observed, a pedicle valve from the west side of Edmunds Hill (Pl. II, fig. 8) is 23 by 34 millimeters and has seven or eight ribs on each side. The smallest specimen observed (Pl. I, fig. 8), from the same locality, is 7 millimeters long and 10 millimeters wide and has six ribs on each side. Large specimens 20 millimeters long or more are not rare, but the majority of specimens are from 14 to 18 millimeters long.

Locality: Chapman sandstone, Edmunds Hill, Presque Isle Stream, and 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59738 to 59740.

Comparison of Chapman forms of Spirifer cyclopterus with New York material.—This species was originally described as having from five to seven rounded plications on each side of the fold and sinus. Only two among scores of individuals from Edmunds Hill were observed with five plications; seven seems to be the predominant number, as in the New York types. Individuals with eight plications are also rather common in the Chapman sandstone, and one specimen was found having nine ribs on the side. Hall fails to mention the occurrence of eight plications in the New York Helderbergian forms of the species, but that number may be counted on the figures of his types as illustrated in Plate XXV, figures 1 h, l, m, n, and (?) r.

In the Coeymans limestone of New York and New Jersey, or basal Helderberg—an early stage of the range of the species—young specimens of *Spirifer cyclopterus* have only three, four, or five plications and are with difficulty distinguishable from the antecedent *Spirifer vanuxemi* of the Manlius. The occurrence of seven plications in the young individuals from the Chapman sandstone of Edmunds Hill suggests that the Chapman represents a stage after the species had become substantially fixed. This deduction is supported by the large size at maturity, and also by the strengthened musculature—a feature that will be referred to again.

The few specimens from the locality 2½ miles west of Presque Isle Stream have only five ribs on each side of the fold and sinus, and one individual has only four. The shells are also of smaller size. If really identifiable with *Spirifer cyclopterus*, they suggest either an earlier stage or adverse conditions of environment.

The larger Chapman specimens represent to some extent a transition toward the Oriskanian *Spirifer murchisoni* Castelnau. The typical *Spirifer cyclopterus* is distinguished by its rounded, not acute lateral extremities, the relative faintness of the muscular scars in the pedicle valve, and the smaller size. In size and in abundance of individuals with strongly impressed musculature the Chapman shells approach the larger and later species *Spirifer murchisoni;* but they have the rounded shoulders and less transverse outline of the normal *Spirifer cyclopterus,* which is more primitive both chronologically and phylogenetically than Castelnau's Oriskanian species.

Stratigraphic and geologic significance of the evolution of Spirifer cyclopterus.—In the succession from the typical Silurian, through the Helderberg, into the basal Devonian of western Europe, represented by the Oriskany of North America and the Taunus quartzite or Siegen graywacke horizon of Europe, the evolution of the Spirifers, from the *plicatus-inchoans-"mercurii"* type through the *cyclopterus-hystericus* and into the *murchisoni-primævus* type, furnishes an admirable example of the intimate relation between phylogenetic evolution and geologic chronology.

The *murchisoni-primævus* form of Spirifer, evidently derived from the *cyclopterus-hystericus* type, abruptly supplants the latter as the diagnostic feature of the fauna in the Oriskany of America and in the Taunusian of Germany, Belgium, France, and England. These formations apparently represent a very small stratigraphic range and constitute the base of the Devonian of western Europe. This fauna is marked, both in America and in Europe, by the attainment of the plicated fold and sinus as a fixed specific character in Spirifer—*Spirifer arenosus* in the American Oriskany and *Spirifer bischofi* and *S. daleidensis* in the European Taunusian. The evolution of the Oriskanian *arenosus* type of Spirifer from the antecedent *Spirifer concinnus* form marks the change into the basal Devonian of western Europe perhaps even more conspicuously than the evolution of the *murchisoni-primævus* Spirifers from the antecedent *cyclopterus-hystericus* type.

It is quite true that in the late Helderbergian there occur, along with *Spirifer cyclopterus,* individuals which attain most of the characters of the Oriskanian *Spirifer murchisoni.* Such a condition gives rise to the occasional recording of *Spirifer murchisoni* in beds older than the Devonian of western Europe. However, such citations evidently indicate only extremes of *Spirifer cyclopterus* developed during the Helderbergian type of that species; the essential fact still remains that as fixed specific types the *Spirifer murchisoni* expression does not supplant the *Spirifer cyclopterus* type until the Oriskany or Taunusian epoch, which marks the beginning of the typical Devonian of Devonshire, Cornwall, and Rhenish Europe.

Below the Coeymans limestone horizon, or base of the Helderbergian, the *Spirifer cyclopterus* expression is unknown in the New York or Appalachian succession, though in the Silurian basins of the Fundy region in North America [1] and of Poland in Europe [2] species approaching the *Spirifer cyclopterus* phase of development originated as early as the Aymestry or Middle Ludlow horizon. These Silurian species, however, seem to be indigenous to their more or less isolated basins. There is little or no indication that they developed continuously into and gave rise to the Helderbergian *Spirifer cyclopterus* of America, or to the *Spirifer hystericus* of the Gedinnian and more especially of the basal Devonian of western Europe. In the Appalachian region of North America *Spirifer cyclopterus,* or species of this type, are so completely unknown in the Manlius or older rocks that it may be safely assumed that they did not exist. In fact, *Spirifer cyclopterus* does not attain its mature development and dominance earlier than the New Scotland and later horizons of the Helderberg group.

Although in the mature stage *Spirifer cyclopterus* is quite distinct from the Manlius species, *Spirifer vanuxemi* Hall, the fact has been long recognized that in some of its phases the Helderberg species is closely related to the antecedent Manlius limestone form. In the description of

[1] *Spirifer subsulcatus* Hall, from Arisaig, Nova Scotia (Hall, James, Canadian Naturalist and Geologist, vol. 5, 1860, p. 145; also in Dawson's Acadian geology, 3d ed., 1878, p. 597). See also Twenhofel, W. H., and Schuchert, Charles, The Silurian section at Arisaig: Am. Jour. Sci., 4th ser., vol. 28, 1909, p. 161, etc. In the Arisaig section the species occurs in the Moydart and Stonehouse formations.

[2] *Spirifer bragensis* Waujukow (Fauna der silurischen Ablagerungen des Gouvernements Podolien: Materialen zur Geologie Russlands, vol. 19, p. 138, pl. 2, figs. 7, 8, 1899), which very closely resembles Hall's *Spirifer subsulcatus,* occurs at Brage, Grentschuka, Orsinena, Sokola, Kamentza-Podolska, and Satanova in Poland. It is the characteristic Spirifer of the Kamenetz or Coral limestone of the Polish Silurian. This horizon is distinguished by *Pentamerus vogulicus* De Verneuil [*Conchidium knighti* (Sowerby)], *Wilsonia wilsoni* (Sowerby), large Chonetes, *Ilionia prisca* Hisinger, Oriostoma [Poleumita], and other large gastropods and other shells besides the corals. The horizon evidently corresponds with the Aymestry of Britain and with the Moydart formation about Arisaig, Nova Scotia. In the Poland basin *Spirifer bragensis* is reported to continue upward into some limestones which contain a fauna strongly suggestive of the Coeymans or lower Helderbergian.

Spirifer vanuxemi, Hall[1] states that the species "differs from the *S. cyclopterus* of the shaly limestone in its smaller size and less numerous plications, as well as in the fine concentric and radiating striæ of the surface"; the supposed distinction in the finer ornament does not exist. I seem to have been the first to suggest[2] the actual derivation of *Spirifer cyclopterus* from *Spirifer vanuxemi* Hall. In 1893 the close relationship of *Spirifer cyclopterus* and *Spirifer vanuxemi* Hall was indicated by Hall and Clarke, who joined *Spirifer cyclopterus* Hall (Helderbergian), *S. tribulus* Hall, *S. murchisoni* Castelnau, and *Spirifer hemicyclus* Meek and Worthen (all three Oriskanian) in the same group with *Spirifer crispus* (Linnæus), *Spirifer vanuxemi* Hall, *Spirifer saffordi* Hall, and *Spirifer octocostatus* Hall. This association was based chiefly on the occurrence of the same type of peculiar surface ornamentation and other characters, in spite of the fact that the first group of species named are true Spirifers, whereas the second group of species, with the exception of *Spirifer vanuxemi* Hall, belong to the round-shouldered, septate division of Spirifer known as Reticularia.[3] The determination of the same type of surface ornamentation in both *Spirifer cyclopterus* and *S. vanuxemi* Hall leaves the only distinction between these two species the larger size and more numerous ribs of *S. cyclopterus.*

Shimer has described from the Coeymans limestone of Trilobite Mountain, N. Y., young *Spirifer cyclopterus* having only three or four ribs and with rounded outline and convexity as in *Spirifer vanuxemi* Hall; but the young *Spirifer cyclopterus* specimens indicated are proportionately wider than *Spirifer vanuxemi.* He observes that "with the exception of this last fact, the similarity between the two species is almost perfect and suggests a possible derivation."[4] A couple of years earlier Weller[5] observed: "A few small specimens [from the Coeymans limestone of New Jersey], which are apparently the young of this species [*S. cyclopterus*], agree closely with specimens of *vanuxemi* from the Manlius limestone, and at first were so identified, and some of these retain the fine surface markings of the species. It is possible that *S. vanuxemi* is ancestral to this Helderbergian species."

It is thus seen that *Spirifer cyclopterus* and *Spirifer vanuxemi* both have the same peculiar fine surface markings; both are small, with both valves subequally convex and with only a few rounded plications, nonextended outline, and rounded cardinal extremities. Finally, and of still greater importance, where *Spirifer cyclopterus* first appears in the Coeymans limestone the young are with great difficulty, if at all, distinguishable from *Spirifer vanuxemi.* *Spirifer cyclopterus* begins its appearance in the Coeymans where *S. vanuxemi* ends its existence; and *Spirifer cyclopterus* differs from *S. vanuxemi* only in its slightly wider form, less broadly rounded shoulders, somewhat larger size, and slightly greater number of plications at maturity—all features that might be expected to develop along this line of descent.[6] It is thus apparent, as has been indicated by many paleontologists, that *Spirifer vanuxemi* is the ancestral form of *Spirifer cyclopterus;* and this conclusion receives additional support from the fact that Scupin,

[1] Paleontology of New York, vol. 3, p. 198, 1859.

[2] Williams, H. S., The life history of *Spirifer lævis:* Am. Jour. Sci., 3d ser., vol. 20, p. 459, 1880; also in New York Acad. Sci. Annals, vol. 11, 1881.

[3] Certain forms of *Spirifer crispus* and of the variety *simplex* Hall, as occurring in the Niagaran of the Mississippi Valley, possess a median septum, dental lamellæ, and minute radiating spines arranged in fringes, characters which serve to remove the shells from true Spirifer and to associate them with Reticularia. (See Kindle, E. M., and Breger, C. L., Paleontology of the Niagara of northern Indiana: Indiana Dept. Geology and Nat. Resources Twenty-eighth Ann. Rept., p. 442, pl. 8, figs. 26–28, 1904.) The same conditions have apparently been noted in European specimens of *Spirifer crispus* by Scupin. On the other hand, forms identifiable with *Spirifer crispus* from the Niagaran or Wenlock faunas of Maine, New York, and Great Britain distinctly lack the median septum and fine radial ornament, as well as any conspicuous dental plates, and appear to be true Spirifer forms. *Spirifer octocostatus* Hall and *Spirifer saffordi* both possess a median septum, dental lamellæ, and fringes of radial spines and belong in the same section of Reticularia with the septate forms of *Spirifer* (*Reticularia*) *crispa.* The genus Cyrtinopsis has been erected by Scupin (Neues Jahrb., 1896, vol. 2, p. 247; Spiriferen Deutschlands, 1900, p. 212) for Kayser's Devonian *Spirifer undosus* and was apparently intended to include the septate *Spirifer* (*Reticularia*) *crispa.* It may ultimately prove advisable to retain the generic name Cyrtinopsis for Reticularias with only single-barreled spines, to restrict the name Reticularia to species having double-barreled spines, and to adopt Gemmellaro's Squamularia (see Girty, G. H., Carboniferous formations and faunas of Colorado: U. S. Geol. Survey Prof. Paper 16, p. 387, 1903) for Reticularia-like shells lacking the median septum and dental lamellæ in the pedicle valve. The generic name Cyrtinopsis, in the strictest sense, was used by Scupin for Reticularia-like fossils in which the median septum, instead of being intercalated between the dental lamellæ, as in true Reticularia, originated by the union of the forward ends of the converging dental lamellæ, as in Cyrtina and some Spiriferina species.

[4] New York State Mus. Bull. 80, p. 248, 1905.

[5] Paleontology of New Jersey, vol. 3, p. 287, 1903.

[6] See Raymond, P. E., Developmental changes in some common Devonian Brachiopoda; Am. Jour. Sci., 4th ser., vol. 17, pp. 279–300, pls. 12–18, 1904. According to Raymond, the steps in the evolution of Spirifers are, first, the development of the transversely extended shell from narrow, nonextended forms; the development of the earlier round-shouldered types into square-shouldered forms, then into the type having acute extremities, and finally into the broad pennate and mucronate forms; the increase in the number of plications and in the size; and the increasing dissimilarity in convexity of the two valves.

working in Europe on entirely independent lines and with different species, has concluded that the ancestral Spirifers are smooth forms of the Reticularia (Cyrtinopsis) type which evolve, through some such form as *Spirifer mercurii* Gosselet in the Gedinnian—a species resembling *S. vanuxemi* or intermediate between *S. vanuxemi* and early *S. cyclopterus*, but septate—into the group of *S. hystericus* (equivalent to mature *S. cyclopterus, tribulus*, etc.), indicating a line of descent similar to that occurring in America.

To geologists acquainted with *Spirifer cyclopterus* and *S. murchisoni* the derivation of the latter from the former is more or less apparent. *Spirifer murchisoni* differs from *S. cyclopterus* in its slightly larger size, less rounded and sharper cardinal extremities, more transverse outline, and persistently very strong musculature, a series of features less distinct and less constant than the differences between *S. cyclopterus* and *S. vanuxemi*. The *S. murchisoni* form first appears in the uppermost Helderberg associated with *S. cyclopterus* in such a way that the derivation of the *S. murchisoni* expression from *S. cyclopterus* is always self-evident. In the Oriskanian *S. cyclopterus* is supplanted by *S. murchisoni*. It is to be noted that *S. cyclopterus*, wherever recorded from the Oriskanian—as at Glenerie, N. Y., and at the Blowhole localities, Gaspe—is accompanied by *S. murchisoni*. Such specimens of *S. cyclopterus* might be regarded as unmature *S. murchisoni* and as corroborating the derivation of the latter from the former. In this connection, too, it should be borne in mind that every large collection of *S. cyclopterus* contains some individuals varying toward the wide form, or the sharper cardinal extremities, or larger size, or stronger musculature of *S. murchisoni;* and that the features named, by which *S. murchisoni* differs from *S. cyclopterus*, are among the evolved features to be expected in this line of descent from *S. cyclopterus* to *S. murchisoni*.

A feature which has received scant attention in the study of the evolution of Spirifers is the strengthening of the muscular impressions in the pedicle valve. This strengthening is due to the fact that the cavities on the interior of the valve between the dental lamellæ and latero-umbonal portion of the shell are filled in, or calloused, toward maturity, so that in internal molds the clean-cut incisions of the lamellæ are absent and the musculature assumes a ponderous appearance well typified by Hall's *Spirifer arrectus* (=*S. murchisoni* Castelnau and the corresponding European *S. primævus* Steininger). As the developing of the shell callosity is a feature of maturity or senility, and the *arrectus* type of musculature may develop in the senile stage in Spirifers where it is not in earlier stages normal, this characteristically deeply impressed musculature may be regarded in the light of a feature of maturity or senility in evolution. The early forms of *Spirifer cyclopterus* have a nonimpressed musculature and distinct dental lamellæ; the later *S. murchisoni* has normally the characteristic deeply impressed musculature, shell callosities, and absence of the incisions left on internal molds by the dental lamellæ. Between these forms so distinct are intermediate types in which specimens of undoubted *S. cyclopterus* affiliation have the shell callosities and thick impressed musculature either only at maturity or else beginning rather early in the life of the individual. The fact that a large number of the Chapman specimens of *Spirifer cyclopterus* have a very strongly impressed musculature shows them to be near the mature or senile stage of the species, and the fact that these specimens are much later than the first appearance of *S. cyclopterus* (Coeymans limestone) is shown also by young specimens having seven lateral plications. Forms with only five ribs in the young or at maturity are extremely rare. Among the Chapman specimens are many individuals tending toward *Spirifer murchisoni* in the transversely extended outline. One or two specimens have square or acute hinge extremities as in *S. murchisoni*. The not uncommon deepening of the musculature impression also recalls *S. murchisoni*, but in the latter the musculature is relatively broader.[1] The strong ribs, sometimes subangular, especially on the internal mold, are also an approach toward *S. murchisoni*. On the whole it may be concluded that the Chapman specimens of *Spirifer cyclopterus* indicate a stage of evolution much nearer the Oriskany *S. murchisoni* than the Manlius or Coeymans *S. vanuxemi*.

[1] This was indicated by Shimer (op. cit., p. 248), who states also that the internal mold of the plications is less pronounced in *S. cyclopterus* than in *S. murchisoni*, a condition that is reversed in the Chapman specimens.

From what has been indicated of the variation of the Chapman specimens of *Spirifer cyclopterus* toward *S. murchisoni*, it might be presumed that there is some doubt attending their identification with *S. cyclopterus*, but this is by no means true. The great bulk of the specimens are most typical of *S. cyclopterus*, and those, relatively very few, individuals which in one or two features vary toward *S. murchisoni* agree with *S. cyclopterus* in their main features, besides being associated with normal forms.

European equivalent of Spirifer cyclopterus.—It will at once be recognized that *Spirifer cyclopterus* is hardly distinguishable from many forms of *S. hystericus* Schlotheim, the fossil which, with *S. primævus*, is the characteristic species of the Taunusian or Siegen graywacke. However, so variable is the specific assemblage designated *S. hystericus* by authors that it is very difficult to define satisfactorily the limits of the species or even to recognize which of the variable forms was intended by Schlotheim as the type. According to Scupin,[1] "As a rule the greatest width, which is along the hinge line or rarely somewhat below it, is only about double the length of the shell; however, by the pennate elongation of the lateral portions, the width may be as much as six or more times the length." *Spirifer cyclopterus* in complete uncrushed specimens is practically never twice as broad as long, the width, in fact, rarely exceeding 1½ times the length. The maximum width is normally below the hinge line and the cardinal extremities are rounded; only very rarely do "sports" occur with the maximum width at the hinge line. Such "sports" seem to be the normal form in *S. hystericus.* The number of ribs in *S. hystericus,* according to Scupin,[2] "varies mostly between nine and thirteen on each side, though also passing below these figures." *Spirifer cyclopterus* does not have more than nine plications, and extremely rarely as many as nine; less rarely eight. The species was, in fact, described by Hall as having only five to seven ribs on each side. In spite of these differences and a few minor points that would seem to indicate an easy distinction between *S. cyclopterus* Hall and *S. hystericus* Schlotheim, there are many European Spirifers, called *S. hystericus*, which seem to be indistinguishable specifically from *S. cyclopterus.* Among these are *S. hystericus* Scupin,[3] a small form with only six or seven ribs on each side, the ribs subangular and about as wide as the interspaces, the greatest width a third the length in front of the hinge and equal to about one and two-thirds times the height. This form is almost a typical *S. cyclopterus;* it is slightly more transverse, though no more so than many of those specimens of *S. cyclopterus* which grade toward *S. murchisoni* in this respect. In fact, if Scupin's figure is, as there is every reason to believe, a good representation of the original specimen, such specimens would with little if any hesitation be referred to *S. cyclopterus* were they found in Helderbergian faunas in America. The specimens do not, however, answer to the description of normal *S. hystericus.* Compare also *Spirifer hystericus*, from the Siegen graywacke of Seifen, in the Westerwald, figured by Drevermann.[4]

Of the modifications of the Taunusian *S. hystericus*, one, *Spirifer prohystericus* Maurer,[5] can not be distinguished from some of the specimens of *S. cyclopterus* as represented in the Chapman fauna. The German fossil is a large form of *S. cyclopterus,* having the musculature well developed, but with distinct incisions of the dental lamellæ. It has six, seven, or eight subangular ribs, the sinus angular and fold carinate, and the width normally less than 1½ times the height in the Freusburg specimens, though it is more elongated transversely in the typical Seifen form. The type is homologous with the form of *S. cyclopterus* prevalent in the Oriskany of Glenerie, Ulster County, N. Y.

[1] Scupin, Hans, Die Spiriferen Deutschlands, p. 13, 1900. That *Spirifer hystericus* is normally a transversely elongated species with acute cardinal extremities and with the width about twice the height or more is not only indicated by Scupin's explicit description and some of his figures, but may also be seen by a glance at Drevermann's figures 1, 2, 5, 7 (Palaeontographica, vol. 50, pl. 30, p. 263, 1904) of *S. hystericus* from the Siegen graywacke about Seifen, in the Westerwald.

[2] Idem, p. 13.

[3] Idem, pl. 1, fig. 3.

[4] Palaeontographica, vol. 50, p. 253, figs. 3, 4, 6 (not figs. 1, 2, 5, 7), 1904.

[5] Die Fauna des rechtsrheinischen Unterdevons, p. 19, Darmstadt, 1886. Scupin (op. cit., p. 15, pl. 1, figs. 9 and 10 a–d) takes the liberty to change the name to *S. subhystericus*. The species is from the Taunusian or *Spirifer primævus* zone of Seifen, near Dierdorf, and also at Freusburg.

The "*Spirifer mercurii*" Gosselet, from the Gedinnian, bears a strong resemblance superficially to small early forms of *S. cyclopterus* approaching *S. vanuxemi*, but the Belgian species has a median septum in the pedicle valve [1] and is therefore not a Spirifer, but belongs rather in the Reticularia-Cyrtinopsis-Delthyris group.

SPIRIFER MURCHISONI Castelnau.[2]

Plate I, figures 3, 10, 23, 25, 26; Plate II, figure 9.

cf. 1842. *Spirifer quichua*. D'Orbigny,[3] Voyage dans l'Amérique méridionale, Paléontologie, p. 37, pl. 2, fig. 21. "Silurian" [Lower Devonian]: Chuquisaca, Bolivia.

not 1843. *Spirifer (Cyrtia) murchisonianus*. De Koninck, D'Omalius d' Halloy, Précis élémentaire de géologie, p. 523.

1843. *Spirifer murchisoni*. Castelnau, Essai sur le système silurien de l'Amérique septentrionale, p. 41, pl. 12, figs. 1–2. Schoharie, N. Y.

1846. *Spirifer hawkinsii*. Morris and Sharpe, Geol. Soc. London Quart. Jour., vol. 2, p. 276, pl. 11, fig. 1. Devonian: Falkland Islands.

1859. *Spirifer arrectus*. Hall, Paleontology of New York, vol. 3, p. 422, pl. 97. Oriskany sandstone: Throughout New York State and at Cumberland, Md.

1862. *Spirifera arrecta*. Hitchkock, Portland Soc. Nat. Hist. Proc., vol. 1, pt. 1, p. 79. Oriskany sandstone: Parlin Pond to Aroostook River, Maine.

1863. *Spirifera arrecta*. Billings, Geology of Canada, p. 960, fig. 466. Oriskany sandstones: North Cayuga, Canada (p. 361).

1868. *Spirifera engelmanni* (not Meek, 1860). Meek and Worthen, Illinois Geol. Survey, vol. 3, pl. 8, figs. 7a, 7d (not fig. 6). Oriskany siliceous limestone: Union County, Ill.

1874. *Spirifera cycloptera*. Billings, Paleozoic fossils, vol. 2, pt. 1, p. 48, pl. 3a, figs. 4, 4a (not ? figs. 4b, 4c). Gaspe limestone No. 8: Grande Greve and Indian Cove, Gaspe, and Split Rock, Perce, Quebec.

1876. *Spirifer arrectus*. Barrett, Lyceum Nat. Hist. New York City Annals, vol. 11, p. 297. Oriskany: Bennett's quarry, Port Jervis, N. Y.

1877. *Spirifer arrectus*. Barrett, Am. Jour. Sci., 3d ser., vol. 13, p. 387. "Trilobite beds"[4] belonging to the Upper Pentamerus division: Bennett's quarry, near Port Jervis, N. Y.

1879. *Spirifera derbyii*. Rathbun, Boston Soc. Nat. Hist. Proc., vol. 20, p. 26. Devonian: Rio Maecuru and Rio Curua, Para, Brazil.

1882. *Spirifer arrectus*. I. C. White, Pennsylvania Second Geol. Survey Rept. G6, p. 123. Oriskany limy shales: South of Carpenters Point, Pike County, Pa.

1882. *Spirifera arrecta*. Stevenson, Pennsylvania Second Geol. Survey Rept. TT, pp. 86, 103, 132, 148. Oriskany, Hyndman section: Exline road, King Township, and Bedford Springs, Bedford County, Pa.

?1883. *Spirifera cycloptera* (not ?Hall). Ells, Canada Geol.-Survey Rept. Progress for 1880–1882, pp. 9DD, 14DD. Upper Gaspe limestone (Oriskany): Perce Rock, the Blowhole, Indian Cove, Grande Greve, and Little Gaspe, Gaspe Bay, Quebec.

1883. *Spirifera arrecta*. Hall, New York State Geologist Second Ann. Rept., pl. 58, figs. 24–27. Oriskany sandstone: Albany County, N. Y.

1883. *Spirifera arrecta*. I. C. White, Pennsylvania Second Geol. Survey Rept. G7, pp. 297, 305, 346. Oriskany (cherty beds): Grove Bros.' tunnel, Cooper Township, and along the road in eastern part of Mahoning Township, Montour County, Pa.; Upper Augusta Township, Northumberland County, Pa.

1884. *Spirifera raricosta* (not Conrad). Walcott, U. S. Geol. Survey Mon. 8, p. 135, pl. 4, fig. 2 (not fig. 2a; not pl. 14, fig. 12). Lower Devonian limestone: Lone Mountain, 18 miles northwest of Eureka, Eureka district, Nev.

1884. *Spirifer arrectus*. Ewing, Pennsylvania Second Geol. Survey Rept. T4, p. 431. Oriskany coarse-grained sands with calcareous cement: Alexander quarry, between Julian and Unionville, Center County, Pa.

1885. *Spirifera arrecta*. I. C. White, Pennsylvania Second Geol. Survey Rept. T3, pp. 119, 274. Oriskany coarse sandstone: Sand Ridge, Mapleton, Huntingdon County, Pa.

?1885. *Spirifera cycloptera* (?not Hall). Ells, Canada Geol. Survey Rept. Progress for 1882–1884, p. 24E. Gaspe limestone No. 8: Grande Greve, Gaspe Bay.

1887. *Spirifera arrecta*. Ami, Canada Geol. Survey Ann. Rept., new ser., vol. 2, p. 9N. Oriskany slates and sandstones: Campbell River, at mouth of the Don, New Brunswick.

1889. *Spirifera arrecta*. Claypole, Pennsylvania Second Geol. Survey Rept. O3, p. 151. Oriskany sandstone: Grove Bros.' lime quarry, Montour County, 3½ miles from Rupert, Columbia County, Pa.

1889. *Spirifera arrecta*. Schuchert, New York State Geologist Eighth Ann. Rept., p. 53.

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[1] See Gosselet, J. A., Esquisse géologique du Nord de la France, pl. 1, fig. 8, 1880.

[2] Does not occur in the Chapman fauna. See remarks on p. 86, which likewise apply to this species.

[3] This species is a pauciplicate form closely resembling *Spirifer murchisoni* and may prove to be identical with the pauciplicate form of that species.

[4] These are now called the *Dalmanites dentatus* zone. They represent a horizon between the Port Ewen limestone (No. 6 of Barrett's section) and the Oriskany, and are commonly included with the Oriskany.

1889. *Spirifera arrecta.* Simpson, Pennsylvania Second Geol. Survey Rept. O3, p. 208.
Oriskany: Cumberland, Md.; New York; and at Cayuga, Canada West.
Oriskany sandstone: Sandy Ridge sand quarry, south of Blacklog Creek.
Oriskany lime-sand beds: South end of Royers Ridge, and on Royers Ridge, north of the road crossing. Both localities at Orbisonia, Huntingdon County, Pa.

1892. *Spirifer arrectus.* Clarke, Am. Jour. Sci., 3d ser., vol. 44, p. 413.
Oriskany hard cherty limestone: Becraft Mountain, Columbia County, N. Y.

cf. 1892. Spirifer sp. *a.* Ulrich, Neues Jahrb., Beilage Band, vol. 8, p. 67, pl. 4, fig. 22.
Lower Devonian (with *Leptocœlia flabellites*): Totora, Bolivia.

cf. 1893. *Spirifer vogeli.* Von Ammon, Gesell. Erdkunde Berlin Zeitschr., vol. 28, p. 362, fig. 6.
Devonian: Taquarassu, Matto Grosso, Brazil.

1893. *Spirifer arrectus.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pp. 17, 19, 37, pl. 33, figs. 24–27.
Oriskany sandstone: Albany County, N. Y.

1894. *Spirifer arrectus.* Darton, Geol. Soc. America Bull., vol. 5, p. 375.
Oriskany quartzite ["Newfoundland grit" or Kanouse standstone]: Kanouse, 750 yards northeast of the depot at Newfoundland, N. J.

?1895. *Spirifera arrecta.* Ami, Canada Geol. Survey Ann. Rept., new ser., vol. 6, p. 15Q.
Nictau beds: Nictau, Nova Scotia.

1897. *Spirifer murchisoni.* Schuchert, U. S. Geol. Survey Bull. 87, p. 398.
Oriskany: Schoharie and Albany counties, N. Y.; Cumberland, Md.; Cayuga, Ontario; near Totora, Bolivia.

1897. *Spirifer worthenanus* (pars). Schuchert, idem, p. 409.
Oriskany: Union County, Ill.

cf. 1897. *Spirifer antarcticus* (not of Morris and Sharpe). Kayser, Deutsch. geol. Gesell. Zeitschr., vol. 49, p. 297, pl. 9, figs. 1, 2, 4 (fig. 3 approaches normal *S. murchisoni*).
Lower Devonian: Jachal Valley, Argentina.

1898. *Spirifer arrectus* s. str. (pars). Scupin, idem, vol. 48, p. 463, pl. 17, figs. 1a, 1b.
Lower Devonian: Chuquisaca, Bolivia (figured specimens); New York. (Not South Africa.)

1898. *Spirifer arrectus* var. *antarcticus* (pars). Scupin, idem, p. 464, pl. 17, figs. 2a, 2b, not figs. 3a, 3b [*Spirifer chuquisaca* Ulrich, 1892, or the apparently identical *Spirifer boliviensis* D'Orbigny, 1842], and not figs. 4a, 4b [*Spirifer capensis* Von Buch?].
Oriskany: New York.

cf. 1898. *Spirifer arrectus* var. *hawkinsii* (not Morris and Sharpe). Scupin, idem, p. 465, pl. 17, figs. 5a, 5b.
Lower Devonian: Icla (figured specimen) and Totora, Bolivia (Ulrich); Jachal Valley, Argentina (Kayser). Not Falkland Islands shells.

1899. *Spirifer arrectus.* Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), p. 341.
Oriskany sandstone: Countryman Hill, Helderberg Mountains, N. Y.

1900. *Spirifer arrectus* and *S.* "*cyclopterus* Billings." Williams, U. S. Geol. Survey Bull. 165, pp. 89, 92.
Moose River sandstone: Parlin Pond and Brassua Stream, Somerset County, Maine.

1900. *Spirifer murchisoni.* Schuchert, Geol. Soc. America Bull., vol. 11, pp. 294, 311–312, 315.
Oriskany and (?) Helderbergian: Potts Grove, Northumberland County, Pa.; Newry, Blair County, Pa.; Keyser, Mineral County, W. Va.; also in Pendleton County, W. Va., on the north fork of the South Branch of Potomac River.

1900. *Spirifer murchisoni.* Clarke, New York State Mus. Mem., vol. 3, No. 3, pp. 46, 74, 76, 77, pl. 6, figs. 26–30.
Oriskany siliceous limestone: Becraft Mountain, Columbia County; near Kingston, on the West Shore Railroad, half a mile southeast of Rondout Creek, in Ulster County, N. Y., Cuddebackville to Port Jervis, Orange County, and on West Mountain, Schoharie, N. Y.

1901. *Spirifer arrectus.* Prosser, New York State Geologist Eighteenth Ann. Rept., p. 59.
Oriskany dark-gray calcareous sandstone: Altamont section, Helderberg Mountains, N. Y.

?1901. *Spirifer murchisoni.* Schuchert, Am. Geologist, vol. 27, p. 249.
Upper Oriskanian:[1] St. Helens Island, Montreal, Canada.

1903. *Spirifer murchisoni.* Weller, Paleontology of New Jersey, vol. 3, pp. 94, 95, 97, 102, 329, 354.
Dalmanites dentatus zone, or lower Oriskany (siliceous limestone): Trilobite Ridge, Peters Valley, N. J.
Orbiculoidea jervensis zone, or middle Oriskany (siliceous limestone): Werden farm, Nearpass district; also at the first crossroad over Wallpack Ridge, 3 miles south of New York State line; and at the second road, 5 miles south of the State line; New Jersey.
Spirifer murchisoni or upper zone of Oriskany (siliceous limestone beds): Werden farm, Nearpass district; 1½ miles north of Layton; three-fourths of a mile west of Layton, on the road to Dingmans; also at Peters Valley, about half a mile east of Flatbrookville, and in the sandstones forming the top of the Oriskany, three-fourths of a mile north of Peters Valley, N. J.

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[1] In 1910, upon critical study of the breccias of St. Helens Island, I failed to discover any true representatives of the species *Spirifer murchisoni.* Specimens of Spirifers presenting the characters of both *S. gaspensis* and *S. cumberlandica* were found in the limestone fragments with *S. arenosus.* These have the deeply impressed musculature of the pedicle valve, giving, in molds, the characteristic tonguelike projection seen in *S. murchisoni,* but no specimens presenting the typical characters of that species were seen. See Williams, H. S., Fossil faunas of the St. Helens breccias: Roy. Soc. Canada Trans., 3d ser., vol. 3, p. 224, 1910.

?1903. *Spirifer macrothyris* (pars). Weller, idem, pp. 105, 375, pl. 52, fig. 3 (not figs. 1, 2).
Newfoundland grit: Newfoundland, N. J.

1903. *Spirifer murchisoni.* Van Ingen and Clark, New York State Mus. Bull. 69, pp. 1202, 1203, 1207.
Oriskany arenaceous limestones: Glenerie and Rondout, N. Y.

1903. *Spirifer derbyi.* Katzer, Geologie des unteren Amazonasgebietes, p. 274, pl. 11, fig. 3.
Spirifer sandstone: Rio Maecuru and Rio Curua, Para, Brazil.

1905. *Spirifer arrectus.* Harris, Guide to the geology of Union Springs, p. 4, pl. 13, fig. 3.
Oriskany sandstone: Yawger's Woods, Union Springs, N. Y.

cf. 1905. *Spirifer antarcticus* (not Morris and Sharpe). Thomas, Deutsch. geol. Gesell. Zeitschr., vol. 57, p. 267, pl. 13, figs. 22 (?), 23–25.
Devonian: Cerro del Agua Negra, on the road to Gualilan, Argentina.

1905. *Spirifer murchisoni.* Clarke, New York State Mus. Bull. 80, pp. 140, 143, 145, 148, 149, 151, 169.
Perce limestone: Blowhole and Perce Rock, Quebec.
Grande Greve limestones, or divisions 7 and 8 of the Gaspe series, Mount St. Anne, Barre Brook, and other localities on the north shore of Gaspe Bay, Quebec.

1905. *Spirifer murchisoni.* Shimer, idem, pp. 205, 206, 227–229, 234, 251, 265.
Port Ewen blue limestone; Port Ewen-Oriskany transition siliceous limestone in coarse shaly beds; Lower Oriskany, with *Dalmanites dentatus* (dense blue limestone); Oriskany zone with *Orbiculoidea jervensis* (dark-blue heavy-bedded siliceous limestone); upper Oriskany or *Spirifer murchisoni* zone (dark-blue dense limestone): Trilobite Mountain, N. Y.

1905. *Spirifer murchisoni.* Williams and Kindle, U. S. Geol. Survey Bull. 244, pp. 34, 39, 43, 48.
Lewistown limestone [in beds of late Helderbergian age]: Cliff on river bank, half a mile below iron furnace, Covington, Alleghany County, Va.
Oriskany coarse sandstone: Rear of Alabama Row, White Sulphur Springs, W. Va.; half a mile southeast of the iron furnace, Jackson River, Covington, Alleghany County, Va.; half a mile west of Clifton Forge, Alleghany County, Va.

The species *Spirifer murchisoni* is a plicated Spirifer, of medium to large size, having rather transversely extended outline, five to eight simple ribs on each side of the simple fold and sinus, and a characteristic strongly impressed musculature.

Hinge line straight, equal to the greatest width of the shell; hinge extremities angular, generally acute, occasionally rectangular, very rarely a little rounded, occasionally slightly auriculate. The width in the brachial valve is about twice the length. In the pedicle valve, on account of the prominent umbone, the width is less than twice the length.

A series of specimens shows the following dimensions:

Dimensions of specimens of Spirifer murchisoni.

No.	Specimen.	Length (millimeters).	Width (millimeters).	Locality.
1	Brachial valve....	17½	38	Eastern New York (drift in Staten Island).
2	.....do...........	16	33	Do.
3	.....do...........	23	45	Glenerie, N. Y. (5122–6).
4	.....do...........	15½	30	Detroit, Maine (5112–8).
5	.....do...........	22	42	Detroit, Maine (5111–6).
6	.....do...........	18	36	Detroit, Maine (5113–6).
7	.....do...........	26½	56	Union Springs, N. Y. Cornell University collection.
8	Pedicle valve.....	28	50	Do.
9	.....do...........	16	30	Detroit, Maine. Princeton collection.
10	.....do...........	16½	29	Detroit, Maine (5113–7).
11	.....do...........	21	33	Detroit, Maine (5113–3).
12	.....do...........	18½	32	Detroit, Maine (5113–2).
13	.....do...........	19	36	Detroit, Maine (5113–4).
14	.....do...........	16(?)	35	Detroit, Maine (5113–1).
15	.....do...........	16	29	Detroit, Maine (5111–4).
16	.....do...........	25	43	Detroit, Maine (5109–3).
17	.....do...........	25	44½	Eastern New York (drift from Staten Island).
18	.....do...........	18	32	Do.
19	.....do...........	29	56	Do.
20	.....do...........	29	46	Glenerie, N. Y. (5122–1).
21a	.....do...........	29	48	Glenerie, N. Y. (5121–9).
21b	Brachial valve....	24	48	Same shell as 21a. This represents the normal and typical outline.

The two valves are about equally convex. The longitudinal profile of the pedicle valve makes an unsymmetrical curve; its greatest convexity (one-fourth to one-third the length) is at about two-fifths the distance from beak to front; beak prominent, arching over the hinge line, strongly incurved, so that the tip is not the posterior point of the shell; cardinal area of medium height, curved, approaching the plane of the margin; delthyrium acute, its sides forming an angle of 60° or more. On the interior of the pedicle valve the teeth are well developed and are supported by dental lamellæ, which occupy, as in *S. cyclopterus*, the second groove or the second plication from the median sinus. The shell is greatly thickened outside of the lamellæ by a secretion of shelly matter on which the ovarian pits are commonly strongly impressed. As a result of this thickening the dental lamellæ do not leave the usual incision in the internal mold, but the musculature, which, in the shell, is sunk in the cavity between the lamellæ, assumes on the internal mold the character of a very conspicuous, highly elevated tonguelike projection, a feature which suggested the name *Spirifer arrectus* given to the species by Hall. In the New York shells the musculature occupies usually more than half the length of the valve. In those from Detroit, Maine, it is proportionately smaller. The width of the musculature is generally about one-fourth less than its length; the outline is ovate or pentagonal, with the greatest width in front of the middle. The adductor scars are indefinable; the diductors are coarsely striated and ribbed longitudinally. The median sinus of the valve is continued through the musculature. There is also a fairly conspicuous pedicle cavity back of the musculature. The brachial valve is of nearly equal convexity to the pedicle valve and occasionally even a little more convex. The longitudinal profile is rather arcuate, abruptly and strongly incurved at the beak and elevated in front by the lingual projection of the sinus of the pedicle valve into the fold of the brachial valve. The transverse profile is low-carinate. The greatest depth of the valve is just back of the center and is equal to one-fourth or very commonly to one-third of the length. On the interior of the brachial valve the thin median septum or elevated line extends half the length or a trifle more. The musculature is not impressed. The cardinal process is simple, radiately striate (12 to 15 striations may be counted on the Detroit specimens). The crural processes are not cemented to the bottom of the valve, and the incisions left on the internal molds by the cemented portion in *S. cyclopterus* are therefore not discernible in the internal molds of the present species.

On each side of the simple fold and sinus there are (in the Maine specimens) usually five or six, rarely seven plications; the outermost one is obsolescent, and the lateral extremities are smooth. The plications are strongly elevated, rounded, and broader than the interspaces. The sinus in the pedicle valve is low, with a broad, flat space in the bottom. The width of the sinus is equal to or less than that of the two bounding ribs on each side; in many specimens the sinus is only as wide as one of the bounding ribs. Not uncommonly the rib bordering the median sinus is weaker than the adjacent ribs, and in such forms the sinus is generally narrow. The front of the sinus is extended as a tonguelike projection up into the fold of the brachial valve. This fold is strongly elevated, sometimes extremely so, depending on the amount of upward extension of the sinus. The fold is occasionally equal in width to the two bounding ribs on either side, but is commonly not quite so wide. Rarely there is a very obscure indication of a faint median riblet in the sinus of the pedicle valve. The finer surface ornamentation consists of closely set, inconspicuous concentric lamellæ crossed by very fine radiating lines. The latter may be continuous over or interrupted in crossing the concentric lamellæ, depending on the strength of the latter. The size of the specimens from Detroit has already been indicated. The largest specimen (No. 16 in the foregoing table) is 25 by 43 millimeters; the smallest specimen is 10 by 18 millimeters.

Locality: Moose River sandstone, abundant at Detroit (locality 1100 A); also at Big Brassua Lake (locality 1062 A′); both in Somerset County, Maine. No shells of the *Spirifer murchisoni-primævus* type occur in the Chapman fauna.

U. S. National Museum, catalogue Nos. 59741, 59742.

Comparison with New York specimens.—The general characteristics of this common Oriskany species are well described by Hall[1] under the name *Spirifer arrectus*. Further descrip-

[1] Paleontology of New York, vol. 3, p. 422, pl. 97, 1859.

tion is given by Clarke,[1] with illustration of the surface markings. In Clarke's paper the propriety of recognizing the name *S. murchisoni* proposed by Castelnau [2] is well stated. Clarke has also called attention to a paper by Scupin,[3] in which the distribution and variation of the form are thoroughly discussed. The specimens from Detroit, Maine, present the prominent characters of the species but show a smaller range of variation than is to be noticed in the New York specimens taken as a whole.

The 60 specimens in the Survey collection are in size rather below the average of specimens from the faunas of New York and Maryland. The largest specimen is 25 millimeters long and 43 millimeters wide. Two specimens (brachial valves) may be selected as representing the average dimensions and variation:

Specimen No. 5382–3, 37.5 millimeters wide, 28.8 millimeters long.
Specimen No. 5382–1, 37.8 millimeters wide, 22.6 millimeters long.

Both of these specimens are apparently undistorted by pressure. The length from beak to front of pedicle valves is greater than the length of brachial valves of the same size, on account of the prominent overarching beak. The convexity of the valves is approximately the same, and the number of plications is normally six on each side of the median fold of the brachial valve; six plications bound the sinus of the pedicle valve and occasionally there is a faint trace of a seventh on the cardinal angle when this is extended and well preserved.

On several of the specimens the plication next to the sinus of the pedicle valve is distinctly less strong and less elevated than the next adjoining plication. The bottom of the sinus in well-preserved molds of the exterior is distinctly flattened for a width of about 1½ millimeters; otherwise all the plications, as well as the grooves between them, are evenly rounded. The median fold of the brachial valve is narrower and less elevated than in the New York Oriskany shells, a difference due partly to smaller size. The muscular scar on the interior of the pedicle valve is narrower and more angular than in typical forms from New York.

The specimens from the Moose River sandstone are specifically the same as the smaller specimens of *S. arrectus* Hall from the New York-Appalachian Oriskany.

Varieties of Spirifer murchisoni.—Scupin [4] has divided the American forms of *Spirifer murchisoni* into two "varieties." The first form, to which the name *S. arrectus* Hall [5] was given, Scupin characterized as being strongly inflated, with high, keel-like or rounded fold, and correspondingly deep sinus. Scupin here includes the following forms:

Spirifer arrectus. Hall, Paleontology of New York, vol. 3, p. 422, pl. 97, figs. 1 (except 1e and 1f), 1859; idem, vol. 8, pt. 2, pl. 33, figs. 24, 26 (not fig. 25), 1893.
Spirifer antarcticus. Sharpe, Geol. Soc. London Trans., vol. 7, p. 206, pl. 26, fig. 1, 1856.
Spirifer orbignyi. Sharpe, idem, p. 207, pl. 26, fig. 3.

The second "variety," in Scupin's interpretation,[6] includes a "less inflated form with lower fold and flat sinus" and comprises the following forms:

Spirifer antarcticus. Morris and Sharpe, Geol. Soc. London Quart. Jour., vol. 2, p. 276, pl. 11, fig. 2, 1846.
Spirifer orbignyi. Morris and Sharpe, idem, p. 276, pl. 11, fig. 3.
Spirifer capensis. Von Buch, K. Akad. Wiss. Berlin Abh., fig. 1, 1846.
Spirifer antarcticus. Sharpe, Geol. Soc. London Trans., 2d ser., vol. 7, p. 206, pl. 26, figs. 2 and 5 (not 1), 1856.
Spirifer orbignyi. Sharpe, idem, p. 207, pl. 26, figs. 4, 6 (not 3).
Spirifer arrectus. Hall, Paleontology of New York, vol. 3, pl. 97, figs. 1e and 1f, 1859.
Spirifer chuquisaca. Ulrich, Neues Jahrb., Beilage Band, vol. 8, p. 65, pl. 4, figs. 19, 20, 1893.
Spirifer antarcticus. Kayser, Deutsch. geol. Gesell. Zeitschr., vol. 49, p. 297, pl. 9, figs. 1–4, 1897.

To his second "variety" Scupin applied the name *antarcticus* of Morris and Sharpe.

It so happens that these "varieties" are of some value, but in a sense somewhat different from that suggested by Scupin. The forms of *Spirifer murchisoni* from Glenerie, N. Y.,[7] repre-

[1] New York State Mus. Mem., vol. 3, p. 46, pl. 6, figs. 26–30, 1900.
[2] Système silurien de l'Amérique, p. 41, pl. 12, figs. 1, 2, 1843.
[3] Deutsch. geol. Gesell. Zeitschr., vol. 50, p. 462, 1899.
[4] Scupin, Hans, Ueber exotische, zur gruppe des *Spirifer primævus* gehörige Formen: Deutsch. geol. Gesell. Zeitschr., vol. 50, pp. 462–467, 1898.
[5] See Paleontology of New York, vol. 3, p. 97, all figures excepting figs. 1e and 1f, 1859.
[6] Scupin, Hans, op. cit., p. 463.
[7] This locality has become well known through the efforts of Gilbert Van Ingen, who has worked out a large series of silicified shells from the Oriskany there. See his report, The Oriskany fauna of Glenerie, Ulster County, N. Y.: New York State Mus. Bull. 69, pp. 1199–1208, 1903. See also Clarke, J. M., New York State Mus. Mem., vol. 3, No. 3, pp. 74–75, 1900. A suite of specimens kindly furnished by Dr. Van Ingen has been of value in the discussion of several species in the present paper.

sent typically Scupin's first form or "variety" *arrectus*, and the forms of *Spirifer murchisoni* from Union Springs, N. Y., represent typically his second form, var. *antarcticus*. In this second form, however, specimens with a high fold and deep sinus, supposedly characteristic of the first variety are common; and vice versa, in the first form from Glenerie, many specimens with a lower fold and shallow sinus, supposedly characteristic of the second variety, have been observed. The development of fold and sinus can not, therefore, be considered a distinctive criterion; and convexity of the valves is an equally or even more interchangeable character. The inadequacy of Scupin's distinctions between the two forms has already been indicated by Clarke,[1] who considers "it practically certain that these differences are altogether fugitive." This conclusion certainly seems proper; but Scupin's two "varieties" as indicated may be retained to some extent on other grounds.

The first form, or variety *arrectus* Hall (per Scupin), is a type characterized by only five or six lateral plications. The outline is commonly a trifle less transversely extended than in the second form and the shells are commonly a trifle smaller. This form occurs at Glenerie, N. Y., and in Maine, as well as at Nictau, Nova Scotia, and is characteristic of the finer-grained rocks. The second form, the so-called variety *antarcticus* of Scupin, is characterized by seven or eight lateral plications. This form occurs in the coarser Oriskany sediments, as at Union Springs, N. Y., and at Cumberland, Md.

These two forms are not persistently sharply differentiated, at least not sufficiently so to warrant distinct specific names. At most localities intermediate forms occur. At Carlisle, N. Y., and probably also at Schoharie, both forms occur together. The distinctions indicated in the present paper have been found to be more constant and valuable than those suggested by Scupin. The gibbosity of the shells and the depth of fold and sinus are features which not only have been found to vary most confusedly, but which are also commonly dependent on modes of preservation of the fossils; at best they are only incidental characters. On the other hand, the number of ribs, the size, and the relative extension transversely are features of evolutional value in the Spirifers; moreover, they are not affected by conditions of preservation, and, most important of all, they are least variable among specimens associated in a single faunule.

Geologic range.—*Spirifer murchisoni* represents a development of Spirifer which appears to be restricted to rocks ranging from the late Helderbergian through the Oriskany or Lower Coblenzian faunas. It is represented in the Lower Devonian of Europe, South Africa, and South America, and practically at all places in North America where rocks of this age occur. In different regions different names have been given to Spirifers of this type. A close study of these will be of some value.

Similar forms in North America.—The *Spirifer cyclopterus* of Hall, the ancestral form of *Spirifer murchisoni*, has already been discussed. It is typically smaller, with rounded, less sharp cardinal extremities and a less transversely extended outline. On the interior the crural processes have been observed to be cemented to the bottom of the brachial valve for about 1 millimeter in *S. cyclopterus;* in *S. murchisoni* the crural processes are free. In *S. murchisoni* the musculature is always deeply impressed; in *S. cyclopterus* typically not so. The fold and sinus commonly are relatively wider in *S. cyclopterus* than in *S. murchisoni. Spirifer cyclopterus* ends in the uppermost Helderberg and Oriskany, where *Spirifer murchisoni* begins.

Spirifer duodenarius Hall, which also presents close affinity with *Spirifer murchisoni*, has the sharp cardinal extremities, transversely extended outline, six or seven rounded ribs, and strong musculature of *S. murchisoni*, but differs in having a narrower cardinal area in the pedicle valve. In the present paper attention has been called to the weakening of the rib bounding the median sinus and the frequent narrowness of fold and sinus in *S. murchisoni*. These are normal features of *Spirifer duodenarius*, in many specimens of which the median fold is not much wider than the bounding ribs. The musculature is a little less strongly impressed in *S. duodenarius* than in *S. murchisoni*. The latter begins in the upper-

[1] Clarke, J. M., Oriskany fauna of Becraft Mountain, Columbia County, N. Y.: New York State Mus. Mem., vol. 3, No. 3, p. 47, 1900.

most Helderbergian and ranges through the faunas of Oriskany and Lower Coblenzian type; *Spirifer duodenarius* is reported from the Schoharie grit and Moose River sandstone and ranges through the "Corniferous."

Spirifer hemicyclus Meek and Worthen,[1] from the Oriskany fauna of Illinois, has been regarded as a synonym of *Spirifer murchisoni*, but under this name Meek and Worthen have included two apparently very distinct species.

Spirifer hemicyclus is a species of the same size and the same proportion of width to length as *S. murchisoni*, but it has ten to twelve angular ribs on each side of the median fold and sinus, compared with five to eight in *S. murchisoni;* its cardinal area is very high and almost perpendicular, whereas in *S. murchisoni* the cardinal area is of medium height and approaches the plane of the margin; and the width of the fold or sinus is equal to that of the three or four bounding ribs, compared with only two or less in *S. murchisoni*. However, the second form of Spirifer, which was doubtfully believed by Meek and Worthen [2] to be identical with *S. hemicyclus*, is quite distinct and presents the normal aspect of *Spirifer murchisoni*, with which it ought to be identified. This second species should be regarded as fixing the occurrence of *Spirifer murchisoni* in the beds in Illinois (Union County) which carry Oriskany fossils. Like the true *Spirifer hemicyclus* of Meek and Worthen their *Spirifer engelmanni* (=*Spirifer worthenanus* Schuchert), which has also erroneously been regarded as an equivalent of *S. murchisoni*, is quite distinct; it seems to be remarkably similar to the European *Spirifer hercyniæ* var. *primæviformis*.

The shell figured by Walcott and doubtfully referred to *Delthyris raricosta* is a true Spirifer, having eight ribs on each side and the wide outline and acute extremities characteristic of *S. murchisoni*, from which it can not be distinguished at present.

If, however, it is found to possess a lower cardinal area, it may be referred to *S. duodenarius*. Walcott mentions a larger series of specimens from Lone Mountain, Nev., as grading from *S. raricosta* to *S. duodenarius*.

South American equivalents of Spirifer murchisoni.—In the Lower Devonian faunas of the Falkland Islands, of Argentina, of Bolivia, and of Brazil are many Spirifers showing more or less resemblance to *Spirifer murchisoni*. These Spirifers have been variously identified as *S. antarcticus*, *S. orbignyi*, and *S. hawkinsii*, all three of Morris and Sharpe; *S. boliviensis* and *S. quichuus* of D'Orbigny; *Spirifer chuquisaca* and Spirifer sp. *a* of Ulrich; *S. vogeli* Von Aumon, and *S. derbyi* Rathbun. Some specimens have been referred to *S. duodenarius* Hall or to *S. arrectus* (= *S. murchisoni*). Practically all these are regarded by Scupin as forms of a single species, identical with *Spirifer arrectus* Hall (=*S. murchisoni* Castelnau).

Under the name *Spirifer antarcticus* Morris and Sharpe several paleontologists have grouped forms of very different aspect. The Falkland Islands Spirifer originally described as *S. antarcticus* is very large, of transversely drawn-out outline (3½ inches wide, 1⅜ inches long in the pedicle valve ?), with a very high cardinal area (five-eighths of an inch), strong musculature, ten to twelve ribs on each side of the deep fold and sinus, the sinus apparently equal in width to three or four lateral ribs, and delthyrium very narrow. This shell does not appear to belong to the group *Spirifer murchisoni*, but rather to the group including *S. hercyniæ* Giebel and the American equivalents *S. gaspensis* Billings and *S. macrothyris* Hall. This species appears in South Africa, and to disentangle the synonymy of *S. murchisoni* to which these forms have been referred the following synonymy of *Spirifer antarcticus* is given. It is not to be inferred that all these "synonyms" represent necessarily one and the same species, but rather that they are closely associated in a group by themselves, apart from the *murchisoni* type here under discussion.

1846. *Spirifer antarcticus.* Morris and Sharpe, Geol. Soc. London Quart. Jour., vol. 2, p. 276, pl. 11, fig. 2. Falkland Islands, apparently with *Leptocœlia flabellites*, *Orthis* [*Chonostrophia*] *tenuis*, etc.

?1856. *Spirifer antarcticus.* Sharpe, Geol. Soc. London Trans., 2d ser., vol. 7, p. 206, pl. 26, figs. 1, 2, 5. Warm Bokkeveld, South Africa, with *Leptocœlia flabellites*.

[1] Meek, F. B., and Worthen, A. H., Illinois Geol. Survey, vol. 3, p. 399, pl. 8, figs. 6, 7, 1868.

[2] Idem, pl. 8, figs. 7a, 7b.

?1856. *Spirifer orbignyi* (not Morris and Sharpe). Sharpe, idem, p. 207, pl. 26, figs. 3, 4 (not 6; = Spirifer cf. *S. duodenarius?*).
Warm Bokkeveld, with *S. antarcticus*.

1903. *Spirifer orbignyi* (not Morris and Sharpe). Reed, South African Mus. Annals, vol. 4, p. 180, pl. 22, fig. 4.
Fossiliferous First sandstone, Bokkeveld series: South Africa.

1903. Spirifer cf. *S. pedroanus*. Reed, idem, p. 183, pl. 22, fig. 5.
Bokkeveld series: South Africa.

not 1897. *Spirifer antarcticus*. Kayser, Deutsch. geol. Gesell. Zeitschr., vol. 49, p. 297, pl. 9.
Argentina.

not 1898. *Spirifer arrectus* var. *antarcticus*. Scupin, idem, vol. 48, p. 464, pl. 17.

Spirifer orbignyi Morris and Sharpe, which was brought back by Darwin from the Falkland Islands, was described as having about ten rounded plications on each side of the median sinus, but the three figures of the species show only six to eight ribs. The fold and sinus are equal in width to two of the bounding ribs or less, the width is only twice the length, and there is a very strong musculature. The figures show a species very similar to *Spirifer murchisoni*, if not identical with it. In the description, however, the species is mentioned as having a low cardinal area, a feature which would associate the specimens rather with *S. duodenarius*. As the description refers to a species with ten lateral ribs on each side (which is more than ever occur in either *S. murchisoni* or *S. duodenarius*), *S. orbignyi* as described by Morris and Sharpe must be regarded as a distinct species. These authors mention a faint groove in the fold of the brachial valve, which is not, however, figured. It is very unfortunate that the figures of the species indicate a form quite different from that suggested by the description. The South African Spirifers identified by Sharpe and by Reed as *S. orbignyi* appear to belong to different species. Reed's figure indicates a Spirifer of the *S. gaspensis-macrothyris-hercyniæ-antarcticus* type.

Spirifer chuquisaca Ulrich is probably the same as *S. boliviensis*, a form meagerly described and figured by D'Orbigny. The species is characterized by a very high cardinal area, which is only slightly concave and which approaches the plane of the margin. The width is twice the length, the cardinal extremities are acute, and the front-lateral margins are evenly curved. The number of ribs on each side averages about six, but increases to seven or eight in the larger specimens. The fold and sinus are very deep, and the fold is sometimes grooved. From *Spirifer murchisoni* this species can easily be distinguished by its higher cardinal area and narrower delthyrium, which is less than 60° in the Bolivian species. In the high cardinal area *S. chuquisaca* resembles *S. antarcticus*, with which it is commonly regarded as a synonym; it is, however, a very distinct form of less transversely extended outline. Moreover, the Bolivian species has only six, seven, or eight lateral ribs; *Spirifer antarcticus* has ten or twelve ribs, with narrower interspaces.[1]

Spirifer hawkinsii Morris and Sharpe has been regarded as a very close ally of *Spirifer murchisoni* and is the type of what Scupin has called a third variety of *Spirifer arrectus*. This third "*arrectus*" type resembles the first in having only five or six lateral ribs but was supposed to differ by the lesser elevation of the fold, shallower sinus, and less gibbous convexity. The original species of Morris and Sharpe is a transversely elongated Spirifer of the general *S. murchisoni* proportions and outline but has only four or five lateral ribs. In the original description the brachial valve is described as having "five imbricated ribs on each side [four or five shown in figure], the two middle ones acute, prominent, and nearly equal to the mesial ridge, which is slightly furrowed; the lateral ribs diminish in importance as they approach the edge; intervening furrows rather wider than the ridges and rounded." In the cast of the pedicle valve the musculature is strongly impressed; only three or four ribs on each side are noted. Except that Morris and Sharpe record a groove in the median fold,[2] this typical form of *Spirifer hawkinsii* approaches the Maine shells described in the present paper as *Spirifer sparsus* Clarke.

In the Lower Devonian of Argentina occurs a shell (*Spirifer antarcticus* (not Morris and Sharpe) Kayser [3]) that is similar to *Spirifer hawkinsii* in having only four or five ribs, which

[1] Morris and Sharpe's figures show only about eight ribs in *S. antarcticus* on each side, but their description mentions ten or twelve.
[2] The extent of persistency of this groove or furrow in the median fold of *Spirifer hawkinsi* is unknown. It does not appear to be constant.
[3] Deutsch. geol. Gesell. Zeitschr., vol. 49, p. 297, pl. 9, figs. 1, 2, 4 (not fig. 3, which is probably *S. chuquisaca*).

increase in width toward the middle, but this shell (fig. 1 of Kayser) lacks the "mesicostulate" characteristic on fold and sinus and varies toward a shell with five or six plications (fig. 2 of Kayser) almost identical with the Bolivian fossils called Spirifer sp. *a* Ulrich[1] and *Spirifer quichuus* D'Orbigny,[2] as well as with the form *S. murchisoni* occurring at Nictau, Nova Scotia. These shells appear to conform with the pauciplicate variety of *Spirifer murchisoni*. If they are really the same species as *S. murchisoni* the name *S. quichuus* D'Orbigny will take precedence [3] over *S. murchisoni* Castelnau and *S. arrectus* Hall; but present knowledge of these South American fossils is not sufficient to warrant definitely replacing the name *S. murchisoni*.

South African Spirifers of the type of Spirifer murchisoni.—One of the earliest described South African Spirifers, *Spirifer capensis* Von Buch,[4] has always been regarded as a very close ally of *Spirifer murchisoni* and the Falkland Islands *Spirifer antarcticus*. The species has an inflated, very convex umbo in the pedicle valve, a high arched cardinal area, and delthyrium about 60° or less; the umbo in the brachial valve is also rather inflated and arched over the hinge line (according to Von Buch's figures); the musculature is strongly impressed. Von Buch mentions eight or nine broad, rounded ribs each side of the fold and sinus, although his figures show ten or eleven. The ribs are rounded, with narrower interspaces; fold and sinus rounded, not keeled, very broad. Von Buch states that the sinus is equal in width to one-sixth the width of the shell; his figures show the fold and sinus to be equal to three ribs in width, and less than a fourth the width of the shell. Scupin, who has examined Von Buch's originals in the Berlin Museum für Naturkunde, states that the sinus is equal in width to four and one-half of the bounding ribs. *Spirifer capensis* Von Buch may be distinguished from *S. murchisoni* by its more numerous ribs, higher cardinal area, and wider fold and sinus, and in these respects it corresponds with *S. antarcticus*, differing from that species in its less transversely extended outline. In *S. antarcticus* the ratio of width to length is over two to one and in the brachial valve is three to one; in *S. capensis* the ratio of width to length is five to three and in the brachial valve a shade over two to one. From both *Spirifer murchisoni* and *S. antarcticus*, *Spirifer capensis* differs in having the umbones more inflated and overarching in both valves.

Spirifer capensis was originally collected by M. Kraus, of Stuttgart, from Kokman's Kloof in Zwellendam, Cape Colony, where a whole stratum of sandstone is almost composed of these Spirifers. Although the species would thus seem to be one of the most abundant Spirifers in the Bokkeveld (?) series, where this sandstone stratum probably belongs, no Spirifer since recorded from South Africa is strictly conformable with Von Buch's figures and description. His figures are imperfect, and reillustration and fuller description of these Zwellendam specimens are highly desirable.

Although no Spirifer since recorded from South Africa has the inflated gibbous overarching umbones and the very wide fold and sinus shown in Von Buch's figures of *S. capensis*, the prevailing Spirifers in the Bokkeveld series as recorded by Sharpe [5] and by Reed [6] agree with Von Buch's species in the rather low rounded ribs and rounded fold and sinus; commonly eight or nine, rarely ten ribs on each side; proportion of width to length 2:1 or slightly more in the brachial valve and less than 2:1 (as low as 3:2) in the pedicle valve; a very high cardinal area, and delthyrium less than 60°.[7] From a comparison of some figures and imperfect specimens it would be almost impossible to separate from *S. murchisoni* a brachial valve of these Bokkeveld Spirifers with eight lateral ribs, such as that shown in Sharpe's figure 4 or in Scupin's figure, or a pedicle valve like that shown in Sharpe's figure 5, which might almost be considered a figure of some New York specimen of *S. murchisoni*. Furthermore, according to Reed's

[1] Neues Jahrb., 1892, p. 67, pl. 4, fig. 22. Totora, Brazil, occurring with *Leptocœlia flabellites*.

[2] Voyage dans l'Amérique méridionale, Paléontologie, p. 37, pl. 2, fig. 21, 1842. Chuquisaca, Bolivia.

[3] Schuchert (U. S. Geol. Survey Bull. 87, p. 398, 1897) gives Ulrich's Spirifer sp. *a* as a synonym of *S. murchisoni*. Ulrich's form seems identical with D'Orbigny's *S. quichuus*, and these fossils are also apparently identical with the specimens figured by Scupin from Chuquisaca (Deutsch. geol. Gesell. Zeitschr., vol. 48, pl. 17, fig. 1, 1898) and from Icla (idem, fig. 5).

[4] Über *Spirifer keilhavii*, über dessen Fundort und Verhältniss zu ähnlichen Formen: K. Akad. Wiss. Berlin Abh., vol. 11, pp. 76–80, pl., 1846.

[5] Geol. Soc. London Trans., 2d ser., vol. 7, 1856.

[6] South African Mus. Annals, vol. 4, 1903.

[7] See Sharpe, Daniel, Geol. Soc. London Trans., 2d ser., vol. 7, pl. 26, figs. 1–5 (not fig. 6) 1856. These figures are now known to represent only a single species, not two (*S. antarcticus* and *S. orbignyi*), as stated by Sharpe. See also Scupin, Hans, Deutsch. geol. Gesell. Zeitschr., vol. 49, pl. 17, figs. 4a, 4b, 1898. Reed, F. R. C., South African Mus. Annals, vol. 4, pp. 180–182, 1904.

descriptions, these South African Spirifers have most commonly sixteen ribs, eight on each side; some have as few as twelve, thus corresponding with *S. murchisoni;* and the number never exceeds eighteen. Unfortunately Reed's only figure [1] shows eleven ribs on one side—there were probably twelve or thirteen—and on Sharpe's figures [2] there are not less than nine lateral ribs on any of the specimens, and on some there are as many as ten or eleven on each side. Not only do these South African Spirifers differ from *Spirifer murchisoni* in the larger number of ribs (*S. murchisoni* never has more than eight distinct ribs on each side), but they have also a much greater cardinal area. They differ from *Spirifer antarcticus* in the smaller number of ribs and less transverse outline, and from *S. orbignyi,* with which they have also been identified, in the higher cardinal area. From *S. chuquisaca* they differ chiefly in the shallower fold and sinus and the lower ribs with narrower interspaces. It is probable that a careful study of the types of Von Buch will show that the South African Spirifers just mentioned are identical with *S. capensis,* which may be considered a distinct species.

European related forms.—In the European faunas the species which most nearly approaches *Spirifer murchisoni* is *S. primævus,* the characteristic fossil of the Taunusian Siegen graywacke. This zone has been regarded as the European representative of the Oriskany of America; so that we might expect some degree of identity in the important diagnostic species of Spirifer. *S. primævus* [3] differs, however, from *S. murchisoni* in being less transverse and in having eight or very commonly nine or ten lateral ribs, whereas in *S. murchisoni* the number of ribs on each side is from five to eight.

SPIRIFER cf. S. DUODENARIUS (Hall).

Plate IV, figures 3, 4.

1843. *Delthyris duodenaria.* Hall, Geology of New York, Rept. Fourth Dist., p. 172, fig. 5.
Corniferous limestone: 5 miles east of Buffalo, N. Y.

1856. *Spirifer orbignyi* (pars) (not of Morris and Sharpe, 1846). Sharpe, Geol. Soc. London Trans., 2d ser., vol. 7, p. 207, pl. 26, fig. 6 (not figs. 3, 4).
Hard gray siliceous rock: Warm Bokkeveld, South Africa.

1861. *Spirifera duodenaria.* Billings, Canadian Jour., vol. 6, p. 256, figs. 65–67.
Devonian (Corniferous): Rama's farm, near Port Colborne, and at Woodstock, Canada West.

1863. *Spirifera duodenaria.* Billings and Logan, Geology of Canada, pp. 372, 428, fig. 394.
Corniferous limestone: Famine River, Quebec.

1867. *Spirifera duodenaria.* Hall, Paleontology of New York, vol. 4, p. 189, pl. 27, figs. 13–16, pl. 28, figs. 24–33.
Schoharie grit: Eastern New York.
Corniferous limestone: Throughout New York, in Canada West, and in Ohio.

1879. *Spirifera duodenaria* (?). Rathbun, Boston Soc. Nat. Hist. Proc., vol. 20, p. 25.
Lower Devonian sandstone: Rio Maecuru, Para, Brazil.

1883. *Spirifera duodenaria.* Hall, New York State Geologist Second Ann. Rept., pl. 58, figs. 8–13.
Schoharie grit: Schoharie County, N. Y.
Corniferous limestone: Western New York.

1884. Spirifer cf. *S. duodenarius.*[4] Walcott, U. S. Geol. Survey Mon. 8, p. 135, ?pl. 14, fig. 12 (not pl. 4, figs. 2, 2a).
Lower Devonian limestone: Lone Mountain, 18 miles northwest of Eureka, Nev.

1889. *Spirifera duodenaria.* Nettelroth, Kentucky fossil shells, p. 114, pl. 12, figs. 12, 13, 16.
Corniferous limestone: Kentucky and Indiana, about the Falls of the Ohio.

1893. *Spirifer duodenarius.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pp. 19, 37, pl. 33, figs. 8–15.
Schoharie grit: Schoharie County, N. Y.
Corniferous limestone: Western New York.

1897. *Spirifer duodenarius.* Weller, Jour. Geology, vol. 5, pp. 627, 629.
Upper Helderberg limestone: Devils Bake Oven, near Grand Tower, Jackson County, Ill. (Nos. 4 and 11 of section).

1897. *Spirifer duodenarius.* Schuchert, U. S. Geol. Survey Bull. 87, p. 388.
Upper Helderberg: New York; Ontario; Columbus, Ohio; Falls of the Ohio; Rio Maecuru, Para, Brazil.

1898. *Spirifera duodenaria.* Bownocker, Denison Univ. Sci. Lab. Bull., vol. 11, p. 11, pl. 7.
Corniferous limestone: Delaware, Marion, and Kellys Island, Ohio.

1899. *Spirifer duodenarius.* Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), pp. 352, 353.
Schoharie grit and Corniferous limestone: Oniskethau Creek, Albany County, N. Y.

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[1] Reed, F. R. C., op. cit., pl. 22, fig. 4.
[2] Sharpe, Daniel, op. cit., pl. 26, figs. 1–5, not fig. 6.
[3] See Scupin, Hans, Die Spiriferen Deutschlands, pp. 84–86, pl. 8, fig. 9, 1900.
[4] Described and figured as *S. raricosta* Conrad.

1900. *Spirifer duodenarius.* Kindle, Indiana Dept. Geol. and Nat. Res. Twenty-fifth Ann. Rept., p. 647, pl. 9, fig. 10.
Sellersburg [1] [? error for Jeffersonville] limestone: Falls of the Ohio and Charlestown, Ind.
1903. *Spirifer duodenarius.* Katzer, Geologie des unteren Amazonasgebietes, p. 194, pl. 10, figs. 3a, 3b.
Upper Helderberg: Rio Maecuru, Para, Brazil.

This Onondaga species does not occur in the Chapman fauna but is present in the fauna of the Moose River sandstone occurring at Big Brassua Lake, Somerset County. It is a medium-sized Spirifer with straight hinge line, width equal to about twice the length, acute hinge extremities, and six or seven rounded ribs with narrower interspaces on each side of the simple, narrow, rounded fold and sinus; both valves are subequally convex. The species is distinguished from *S. murchisoni* chiefly by the low cardinal area of the pedicle valve, which is only slightly higher than that of the brachial valve. Figure 3 of Plate IV shows a fragment of a brachial valve (enlarged 2 diameters) with a distinct cardinal area, in which the cardinal process is radially striate, but this is not indicated in the figure. The second specimen (fig. 4) is a pedicle valve in which the cardinal area is but slightly greater than that in the brachial valve shown in figure 3. This species is a characteristic fossil of the Onondaga ("Corniferous") limestone of New York. It ranges throughout the Schoharie grit and Onondaga limestone and has not been reported below the Schoharie. Its occurrence in a belt of rocks which has heretofore been considered to represent the Oriskany is therefore of some importance. Its appearance in the *Spirifer arenosus* fauna in central northern Maine is suggestive of later persistence of that fauna than in the New York area, a suggestion which is in harmony with the evidence brought out by the breccias of St. Helens Island already referred to (p. 83). In this connection may also be mentioned the occurrence of the "Corniferous" species *Chonetes* (*Eodevonaria*) *arcuatus* and *Chonetes vicinus* at Little Brassua Lake.

Locality: Moose River sandstone: Big Brassua Lake (locality 1062 A′), Somerset County, Maine.

U. S. National Museum, catalogue No. 59743.

SPIRIFER SPARSUS Clarke.[2]

Plate I, figures 11, 13, 14, 15, 17, 21, 22, 24; Plate II, figure 17; Plate IV, figure 2.

cf. 1874. *Spirifer raricosta.* Billings, Paleozoic fossils, vol. 2, pt. 1, p. 47, pl. 3, fig. 5.
Gaspe limestone No. 8 [Oriskany]: Grand Greve, Gaspe Bay, Quebec.
cf. 1884. *Spirifera raricosta.* Walcott, U. S. Geol. Survey Mon. 8, p. 135 (pars), pl. 14, fig. 12; pl. 4, fig. 2a (not fig. 2, which represents a Spirifer of the *S. murchisoni* type).
Lower Devonian limestone: Combs Peak, and at Lone Mountain, 18 miles northwest of Eureka, Nev.
1907. *Spirifer cymindis* var. *sparsa.* Clarke, New York State Mus. Bull. 107, p. 257, figs.
Lower Devonic: Presque Isle Stream, Chapman Plantation, Aroostook County, Maine.

A pauciplicate, trapezoidal Spirifer of medium to small size; with broad, straight hinge line; rounded extremities; and three to five plications on each side of the strong fold and sinus—the inner three plications of each side strong, the outer one or two weak when present at all. Hinge line long, straight, varying in length from five-sixths to very nearly equal the greatest width of the shell. The width in the pedicle valve varies from one-sixth to one-half greater than the length. Hinge extremities rounded, sometimes broadly so, sometimes nearly rectangular, but never sharp, acute, nor auriculate. Pedicle valve gibbous with broad, inflated, overarching umbone. Greatest depth is over the hinge line, one-third the distance from beak to front, where it is one-half to one-third the length of the valve. The transverse profile is arcuate with rather depressed sides. Cardinal area in the pedicle valve of medium height, strongly arched, inclined at an angle of 135° or more from the plane of the margin of the valve.

[1] In the lists of fossils under localities *S. duodenarius* is not mentioned. As both the Jeffersonville ("Corniferous") limestone and the Sellersburg limestone (of Hamilton age) occur at the places named, and as *S. duodenarius* has never before been found above the "Corniferous," it is probable that Jeffersonville ("Corniferous") is intended instead of Sellersburg limestone. If the species really occurs in the Sellersburg, this is the first and only occurrence, so far as known, in the Middle Devonian. Mr. Kindle informs me that the specimens of *S. duodenarius* referred to above were collected by G. K. Greene from residual clays but showed the peculiarities of fossilization which can be pretty definitely relied upon to distinguish fossils of the siliceous Sellersburg from the nonsiliceous Jeffersonville limestone.

[2] In the manuscript of the present paper this species was already figured and described under the name *Spirifer chapmani* when Clarke's name *S. cymindis* var. *sparsa* was published. On comparison there seems to be no doubt as to the identity of the two forms.

Delthyrium acute, 60° to nearly 90°. On the interior of the pedicle valve dental lamellæ are well developed and occupy the first plications—rarely the first fold—on each side of the median sinus. The musculature is inconspicuous, except in old shells, and the cavity outside the dental lamellæ is not filled in; hence in internal molds the characteristic incisions of the lamellæ are present. The musculature reaches the midlength. No median septum is observed in the pedicle valve.

The brachial valve is convex, but much less so than the pedicle valve. The greatest depth is near the midlength and is equal to two or three tenths of the length; the cardinal area is linear. On the interior of the brachial valve the cardinal process is radially striate as in *S. murchisoni*. The dental sockets show obscure indications of crenulation in the only specimen in which the sockets have been observed. The "median septum" of the brachial valve is extremely faint. On each side of the simple fold and sinus are three strong ribs; and commonly there are one or two additional, more or less obsolescent ribs which do not quite reach the beak. The sinus is deeply excavated, rather flat in the bottom, equal to about two (always less than three, rarely only a little more than one) of the bounding ribs, in width, and more or less strongly extended as a tonguelike projection toward the fold of the opposite valve. The fold is strongly elevated, rapidly expanding toward the front and equal in width to about two of the bounding ribs in two small shells only slightly wider than each bounding rib, in one equal to two ribs and in another nearly equal. The ribs are rounded and, on shells showing the surface, appear of medium height with narrower interspaces. On internal molds they are strongly elevated, frequently subangular, and the interspaces are equal to or much wider than the ridges. The finer surface ornamentation consists of concentric sublamellose lines, sometimes lamellar and crowded toward the front; the specimens do not show the coarse radial lineation of the type of *S. macropleurus*, etc., which the specimens sometimes resemble, and they are not well enough preserved to show any such fine radial lines as those of *S. murchisoni* or *S. cyclopterus*. No such radial lines are recorded by Clarke.

Shell structure fibrous, impunctate under a hand lens. The largest specimens observed (two pedicle valves) are 21.5 by 29 millimeters and 21 by 28 millimeters; the smallest specimen observed (a brachial valve) measures about 10 by 15 millimeters; most of the specimens measure about 15 by 25 millimeters.

Locality.—Chapman sandstone: Edmunds Hill, also 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59744 to 59746.

Comparisons.—This species strongly resembles in external aspect the *Spirifer* (*Delthyris*) *raricosta* of Conrad and authors, but that species belongs to the genus Delthyris, having a strong median septum in the pedicle valve, while not the slightest indication of such a structure is present in *S. sparsus*. *D. raricosta* has commonly only two ribs on each side, and only very rarely three. *S. sparsus* has never less than three ribs on each side, and commonly four or five. *Delthyris raricosta* was described from the "Corniferous" limestone, of which it is a characteristic and widespread fossil.

Shells agreeing in external aspect with *Delthyris raricosta* have been recognized in the Gaspe limestone[1] and in the middle Helderbergian, of Square Lake, Maine, *Spirifera raricosta?* Conrad (*S. hesione* Billings nom. nov.).[2] In neither of these forms is a median septum noted or figured in the pedicle valve, so that they resemble *Spirifer sparsus* in that respect. The Square Lake form (*Spirifer hesione* Billings) has only two broadly undulating ribs on each side of the fold and sinus, corresponding closely with Vanuxem's *Spirifer undulatus* (=*D. raricosta*) superficially; it is quite distinct from *S. sparsus*. The Gaspe *Spirifera raricosta* of Billings has three or four ribs and may possibly prove to be identical with *S. sparsus* Clarke. *Spirifer ilsæ* Kayser,[3] from the lowest Devonian of the Harz, at Klosterholtz, also bears a strong resemblance to *S. sparsus* (compare Pl. I, fig. 14; Pl. IV, fig. 2), having a broad fold and sinus, rounded

[1] Billings, Elkanah, Paleozoic fossils, vol. 2, p. 47, pl. 3A, fig. 5, 1874 (*Spirifera raricosta*).
[2] Billings, Elkanah, Portland Soc. Nat. Hist. Proc., vol. 1, pt. 2, p. 117, plate, fig. 17.
[3] Kayser, Emanuel, Die Fauna der ältesten Devon-Ablagerungen des Harzes, p. 162, pl. 22, figs. 3, 4, 1878.

extremities, and only three to five ribs on each side; but the fold in *Spirifer ilsæ* is much more highly elevated and more keeled than that in *S. sparsus*.

Spirifer hawkinsii Morris and Sharpe, collected by Darwin from the Lower Devonian of the Falkland Islands, has already been mentioned as resembling *S. sparsus* in having four or five ribs, but it differs in the more transverse outline, sharp acute extremities, strong musculature, and grooved fold.

The shells figured by Walcott from the Lower Devonian of Nevada and doubtfully identified with *Delthyris raricosta* are very closely related to and possibly identical with *S. sparsus*. As was emphasized by Walcott, this Nevada Spirifer has no median septum and hence can not be congeneric with *Delthyris raricosta*. The proportions are approximately the same as in *S. sparsus*, and the characteristic ribbing is precisely the same—a highly elevated fold and deep sinus, with four or five ribs on each side, the three inner ribs very strong, the two outer ones narrow and obsolescent. The only apparent distinction between *S. sparsus* and the form shown by Walcott's figures is that the latter appears to have slightly more acute hinge extremities. Walcott's figure 2, Plate IV, indicates a Spirifer which may be referred with little, if any, hesitation to *S. murchisoni*.

SPIRIFER GASPENSIS Billings.

Plate IV, figure 7.

?1837. "Terebratulæ." Jackson, First report on the geology of the State of Maine, p. 128, pl. 1, fig. 10.
Graywacke period: Maine.

cf. 1846. *Spirifer antarcticus*. Morris and Sharpe, Geol. Soc. London Quart. Jour., vol. 2, p. 276, pl. 11, fig. 2.
Devonian: Falkland Islands.

cf. 1850. *Spirifer pollens* (not Barrande). F. A. Roemer, Beiträge zur geologischen Kenntniss des nordwestlichen Harzgebirges, p. 58, pl. 9, fig. 10 (young).
Formation and locality not given; in the Harz Mountains, Germany, probably Klosterholtz.

cf. 1853. *Spirifer paradoxus* (not Schlotheim). Schnur, Palaeontographica, vol. 3, p. 198, pl. 32B, figs. 1b, 1c (1a? 1d?).
Graywacke: Everywhere in the Eifel, Germany.

cf. 1858. *Spirifer hercyniæ*. Giebel, Die silurische Fauna des Unterharzes, p. 30 [of separate], pl. 4, fig. 14 (young).
Silurian: Magdesprung, Harz Mountains, Germany.

1863. *Spirifera gaspensis*. Billings and Logan,[1] Geology of Canada, pp. 398, 410.
Gaspe sandstone [York River]: Douglastown River, and on the north side of the inner basin at Gaspe, Quebec.

1865. *Spirifer macropterus* (not Goldfuss). Roemer, Deutsch. geol. Gesell. Zeitschr., vol. 17, p. 592, pl. 17, fig. 6.
Graywacke: West slope of the Altvater Mountains, Moravia, Austria.

?1868. *Spirifer engelmanni* (not Meek, 1860). Meek and Worthen, Paleontology of Illinois, vol. 3, p. 398, pl. 8, fig. 5.

?1868. *Spirifer hemicyclus* (pars). Meek and Worthen, idem, p. 393, pl. 8, fig. 6.
Oriskany: Union County, Ill.

1870. *Spirifer macropterus* (not Goldfuss). F. Roemer, Geologie von Oberschlesien, pl. 1, fig. 3.
Wurbenthal quartzite: Einsiedler, Durrberg, half a mile from Wurbenthal, Austrian Silesia.

1871. *Spirifer paradoxus* (not Schlotheim). Kayser, Deutsch. geol. Gesell. Zeitschr., vol. 23, p. 314.
Taunusian: Between Oberstadtfeld and Niederstadtfeld, near Daun, in the Eifel, Germany.

1874. *Spirifera gaspensis*. Billings, Paleozoic fossils, vol. 2, pt. 1, p. 44, pl. 3, figs. 8, 8a, 8b.
Gaspe [York River] sandstone: Gaspe Bay, Quebec.
Gaspe limestones: Split Rock, Perce, Quebec.

?1876. *Spirifer macropterus* (not Goldfuss). Ribbentrop, Naturhist. Ver. preuss. Rheinlände und Westphalens Corr.-Bl., vol. 33, p. 103.
Hundsrückian: Between Nerother Kopf, Oberstadtfeld, and Salm, in the Eifel, Germany.

1878. *Spirifer hercyniæ*. Kayser, Abh. zur Specialkarte von Preussen, etc., vol. 2, pt. 4, p. 168, pl. 23, figs. 7–13; pl. 34, fig. 3.
Hercynian limestone: Magdesprung, Zorge, Wilda, and Ilkenburg, in the Harz Mountains, Germany.

1878. *Spirifera nictauensis*. Dawson, Acadian geology, 3d ed., p. 499, fig. 176 (also 4th ed., 1891).
Oriskany iron ore and slates: Nictau, Nova Scotia.

1879. *Spirifera nictauensis*. Dawson, Canadian Naturalist, new ser., vol. 9, p. 3.
Oriskany iron-ore beds and coarse slates: Nictau, Nova Scotia.

1879. *Spirifera buarquiana*. Rathbun, Boston Soc. Nat. Hist. Proc., vol. 20, p. 28.
Devonian: Rio Maecuru, Para, Brazil.

?1880. *Spirifer paradoxus* (not Schlotheim). Gosselet, Esquisse géologique du Nord de la France, p. 75, pl. 2, fig. 25; cet. excl.
Montigny graywacke: Montigny-sur-Meuse, Amberloup, near St. Hubert, La Roche, Houffalize, Sugny, etc., Belgium and northern France.

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[1] Also (p. 393) from Gaspe limestone No. 8 at Gaspe, as Spirifera sp. indet.

1883. *Spirifera gaspensis.* Ells, Canada Geol. Survey Rept. Progress for 1880–1882, pp. 9DD, 14DD.
Upper Gaspe limestone (Oriskany): Perce Rock, Indian Cove, Grande Greve, and Little Gaspe; Gaspe Bay, Quebec.

1885. *Spirifera gaspensis.* Ells, idem for 1882–1884, pp. 23E, 24E.
Gaspe [York River] sandstone: Miners Brook branch of Cascapedia River, Gaspe Peninsula, Quebec.
Gaspe Oriskany (whether limestone or sandstone not stated): In hills back of Gaspe village, Quebec.

1886. Spirifer cf. *S. hercyniæ.* Gosselet, Soc. géol. du Nord Annales, vol. 13, p. 298.
Hundsrückian (Montigny graywacke): La Roche, Belgium.

?1887. Spirifera sp. indet. Ami, Canada Geol. Survey Ann. Rept., new ser., vol. 2, p. 9N.
Oriskany slates and sandstones: Campbell River, near mouth of Don River, New Brunswick.

1889. *Spirifer paradoxus* var. *hercyniæ.* Barrois, Soc. géol. du Nord Mém., vol. 3, p. 132, pl. 9, fig. 1.
Erbray limestone: Erbray, Loire Inferieure, France.

1889. *Spirifer dunensis.* Kayser, K. preuss. geol. Landesanstalt Abh., neue Folge, Heft 1, p. 33, pl. 15, figs. 3, 4, 5, 5a.
Lower Coblenzian: Daun, in the Eifel, Germany.

1889. *Spirifer paradoxus* mut. *præcursor.* Frech, Deutsch. geol. Gesell. Zeitschr., vol. 41, p. 194.
Lower Coblenzian: Stadtfeld, near Daun, in the Eifel; Zenschiedan der Kyll,[1] a few miles from Gerolstein; and about Siegen, Germany.

1889. *Spirifer phalæna.* F. von Sandberger, Über die Entwickelung der unteren Abtheilung des devonischen Systems in Nassau, p. 105, pl. 3, figs. 3, 3a.
Lower Spirifer beds (Lower Coblenzian): Stadtfeld, near Daun and other localities in the Eifel, Germany.
Vireux sandstones: Vireux, Ardennes, France (*S. paradoxus* Gosselet, 1880).

1891. *Spirifer dunensis.* Kayser, Lehrbuch der geologischen Formationskunde, p. 83, pl. 12, fig. 6.
Lower Coblenzian coarse graywacke: Stadtfeld, etc., in the Eifel, Germany.

1897. *Spirifer hercyniæ.* Frech, Lethæa Paleozoica, pl. 23 A, figs. 5a, 5b.
Lower Coblenzian ("zone of *Spirifer hercyniæ*"): Oberstadtfeld, in the Eifel, Germany.

1897. *Spirifer buarquianus.* Schuchert, U. S. Geol. Survey Bull. 87, p. 383.
Middle Devonian [2]: Rio Maecuru, Para, Brazil.

1897. *Spirifer gaspensis.* Schuchert, idem, p. 391.
Oriskany: Gaspe.

1897. *Spirifer nictauensis.* Schuchert, idem, p. 399.
Oriskany: Near Nictaux, Nova Scotia.

?1899. *Spirifer paradoxus.* Collins, Roy. Geol. Soc. Cornwall Trans., vol. 12, p. 239.
Lower Devonian [Siegen, or more probably Lower Coblenzian]: Fowey, Cornwall.

1900. *Spirifer hercyniæ.* Scupin, Paleontol. Abh. (Dames & Koken), new ser., vol. 4, pt. 3, p. 290, pl. 21, figs. 4, 5a, 5b.
Lower Coblenzian: Along the Rhine, at Stadtfeld, near Daun, St. Johann, and Landscheid, Germany.
Lower Coblenzian quartzite: Bienhorn Valley, near Ehrenbreitenstein, Germany.
Ahrien beds: Belgium.
Erbray limestone: Erbray, France.
Lower Coblenzian: In the Kellerwald, Germany.
Middle Eo-Devonian: Harz Mountains, Germany.
Würbenthaler quartzite: Wurben Valley, Germany (Austrian border).

1900. *Spirifer hercyniæ* var. *primæviformis.* Scupin, idem, p. 292, pl. 31, figs. 3, 10a–c.
Lower Coblenzian: Vallendar and Bienhorn Valley, Germany.

1902. *Spirifer hercyniæ.* Drevermann, Palaeontographica, vol. 49, p. 95.
Lower Coblenzian: Oberstadtfeld near Daun, in the Eifel, Germany.

1903. *Spirifer buarquianus.* Katzer, Geologie des unteren Amazonasgebietes, p. 272, pl. 10, fig. 1.
Upper Helderberg: Rio Maecuru, Para, Brazil.

1903. *Spirifer buarquianus* var. *contracta.* Katzer, idem, fig. 1a.
Upper Helderberg: Rio Maecuru, Para, Brazil.

1903. *Spirifer buarquianus* var. *alata.* Katzer, idem, figs. 1d, 1e.
Upper Helderberg: Rio Maecuru, Para, Brazil.

1904. *Spirifer orbignyi* (not Morris and Sharpe). Reed, South African Mus. Annals, vol. 4, pt. 3, p. 180,[3] pl. 22, fig. 4.
Lowest fossiliferous sandstone, Bokkeveld series: North of Montagu, South Africa.

?1904. Spirifer cf. *S. pedroanus* (not Hartt). Reed, idem, p. 183, pl. 22, fig. 5.
Lowest fossiliferous sandstone, Bokkeveld series: 3 miles southeast of Triangle; north of Homestead; Uitkomst; Gydo Pass; Witzenberg Valley; and point just north of Stinkfontein, Ceres, South Africa.

1905. *Spirifer gaspensis.* Clarke, New York State Mus. Bull. 80, p. 145.
Perce limestone: Perce Rock, Perce, Quebec.
Gaspe sandstones: Gaspe Bay, Quebec.

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1 Also called Densborn, or St. Johann.

2 This fauna is probably of Onondaga or Coblenzian (upper Eo-Devonian) age, not Meso-Devonian.

3 The description here indicates a Spirifer of the type of *S. capensis*, which has been discussed under *S. murchisoni*. The figure, however, represents a very different species, which can not be distinguished from *S. gaspensis* or *S. hercyniæ*.

1907. *Spirifer perimele* (pars). Clarke, New York State Mus. Bull. 107, p. 253, middle figure (cet. excl., not the two side figures).
Lower Devonic: Baker Point, Moosehead Lake, Somerset County, Maine.
1907. *Spirifer primævus atlantica.* Clarke, idem, p. 260, figs.
Lower Devonic: Baker Point, Moosehead Lake, Maine.
1910. *Spirifer gaspensis* Billings. Williams, Roy. Soc. Canada Trans., 3d ser., vol. 3, pp. 211, 224.
Spirifer arenosus fauna, St. Helens breccia: St. Helens Island, near Montreal, Canada.

This Spirifer from the Moose River sandstone represents a form characteristic the world over of rocks well up in the Eo-Devonian, following the *S. murchisoni-primævus* or Oriskany (Taunusian) régime. It is unknown as low as the Chapman sandstone. The species is of medium to large size and is characterized by great transverse extension of the shell, so that the width is typically more than twice and as much as three or more times the length; cardinal extremities pointed, acute; lateral plications 10 or 11 to 13 or 14 (12 to 18 according to Billings) on the side. There is an elevated cardinal area, and the brachial valve is as deep as the pedicle valve, or deeper; fold highly elevated.

The outline is broadly triangular, with acute pennate extremities. Both valves are about equally convex, with the brachial valve perhaps a trifle the more convex of the two. In the pedicle valve the umbo is arched and the beak incurved. On the interior the dental lamellæ occupy the third furrow, or fourth ridge on each side of the median sinus. The musculature is strongly impressed, extends about half the length of the shell, and is marked by a sharp elevated line which reaches perhaps half the length of the musculature. This line can not, however, be compared with the strong median septum characteristic of Delthyris. Billings, in his figure 8, shows the same line, impressed in the internal mold. In old shells the umbo is thickened on the outer side of the lamellæ, and on internal molds pits (the impressions of ovarian pustules?) are impressed in this calloused part of the shell, as in *S. murchisoni, S. primævus,* etc. The hinge line is long and straight and constitutes the maximum width of the shell. The proportions of length and width are indicated by the following figures:

Dimensions of Maine specimens of Spirifer gaspensis.

[All from Little Brassua Lake (locality 1061 B').]

	Length (millimeters).	Width (millimeters).
Brachial valve	14	32
Do	17.5	54
Pedicle valve	31	92

The cardinal area is of low to medium height. The delthyrium has not been clearly observed but appears to be very nearly if not quite 90°.

The brachial valve is also strongly convex, in some shells apparently more convex than the pedicle valve; the cardinal area is linear or absent; on the interior the median elevated line is strongly pronounced, assuming the character of a low septum; it extends nearly half the length and becomes thickened and prominent in its posterior portion, where the posterior adductor scars are sometimes discernible.[1]

In the Maine specimens, which are preserved in a dark bluish-black siliceous shale, the ribs are of moderate elevation, rounded, and with narrower interspaces; in the internal molds the ribs are commonly rounded and low (rarely angular and high), and the interspaces are almost if not quite as wide as the ribs. The sinus is of moderate depth, rounded or flattish in the bottom, very commonly marked on the exterior by an obsolescent riblet, and is extended as a tonguelike projection in front. The fold in the brachial valve is strongly elevated and carinate, expanding in width rapidly toward the front. Fold and sinus are equal in width to three or four of the bounding ribs. The number of ribs in the Maine specimens is 10 or 11

[1] Cf. Billings, Elkanah, op. cit., fig. 8A.

or more, commonly 13 or 14, in mature shells; some smaller specimens show more. The usual number at Gaspe, to judge from Billings's figures, is 13 or 14, though Billings states that the number of ribs on each side is from 12 to 18. In the small specimens from Maine, of which only four or five have been seen, the ribs are not more than 15 in number, though it is possible that the larger specimens, which are only fragmentary, may have had more. At Nictau, Nova Scotia, the species has only 9 to 11 ribs on each side, generally about 10. In the specimens from Nictau the outline is less extended transversely, and in this particular they present a close approach to *Spirifer murchisoni*.

The finer surface ornamentation of *Spirifer gaspensis* consists of sublamellose closely set concentric lines. No indication of radial lineation was observed, but the specimens are too poorly preserved to show it, even if it should exist.

Locality: Moose River sandstone, Little Brassua Lake, Somerset County, Maine.

U. S. National Museum, catalogue No. 59747.

Comparisons.—Billings described his species as having a width "often twice the length; in some specimens shorter, one-fourth or only one-fifth greater than the length." Some of the Maine specimens are as much as three times as wide as long, and in none of the specimens at hand is the width less than twice the length. There can be no doubt of the identity of the Maine forms with Billings's species, particularly as the exact proportion of length and width is commonly variable in the Spirifers of this transversely elongate type. The ribs in the Gaspe specimens are slightly more angular than is common in those from Maine, but this character is more or less variable and is also strongly influenced by the conditions of preservation. In one of the Maine specimens the ribs are angular, corresponding to Billings's description, but in other parts of the same specimen the ribs are rounded. In all other respects and in the minuter details Billings's description might equally well have been drawn up from the Maine specimens at hand; and in none of the other characters do the Maine specimens depart from Billings's description or illustrations of *S. gaspensis*.

Spirifer gaspensis Billings and its allies may be distinguished from the *Spirifer murchisoni-primævus* type by its more transversely elongated outline. The dental lamellæ are farther removed from the median sinus, and the number of plications is greater. At Nictau, Nova Scotia, *Spirifer gaspensis* has a less transverse outline than is usual, and the specimens from this locality present a near approach to *Spirifer murchisoni;* but they may be distinguished by having 10 or 11 ribs on each side of the median fold and sinus, compared with a maximum of 8 or very rarely 9 in *S. murchisoni*. Moreover, the dental lamellæ are at the third groove or fourth ridge on each side of the middle in the Nictau forms, but at the second groove or second ridge in *S. murchisoni*.

Transversely elongated Spirifers of the *S. gaspensis* type have not been reported from the New York and New Jersey Oriskany nor below the Onondaga. In the Oriskany of Maryland, however, occur two species very similar to *S. gaspensis*, namely, *Spirifer cumberlandiæ* Hall and *Spirifer submucronatus* Hall. These forms differ from *S. gaspensis* in having a persistently lower, rounded fold and sinus, in having the musculature in the pedicle valve proportionately narrower and more elongate, and in never attaining the more extreme pennate form of *Spirifer gaspensis* as found in Maine. In the Maryland Spirifers the brachial valve is less convex than the pedicle valve. In New York the earliest Spirifer of the transversely elongated *S. gaspensis* type is *Spirifer macrothyris* Hall,[1] in which the width is more than twice the length, and the brachial valve is distinctly and persistently more convex than the pedicle valve, with keeled fold, broad sinus, and strong musculature. *Spirifer macrothyris* differs from *S. gaspensis* in having rectangular or rounded cardinal extremities, which give the shell a rectangular or transversely oval instead of pennately triangular aspect, as in *S. gaspensis*. The ribs are also coarser in *Spirifer macrothyris*, and that species, though it attains a width of 100 millimeters [2] or more, has only from 6 to 10 plications, never more than 10, whereas there are rarely less

[1] Hall, James, Paleontology of New York, vol. 4, p. 202, pl. 30, figs. 16, 20, 1867. See Schuchert, Charles, U. S. Geol. Survey Bull. 87, 1897, for additional references.

[2] Weller, Stuart, Paleontology of New Jersey, vol. 3, pl. 52, figs. 1, 2, p. 375, 1903.

than 10 in *S. gaspensis*. *S. macrothyris* has also an obtuse delthyrium. On the whole it is very closely allied to *S. gaspensis* and may prove to be a variant of that species.

It is important to note that for these large shells of the *S. gaspensis* type the internal mold differs conspicuously from the external shell in the number of visible plications, as well as in the outline of the valves. The thickening of the shell in the old specimens extends to the hinge extremities, so that the large internal molds are frequently not so pennate and seem to show more rounded extremities than are found on the exterior. This feature has been strongly emphasized by Drevermann,[1] who also points out that because of this internal thickening at the hinge extremities several plications which are found on the surface are not represented in the internal molds, so that such large internal molds seem to have fewer plications than are visible on much younger specimens. This condition is noteworthy in the Maine specimens, where a large pedicle valve over 90 millimeters wide has only 10 ribs on each side, with possibly one or two obsolescent additional ones, whereas another specimen only one-third that width has 13 or 14 ribs. As the published figures of *S. macrothyris* generally represent internal molds, the species as represented by external molds might be more pennate and might have more plications.

In South America the transversely elongated Spirifers, as has already been indicated, are represented by *Spirifer antarcticus* of the Falkland Islands. This species was described as transversely fusiform, nearly equivalved, with a strongly elevated fold and deep sinus, strong musculature, and 10 to 12 ribs on each side. It has also a very high cardinal area and narrow delthyrium, features which seem to distinguish it from *S. gaspensis;* but too little is known of *S. antarcticus* to warrant definite separation or union with the Gaspe species, though it is certainly a very close ally and very probably identical.

In the Onondagan faunas of Brazil the *gaspensis* type is the dominant form of Spirifer. In the Rio Maecuru fauna this form has been called *S. buarquianus* Rathbun, as indicated below, but it is hardly distinct from the specific type represented by *Spirifer gaspensis* and *S. hercyniæ*.

1879. *Spirifera buarquiana.* Rathbun, Boston Soc. Nat. Hist. Proc., vol. 20, p. 28.

1903. *Spirifer buarquianus* var. *contracta.* Katzer, Geologie des unteren Amazonasgebietes, p. 272, pl. 10, fig. 1a. This form has the width less than 2½ times the length; 9 to 12 ribs on each side.

1903. *Spirifer buarquianus* var. *alata.* Katzer, idem, p. 272, pl. 10, figs. 1d, 1e. Width as much as four times the length; 12 to 16 ribs on each side.

S. buarquianus is more than twice (in some specimens as much as four times) as wide as long, the common proportion of width to length being 2.8 to 1. The outline is pennately triangular, with acute hinge extremities; the brachial valve is equal to or exceeds the pedicle valve in convexity. The cardinal area is of moderate height with delthyrium less than 90°; mesial fold in the brachial valve strongly elevated and keeled, sinus fairly deep and equal in width to three or four ribs; ribs 9 to 16 on each side, commonly 12 to 14. Katzer's figure 1a represents a specimen practically indistinguishable from the one shown in Plate IV, figure 7, of the present work, and his *S. buarquianus* var. *contracta* can not be distinguished in appearance from *S. gaspensis* as it occurs in Maine. Katzer mentions the occurrence of an obscure riblet in the sinus but states that no corresponding groove is ever observable on the fold except, rarely, near the beak. In this respect his form is like *Spirifer gaspensis* and also *S. hercyniæ*.

Katzer described another transverse Spirifer from the Eréré (Meso-Devonian) fauna of Brazil as *Spirifer pedroanus*. This shell is very similar to *S. gaspensis* and was described by Rathbun[2] as having 10 to 16 ribs on each side, but Katzer states that the larger collections show the number to be nearer 20 and in some specimens as great as 23. This number is greater than occurs in *S. gaspensis*, from which the Brazilian species is also easily separated by its low cardinal area, which serves to associate *S. pedroanus* with the Middle Devonian *Spirifer mucronatus* or *pennatus* in America and with the Middle Devonian *S. speciosus* (pars auct.) in Europe.

In the Lower Devonian of South Africa the specific type of *S. gaspensis* is represented by the specimen figured by Reed[3] and called *Spirifer orbignyi* Morris and Sharpe. The width is

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[1] Palaeontographica, vol. 49, p. 95, 1902.

[2] Rathbun, Richard, Buffalo Soc. Nat. Sci. Bull., vol. 1, p. 237, pl. 8, figs. 1-9, 13, 14, 16-20, 1874. *Spirifira pedroana* (Hartt MS.).

[3] South African Mus. Annals, vol. 4, pl. 22, fig. 4.

somewhat more than twice the length, and the musculature is strongly impressed and equal to half the length, with a very faint, low septum or line as in *S. gaspensis* (also in *S. hercyniæ* Giebel, *S. macrothyris* Hall, *S. cumberlandiæ* Hall, *S. submucronatus* Hall, and (?) *S. antarcticus* Morris and Sharpe). The dental lamellæ occupy the third furrow or the fourth ridge on each side of the median sinus; this is also their position in *S. gaspensis* Billings from Nictau (Nova Scotia), Gaspe (Quebec), and Maine; *S. macrothyris* Hall, from New York and New Jersey; *S. cumberlandiæ* and *S. mucronatus*, from Maryland; *S. antarcticus* Morris and Sharpe, from South America; and *S. hercyniæ* Giebel, from Germany and France. The cardinal area is of medium height, and there are 11 or more ribs on each side of the fold and sinus. Reed's figure 4 might almost exactly represent one of the Maine specimens, and his figure 5 apparently belongs to the same species. These South African specimens differ from *S. hercyniæ* and *S. gaspensis*, if at all, in having the sinus equal in width to two or three ribs instead of three or four or more, but it seems that they ought to be united under the same specific name with *S. gaspensis*.

S. gaspensis is equivalent to and identical with *S. hercyniæ* Giebel. The masterly treatment of Giebel's species given by Scupin [1] firmly establishes this point. Had the Maine specimens been found in Germany, they would no doubt have been identified with *Spirifer hercyniæ*, even after the most detailed study. The only distinction that can be pointed out is that Scupin describes the musculature as equal to or more than one-third the length; it is frequently figured as half the length and in the variety *primæviformis* Scupin [2] it is considerably more than half the length. Scupin states also that in *S. hercyniæ* there are 20 or more ribs on each side, whereas the highest number recorded by Billings for *S. gaspensis* is only 18; but a glance at the published figures of *S. hercyniæ* shows that the common number of plications is 13 or 14 on each side and in old shells (internal molds) apparently only 11 (occasionally 10 or 12), exactly as in *S. gaspensis*. In *Spirifer hercyniæ* the sinus is occasionally equal in width to as many as six ribs, but by far most commonly only to three or four, as in *Spirifer gaspensis*. In all observed respects *Spirifer gaspensis* agrees with *Spirifer hercyniæ;* and as the two species have been carefully studied and no substantial distinctions can be pointed out, it seems necessary to recognize this European species as occurring in America.

This species is frequently confused [3] with *Spirifer paradoxus* Schlotheim (= *Spirifer macropterus* Goldfuss), an abundant species characterizing the higher Coblenzian horizons above the "zone of *Spirifer hercyniæ*." The later shell is distinguished from *Spirifer hercyniæ* or *S. gaspensis* chiefly by its lower, ribbon-shaped cardinal area, in which it approaches the Meso-Devonian types *Spirifer speciosus* Schlotheim, *Spirifer mucronatus* Conrad, and *Spirifer pedroanus* Hartt and Rathbun. *Spirifer paradoxus* is more profusely plicate than *Spirifer gaspensis* or *S. hercyniæ*, having a minimum of 16 to 20 ribs on each side, whereas this number is only occasionally attained as a maximum in the Lower Coblenzian form.

Stratigraphic significance of the gaspensis type.—*Spirifer gaspensis* occurs in the Gaspe limestones Nos. 7 and 8, and in the lower part of the Gaspe sandstones, associated with such typical Oriskany species as *Rensselaeria ovoides*, *Leptocœlia flabellites*, *Spirifer arenosus* (or *superbus*), *Spirifer murchisoni*, *Eatonia peculiaris*, Leptostrophias, etc.; consequently these beds have heretofore been considered of Oriskany age. The same fauna also characterizes the Moose River sandstone in Maine. However, transversely elongated shells with 10 or commonly more ribs on each side, represented by the *gaspensis* type of Spirifer, are unknown in the New York Oriskany; and in the New York section this type does not appear before the Schoharie grit. In Europe it is also absent in the Taunusian (Siegen graywacke) or zone of *Spirifer primævus* (the supposed equivalent of the Oriskany), and makes its first appearance in the ensuing zone of *Spirifer hercyniæ*, or Lower Coblenzian, which is below the Middle and Upper Coblenzian, the latter being correlated with our Onondaga limestone. This would indicate that beds containing elongated Spirifers of the type of *Spirifer gaspensis* (= *hercyniæ*) are related to the European Lower Coblenzian and probably later than the New York Oriskany. The same thing

[1] Scupin, Hans, Palaeontol. Abh. (Dames & Koken), new ser., vol. 4, pt. 3, p. 290, 1900.

[2] The variety *primæviformis* of Scupin strongly resembles the Oriskany shell from Illinois called *S. engelmanni* by Meek and Worthen in 1866 (=*Spirifer worthenana* Schuchert).

[3] See Béclard, Ferd., Les spirifères du Coblenzien belge: Soc. belge géologie Bull., vol. 9, pp. 199-218, p. 272, pl. 14, 1895; Catalogue synonymique et critique des spirifères du Dévonien inférieur: Idem, pp. 260-288.

is further indicated by the occurrence at Gaspe of such Onondaga ("Corniferous") types as *Chonetes antiopa*, *Chonetes laticosta* Hall, *Chonetes* (*Eodevonaria*) *melonicus* Billings (and, in the Moose River sandstone, of *C.* (*E.*) *arcuatus* and *Spirifer duodenarius*), *Orthis* (*Rhipidomella*) *livia*, *Leptostrophia blainvillei* (cf. *L. perplana*, "Corniferous" form), *Delthyris raricosta*, etc., and the great abundance of *Fucoides* (*Spirophyton*) *caudagalli*, the characteristic fossil of the otherwise barren Esopus ("Caudagalli") grit overlying the Oriskany in New York.

In the Oriskany of the region from southern Pennsylvania to Virginia, which yields the normal Oriskany fauna augmented by *Spirifer cumberlandiæ* Hall and *Spirifer submucronatus* Hall, the two species named represent the *gaspensis* type of Spirifer. It was therefore inferred that this Oriskanian region, like that in Acadia, represented the Lower Coblenzian or "zone of *Spirifer hercyniæ*" of Europe, a zone which is a trifle younger than the Oriskany of New York. This inference, which was supported by the occurrence in the Pennsylvania-Virginia region of the European *Spirifer daleidensis* Steininger and by Schuchert's recent discovery of *Tropidoleptus carinatus* (Conrad)—a most characteristic Lower Coblenzian guide fossil in Europe, South Africa, and South America—is confirmed by E. O. Ulrich, who states that within the Oriskany of the Pennsylvania-Virginia region is recognizable a distinct interval antedating the occurrence of the *cumberlandiæ-submucronatus-gaspensis* type of Spirifer.

In Illinois, in the beds which have yielded the *Spirifer engelmanni* and the *Spirifer hemicyclus* of Meek and Worthen with the so-called Oriskany fauna in Union County, as well as in the lowest beds (the beds preceding these containing the Onondagan or "Corniferous" fauna) in the section at the Devils Backbone and Devils Bake Oven,[1] in Jackson County, the Lower Coblenzian or "zone of *Spirifer hercyniæ*" also seems to be present.

In South America the Falkland Islands Eo-Devonian with *Spirifer antarcticus*, *Leptocœlia flabellites*, *Chonostrophia* (?) *tenuis*, etc., seems to represent this same horizon, and there is some ground for believing that the Devonian of South Africa, the Rio Maecuru fauna of Para, Brazil, and the Eo-Devonian limestones of the Eureka district, Nev., likewise represent substantially the same zone.

It is therefore of great interest to note that not only has *Spirifer hercyniæ* been found in America, but, as in Europe, it is the dominant type of Spirifer of a narrowly limited series of fossiliferous beds that are widely distributed in North and South America (probably in South Africa also) and that hold the same stratigraphic position as the Lower Coblenzian in Europe. This position in the column represents some part of the interval between the Oriskany and "Corniferous," an interval which, in the New York section, is occupied by the barren Esopus grit and the nearly barren Schoharie grit. A new fossiliferous zone is thus added to the New York Lower Devonian. An extended discussion of this point would be out of place in the present paper. The preceding relatively brief notes have been framed because of the interesting fact that the zone of *Spirifer hercyniæ* or Unter Coblenzian of European authors has never before been recognized as such in America, and the occurrence here noted is the first one reported outside of Germany, France, and Belgium.[2] This Lower Coblenzian zone of *Spirifer hercyniæ* comprises the so-called "Oriskany" of Quebec, Maine, Nova Scotia, and New Brunswick, and is well developed in Somerset County, Maine. The typical or theoretically older New York Oriskany is apparently absent. The Chapman sandstone represents a still lower horizon than either.

SPIRIFER MONTREALENSIS Williams.

Plate I, figure 2; Plate II, figures 2, 18.

1901. Spirifer cf. *S. granulosus* Conrad. Schuchert, Am. Geologist, vol. 27, p. 252.
Limestone with *Spirifer macrus*: St. Helens Island, Montreal, Canada.

1910. *Spirifer montrealensis*. Williams, Roy. Soc. Canada Trans., 3d ser., vol. 3, p. 222, pls. 1, 2.
Limestone breccia: St. Helens Island, Montreal, Canada.

[1] Weller, Stuart, Correlation of the Devonian faunas in southern Illinois: Jour. Geology, vol. 5, pp. 625-633, 1897.

[2] Since the above paragraph was written J. M. Clarke has published a paper entitled "Evidences of a Coblenzian invasion in the Devonic of eastern North America" (Memorial volume to Prof. Adolf von Koenen, pp. 359-368, Stuttgart, 1907). In this paper Clarke emphasizes the Lower Coblenzian aspect of the Moose River sandstone.

Although this species does not appear in the fauna of the Chapman sandstone, it is here described and illustrated in order that the reader may compare it with *S. concinnus*, which belongs to the Chapman fauna, and with *S. granulosus*, which is of much later date. In the upper breccia of St. Helens Island *S. montrealensis* is found associated with *S. arenosus*, but *S. concinnus* is absent. The latter species, however, is present in the lower fauna of St. Helens Island. In the Gaspe series *S. concinnus* is lacking, although *S. arenosus* appears as low as the Grande Greve limestone. In the New York section *S. concinnus* appears to be restricted to the faunas underlying the zone of *S. arenosus*. The problem of correlation thus involves considerable difficulty.

The first reference to the species was made by Schuchert; later it was fully discussed by Williams, as indicated by the references cited above in the synonymy. The specimens referred to by Schuchert came from a large block of slightly granular siliceous limestone, dark gray when fresh, weathering a rusty yellow, associated with an agglomerate. These specimens, which present an unmistakable Hamilton aspect, led Whiteaves[1] to state that the St. Helens Island fossils "are probably the equivalent of part of the Hamilton formation of Ontario and New York, and not of the Lower Helderberg." That Helderberg fossils of about the age of the Becraft limestone occur on St. Helens Island was shown by Schuchert,[2] and a Becraft Spirifer from these rocks, *S. concinnus*, is figured in the present work. The limestones, however, which contain the species *S. concinnus* were shown by Williams in 1910 to belong to a fauna quite distinct from the block in the breccia containing *S. arenosus* and *S. montrealensis*.

The present species is a large Spirifer with the brachial valve gibbous, as deep as the pedicle valve, or deeper. The pedicle valve has a high, slightly arched cardinal area, with a delthyrium of about 60°, or as wide as it is high; the surface is covered with about 18 low, rounded, narrow ribs, with much narrower interspaces, on each side of the simple fold and sinus; the latter equal in width five to seven ribs. The sinus is angular; the fold is rather strongly elevated but not keeled and is evenly rounded except for a slight median groove on the surface, confined to the posterior part and hardly if at all impressed on the internal molds. The ratio of length to width is 10 to 17. Schuchert mentions strong dental plates, but his specimens were internal molds, and the specimens figured here are external casts on which the dental lamellæ are not represented.

Locality: Upper beds of the limestone breccia (probably Meso-Devonian), St. Helens Island, Montreal, Canada.

Comparisons.—The Montreal shell resembles *Spirifer oweni* Hall, which is usually regarded as the Mississippi Valley equivalent of *S. granulosus*, but it lacks the grooving of the ribs commonly developed in *S. oweni* Hall. As compared with the New York forms of *S. granulosus*, *S. montrealensis* has slightly narrower ribs and lacks the median riblet in the sinus; in adult specimens, moreover, the median groove on the fold is confined to the posterior (young) part of the shell. In small specimens this groove is evident for at least half an inch from the beak forward. In *S. oweni* and typical *S. granulosus* it is often strongly developed on maturer specimens all the way to the front margin.

Genus ANTISPIRIFER, gen. nov.

Among the fossils from the Somerset County localities of the Moose River sandstone have been found a considerable number of specimens of a small Spirifer resembling crushed specimens of a small *Spirifer murchisoni*. Critical examination shows that they are not crushed but exhibit what may be called a resupinate growth of the shell, such as makes the Orthothetes form of strophomenoids or the Chonostrophia form of Chonetes. The name Antispirifer is proposed to designate this peculiar genus, the character of which is indicated by the following diagnosis:

Small shells having the brachial valve convex, as is normal in Spirifer, but with the pedicle valve flat, depressed convex, or slightly concave, sometimes becoming subgeniculate or convex in front in the older shells. Outline, as in Spirifer, semicircular or triangular with a long, straight

[1] The Devonian system in Canada: Am. Assoc. Adv. Sci., Sec. E, Presidential address, 1896, p. 16.

[2] Am. Geologist, vol. 27, p. 252, 1901.

hinge line equal to the greatest width of the shell. Cardinal area distinct, triangular, equal in width to the width of the valve, and of medium height. The cardinal area is either plane or slightly arched; when arched the direction of the arching is convex, the reverse of that common in Brachiopoda. Delthyrium triangular; probably closed, as in Spirifer, by a deltidium. In the internal and external molds of isolated valves, the condition in which the fossils are preserved, it is not apparent whether the delthyrium was closed or open. On the interior of the pedicle valve dental lamellæ are developed as in normal Spirifers, and in older individuals there is a thickening deposition of shelly matter on the interior at the outer side of the lamellæ. The musculature is then strongly impressed and triangular in outline, recalling in character that of *Spirifer murchisoni* and *S. gaspensis*. There is sometimes discernible a faint elevated line in internal molds, or an incipient median septum extending down the middle of the musculature, somewhat as in *S. gaspensis;* but there is no real median septum in the pedicle valve, such as occurs in Delthyris, Cyrtina, Spiriferina, etc. In the brachial valve the cardinal process is simple and radiately striate; the crural bases diverge strongly, producing an elevated front margin for the rather deep dental sockets, which are smooth—that is, uncrenulate. The hinge plate is thus the same as in Spirifer, as is also the musculature. The narrow elevated line or incipient "median septum" of the brachial valve of Spirifer is obscurely developed. Brachial structures unknown.

The surface ornamentation consists of radial plications with sinus in the pedicle valve and fold in the brachial valve, as in Spirifer. The type and only species of Antispirifer has strong concentric close-set lamellæ crossed by fine radial lines as in *Spirifer murchisoni*. Shell structure finely fibrous, impunctate under a hand magnifying glass. The fossils as preserved present a close resemblance to the well-known *Vitulina pustulosa*. The shells are of about the same size and outline and have also the same convexity and number of ribs. The more convex valve has a median fold, and the flat valve has a narrow, simple, abrupt median sinus; but in Vitulina the flat valve is the brachial valve, whereas in Antispirifer the flat valve is the pedicle valve and may be easily recognized by its strong triangular musculature and cardinal area. In Vitulina the shell structure is punctate; in Antispirifer it is impunctate, under a hand magnifying glass. In *Vitulina pustulosa* there is a median groove in the fold, and the base of the median sinus is convex, so that there appears to be a strong plication filling the bottom of the sinus. In *Antispirifer harroldi* the fold is simple, and the bottom of the sinus is flat or concave, with (rarely) a faint narrow obsolescent riblet in the base. The musculature on the interior is very distinct in Vitulina and Antispirifer; unfortunately no comparison can be made of the brachial structures, for these are imperfectly known in Vitulina and not at all known in Antispirifer. Antispirifer also presents some analogies with Leptocœlia, "Cœlospira," etc., but in these plicated plano-convex shells, as in Vitulina, the brachial valve is flat and the pedicle valve more strongly convex, whereas the reverse is true of Antispirifer. They are also smaller, have no cardinal area, and show a curved hinge line.

One of the closest allies of Antispirifer is Anabaia Clarke.[1] This spiriferid genus shares the peculiar feature of Antispirifer in having a flat pedicle valve and a convex brachial valve, but it is affiliated with "Cœlospira," Leptocœlia, etc., in the absence of any cardinal area, in the rounded hinge line, and in the character of the musculature, septa, and cardinal process, which are similar to those of *Leptocœlia flabellites*.

Antispirifer shows the closest affiliation with Spirifer in the wide, straight hinge line, well-developed cardinal area, and triangular delthyrium; in the musculature, dental lamellæ, and absence of real septa; in the simple, radially striate cardinal process; and finally in the general outline, ribbed surface, and finer surface markings. The only distinction which can be pointed out between Spirifer and Antispirifer is that in the latter the pedicle valve is less convex than the brachial valve. It is well known that in the genus Spirifer the pedicle valve is always strongly convex—with very rare exceptions, more convex than the brachial valve. In these rare exceptions, which include *Spirifer macrothyris* Hall, *S. acuminatus* (Conrad), *S. granulosus* (Conrad), *S. cultrijugatus* Roemer, *S. gaspensis* Billings (= *S. hercyniæ* Giebel), and sometimes *S. murchisoni*

[1] Clarke, J. M., Upper Silurian fauna of the Rio Trombetas, Province of Para, Brazil: Mus. Nac. Rio de Janeiro Arch., vol. 10, 1899 (author's English ed., p. 12, Albany, 1900). See also Hall, James, and Clarke, J. M., Paleontology of New York, vol. 8, pt. 2, p. 141, figs., 1893.

Castelnau, the greater convexity of the brachial valve is effected by the development of a high keeled fold. These large Spirifers can not be mistaken for Antispirifer, for they have a strongly convex pedicle valve, whereas in Antispirifer the pedicle valve is flat. Moreover, in the brachial valve of Antispirifer the fold is not keeled but is, on the contrary, rather low and broadly rounded. Antispirifer, as has been indicated, is represented by much smaller shells.

ANTISPIRIFER HARROLDI sp. and gen. nov.

Plate V, figures 1–13.

Small Spirifer-like shell with flattened or resupinate pedicle valve; width slightly greater than the length; four to six ribs on each side of the simple fold and sinus. Pedicle valve flat or very depressed convex, rarely slightly concave; beak elevated above the hinge line, tip slightly incurved, and surface sloping in a plane to the sides and front; very slightly curved near the anterior margin. Outline somewhat pentagonal; posterior margin diverging in two nearly straight lines at an angle of about 145° to 155° from the beak to the hinge extremities, which are rectangular and somewhat pointed or slightly rounded. The lateral margins are subparallel, converging from the cardinal extremity nearly opposite the midlength, where they curve into the front margins, describing nearly a semicircle. The greatest width, which is between the cardinal extremities, exceeds the length 25 to 30 per cent. The cardinal area is well developed, of medium height, plane, or rather commonly very slightly arched, with the convex side of the arch directed posteriorly—contrary to the normal arching of the area in the Brachiopoda—and forming an angle of 140° to 160° with the plane of the margin. The delthyrium is large, triangular, acute, 60° to almost 90°, but it is impossible to state definitely whether it was closed or open. In the great majority of Spirifers as ordinarily preserved the deltidium has become detached, so that the delthyrium appears to be open. When such shells are preserved as internal molds the interior filling of the valve is continuous with the external matrix through the delthyrium, which would not be the case if the deltidial covering intervened. These molds therefore seem to indicate an open delthyrium, as do the few clean pedicle valve molds of *Antispirifer harroldi* which have been observed. However, as the true Spirifers that are known to have had a closed delthyrium are commonly preserved in the same way, and as Antispirifer so closely resembles Spirifer in most of its essential features, its delthyrium was probably closed as in Spirifer. On the interior of the pedicle valve there is a strongly impressed musculature, which is triangular to lozenge-shaped or pentagonal in outline, much like that of *Spirifer murchisoni*. It extends one-half to three-fifths the length of the shell and is longer than wide, the ratio of length to width varying from $1\frac{1}{4}$:1 to 2:1, commonly nearer the former figures. It is limited on the sides by well-developed dental lamellæ, standing under the third ridge on each side of the median sinus and extending one-fifth the length of the valve or less. The dental lamellæ are strong in young shells, where they leave in the internal mold a clean incision; but toward maturity the cavity on the interior of the valve outside of the dental lamellæ becomes filled in by the deposition of shell substance, and the internal molds of such mature forms present the highly elevated tonguelike cast of the musculature so characteristic of *Spirifer murchisoni*, *Spirifer gaspensis*, etc. An incipient median septum, or rather low elevated line, is developed between the muscular scars toward maturity (as in *Spirifer hercyniæ* and *S. gaspensis*), beginning at the posterior edge and extending only part way down the musculature. It is absent in most specimens, and when at all recognizable leaves a barely discernible impressed line in the internal mold, thickening at the posterior tip of the musculature. Such a line is present in many if not in most Spirifers and should not be confounded with the strong, sharp median septum of Delthyris. The brachial valve is decidedly convex, the greatest height in the middle being from three-tenths to one-third the length. It presents the aspect of a convex brachial valve of *Cyrtina hamiltonensis*, *C. heteroclita*, or *C. dalmani*, and may indeed be readily mistaken for Cyrtina in detached specimens. The outline is trapezoidal or semicircular, with a wide, straight hinge line equal to the width of the valve; the beak extends slightly over the hinge border. The lateral margins are subparallel from the rectangular hinge extremities, at first converging only slightly and then curving into the front margin, forming a semicircle. The width is from 30 to 50 per cent greater than the length, commonly nearer the former figure. A narrow cardinal area is discernible in some specimens. On the interior of the brachial valve the cardinal process is simple and radially striated, as in Spirifer, and seems to be merely the coalesced extremities of the crural bases. The crural bases diverge at a wide angle, are almost parallel to the hinge line, and produce an elevated front border for the diverging dental sockets. The brachial structures are unknown. The adductor scars are feebly if at all impressed. A trace of the elevated median line present in Spirifer, Cyrtina, etc., is sometimes discernible, thickening slightly toward the beak.

On each side of the simple fold and sinus the surface is elevated into five or six radial plications, the outermost one rather obsolescent; rarely only four are discernible. The plications are rounded, moderately to strongly elevated (only moderately elevated or rather low in the brachial valve), and with narrower interspaces. The ribs are preserved on the internal molds, where they are sometimes subangular, and, as is normal in plicated shells, the interspaces are wider than on the surface. The sinus in the pedicle valve is abruptly sunken below the plane of the surface and is flat at the bottom. The fold is of low or moderate height and rounded. Fold and sinus are simple. The sinus is slightly wider or slightly narrower than the bounding rib. The width of the fold is nearly equal to the width of two bounding ribs. The finer surface markings consist of close-set, concentric, elevated imbricating lamellæ, of which eight or nine may be counted in the length of 5 millimeters near the front of the shell. These are crossed by fine radiating lines, of which there are four to six in the width of a millimeter, and which become spinulose on the crests of the lamellæ. The ornamentation, both coarse and fine, seems to be more conspicuous on the pedicle valve than on the brachial valve.

The measurements of a few pedicle valves show the following dimensions of length and width, respectively: 12 by 16 millimeters; 11 by 15 millimeters; 12.5 by 17 millimeters; 12 by 15 millimeters; 15 by 17+ millimeters.

Three brachial valves measure: 11 by 14.5 millimeters; 12.3 by 17 millimeters; 8.3 by 13 millimeters.

The shell structure is finely fibrous and impunctate under a hand lens.

The gregarious habit of the species is indicated by its abundance wherever it occurs. The only fossil with which *Antispirifer harroldi* is likely to be confused is *Spirifer murchisoni*, which it resembles in the strong musculature, number of plications, and fine surface markings. From this form Antispirifer may be distinguished by its smaller size, less transverse outline (especially conspicuous in the brachial valve), flat pedicle valve, and plane or inversely arched cardinal area. The concentric ornamentation is stronger and the dental lamellæ are farther from the middle, being at or beyond the third ridge from the median sinus; they are at the second ridge or second furrow in *S. murchisoni*. As has been stated, isolated brachial valves of *Antispirifer harroldi* may be easily mistaken for the brachial valves of such Cyrtinas as *C. hamiltonensis* Hall, *C. dalmani* Hall, or *C. heteroclita* De France.

Localities: Moose River sandstone (locality 1100 A or A′), abundant; associated with *Leptocœlia flabellites, Spirifer murchisoni;* Moosehead Lake (locality 1076 E 3), associated with *Leptocœlia flabellites;* Parlin Pond (locality 1059–12), associated with *Leptocœlia flabellites*. All these localities are in Somerset County, Maine.

U. S. National Museum, catalogue Nos. 59748, 59749, 59750.

ANTISPIRIFER HARROLDI var. TRANSVERSA n. var.

Plate IV, figures 8, 9.

A few Antispirifers in the Maine collections are distinguished from the normal forms by a more transverse outline. The length and width of some of these transverse specimens, in millimeters, are: Pedicle valves, 12 by 25, 10 by 18; brachial valves, 11 by 22, 12 by 22.

No intermediate forms occur. These specimens might be regarded as aberrant forms of *Spirifer murchisoni*, for they have the dental lamellæ on the second ridge as in that species, but they have the flat pedicle valve and plane or inversely arched cardinal area of Antispirifer. The fossils may represent a distinct species instead of variety.

Localities: Moose River sandstone, Detroit (locality 1100 A′), rare; Parlin Pond (locality 1059–12, common; locality 1059, rare; and locality 1059 C, abundant and large). All in Somerset County, Maine.

U. S. National Museum, catalogue Nos. 59751, 59752, 59753.

Family ATHYRIDÆ Phillips.

Genus NUCLEOSPIRA Hall, 1859.

NUCLEOSPIRA VENTRICOSA Hall.

Plate V, figures 31–33.

1857. *Spirifer ventricosa.* Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 57.
Lower Helderberg limestone: Albany County, N. Y.

1859. *Nucleospira ventricosa.* Hall, Paleontology of New York, vol. 3, p. 220, pl. 14, fig. 1; pl. 28 (B), figs. 2–9.
Shaly limestone of the Lower Helderberg group: Helderberg Mountains, Schoharie, and Cherry Valley, N. Y.; Cumberland, Md., etc.

1859. *Nucleospira ventricosa.* Hall, New York State Cab. Nat. Hist. Twelfth Ann. Rept., p. 25, figs.
Lower Helderberg: New York.

1867. *Nucleospira ventricosa.* Hall, Paleontology of New York, vol. 4, pp. 277, 278.
Lower Helderberg: New York.

1886. *Nucleospira ventricosa.* Darton, Am. Jour. Sci., 3d ser., vol. 31, pp. 212, 214.
Lower Helderberg: Cornwall station, Orange County, N. Y.

1893–95. *Nucleospira ventricosa.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, p. 145, figs. 128–130; pl. 48, figs. 2–6, 18; pl. 84, figs. 39–40.
Lower Helderberg: Helderberg Mountains and Schoharie, N. Y.

1897. *Nucleospira ventricosa.* Schuchert, U. S. Geol. Survey Bull. 87, p. 273.
Lower Helderberg: Schoharie, Cherry Valley, etc., N. Y.; Cumberland, Md.

1897. *Nucleospira ventricosa.* Weller, Jour. Geology, vol. 5, No. 6, p. 627.
Lower part of Upper Helderberg:[1] Devils Bake Oven, near Grand Tower, Jackson County, Ill. (Zone I).

1899. *Nucleospira ventricosa.* Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), p. 340.
New Scotland shaly limestone: Countryman Hill, Albany County, N. Y.

1901. *Nucleospira ventricosa.* Prosser, New York State Geologist Eighteenth Ann. Rept. (for 1898), p. 55.
New Scotland shaly limestone: Indian Ladder section, Countryman Hill, Albany County, N. Y.

?1903. Nucleospira cf. *N. ventricosa.* Schuchert, U. S. Nat. Mus. Proc., vol. 26, p. 417.
Manlius shaly limestone: Cash Valley, near Cumberland, Md.

1903. *Nucleospira ventricosa.* Weller, Paleontology of New Jersey, vol. 3, pp. 83, 87, 290, 316, pl. 30, figs. 19–22; pl. 37, fig. 16.
Upper Coeymans limestone: 1¾ miles northeast of Hainesville, N. J.
Upper New Scotland shaly limestone: Nearpass section, N. J.

1903. *Nucleospira ventricosa.* Van Ingen and Clark, New York State Mus. Bull. 69, pp. 1189, 1193, 1203, 1207.
Upper Coeymans and upper Becraft limestones: Near Rondout, N. Y.
Oriskany siliceous limestones: Glenerie, N. Y.

1905. Nucleospira cf. *N. ventricosa.* Clarke, New York State Mus. Bull. 80, p. 146.
Grande Greve limestones: North shore of Gaspe Bay, Quebec.

1905. *Nucleospira ventricosa.* Shimer, idem, pp. 207, 219, 220, 255, 264.
Coeymans limestone and (?) upper New Scotland: Trilobite Mountain, Orange County, N. Y.

?1905. Nucleospira cf. *N. ventricosa.* Hartnagel, idem, p. 355.
Rosendale cement bed: High Falls, N. Y.

1905. Nucleospira sp. Williams and Kindle, U. S. Geol. Survey Bull. 244, pp. 28, 32, 48.
Top of Hancock limestone: East fork of Powell River (above flouring mill; station 1376A), Big Stone Gap, Wise County, Va.
Giles sandstone [in beds of Oriskany age]: 1½ miles above Hicksville (station 1379A′), Bland County, Va.

An internal mold with both valves in conjunction and an isolated pedicle valve have been found in the Chapman sandstones at locality 1099 C′, on Edmunds Hill. Another isolated pedicle valve comes from a point 2½ miles west of Presque Isle Stream. The specimens are too poorly preserved for a detailed specific description, but the outline, convexity, and curvature are those of *N. ventricosa;* there is a narrow median sinus or groove on the pedicle valve, and in the interior a low linear median septum and two thick unsupported teeth. A circular or

[1] Probably representing the horizon of the Moose River sandstone of Maine, or zone of "*Spirifer hercyniæ.*"

oval muscular scar is divided longitudinally by the median septum and extends from the middle of the shell a trifle more than half the distance to the beak; this seems to be the scar of the adductors, while the diductor muscles apparently do not leave any discernible impression. In the brachial valve there is also a linear median septum extending nearly to the front margin, slightly stronger than that of the pedicle valve and ending in a massive bilobed cardinal process. The peculiar distinctness of the oval adductor scar, especially as compared with the diductor scar, the occurrence of a median linear septum in both valves, and a massive cardinal process, which is remarkably ponderous for such small shells, serve to recall the internal structures of *Leptocœlia flabellites*.

Locality: Chapman sandstone, Edmunds Hill, and 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59754, 59755.

Genus LEPTOCŒLIA Hall.

The first definition and illustration of the genus Leptocœlia was published by Hall [1] in 1859. The date (1859) for the original and valid publication of the name Leptocœlia is determined by the rules of zoologic nomenclature adopted by the British Association in 1842,[2] according to which "two things are necessary before a zoological term can acquire authority, viz, definition and publication."

In 1857 the nude generic name Leptocœlia[3] had been applied to three new species, *L. concava*, *L. imbricata*, and *L. propria*, but no definition of the name was given.

In connection with the publication of the definition in 1859 three species were named, described, and figured. The first species was *Leptocœlia flabellites* (Conrad), which must, therefore, serve as the genotype.

In the original definition of the genus a supposed brachial loop similar to the loop of terebratuloid brachiopods was interpreted from some mineral fillings described and figured in a single cast of *Leptocœlia flabellites*. No confirmation of the interpretation of these appendages has ever been made. For several years Leptocœlia was supposed to belong with the Terebratulas, but in 1863 spiral appendages were discovered in the species *Leptocœlia concava* Hall,[4] and this feature is sufficient to remove that species from the terebratuloid type. The discovery of the spiral appendages in itself, however, did not justify the founding of the genus Cœlospira, to which *L. concava* was referred.

Studies by Hall and others have cast much doubt on the correctness of the interpretation of the "brachial loop" in *L. flabellites*. Paleontologists to-day regard the loop as nonexistent in Leptocœlia, which is regarded as spire-bearing.[5] *Leptocœlia flabellites* is similar in internal features to *Nucleospira ventricosa*, as has been indicated in the description of the latter form.

The uncertainty regarding the brachial appendages of Leptocœlia does not, however, invalidate the original definition of the genus. So long as there is no certain knowledge regarding the appendages of *Leptocœlia flabellites*, the genus Leptocœlia may be assumed to be different from Cœlospira. Even if *Leptocœlia flabellites* were found to possess spiral appendages like those of Cœlospira, the result would not disturb the validity of Leptocœlia; it would merely serve to prove that Cœlospira is congeneric with Leptocœlia, from which it was removed chiefly on account of the presence of spiral appendages. In any event the name Leptocœlia is applicable to *Atrypa flabellites* Conrad.

Reference of Leptocœlia to Anoplotheca Sandberger, as proposed by Schuchert,[6] on the ground of certain similarities, seems untenable. In the definition of Anoplotheca Sandberger emphasizes the absence of pedicle opening, hinge area, and deltidium,[7] as follows: "Testa ovata, convexo-concava, imperforata, area et deltidio carens," and, in German, "Schale von

[1] Paleontology of New York, vol. 3, p. 447, pls. 103B and 106.
[2] See Am. Jour. Sci., 2d ser., vol. 48, p. 102, 1869.
[3] New York State Cab. Nat. Hist. Tenth Ann. Rept., pp. 107-108, 1857.
[4] New York State Mus. Sixteenth Ann. Rept., p. 60, 1863.
[5] New York State Geologist Thirteenth Ann. Rept., p. 803, 1894.
[6] U. S. Geol. Survey Bull. 37, p. 144, 1897.
[7] K. Akad. Wiss. Wien, Sitzungsber., Math.-naturw. Kl., vol. 16, p. 6, April, 1855.

eiformigem Umrisse, convex-concav, ohne Stieloffnung, Schlossfeld, und Deltidium." In the specific description of *Leptocœlia flabellites* the beak is described as having "a small round perforation in the extremity which is completed on the lower side by the deltidial pieces." [1] In the description of *Leptocœlia fimbriata* the same pedicle opening and deltidial pieces are noted.[2] These differences in structure, so positively indicated in the original definition of the genera, and present doubt regarding the similarity of the brachial appendages of Leptocœlia and of Anoplotheca are sufficient grounds for not confusing the genera. Leptocœlia will therefore continue to stand as the proper generic name for *Leptocœlia flabellites* (Conrad), *Leptocœlia fimbriata* Hall, and their congeners.

LEPTOCŒLIA FLABELLITES (Conrad).

Plate V, figures 19–30.

1837. "Terebratulæ." Jackson, First annual report on the geology of the State of Maine, p. 128, pl. 50, fig. 6, (pars), 9.
Graywacke: Maine.
1839. cf. *Orthis callactis* (not Sowerby). Murchison, Silurian system, p. 701.
Brownish sandstone: Cedar Mountain, north of the Cape Colony.
1840. *Orthis callactis* (not Sowerby). De Verneuil, Soc. geol. France Bull., vol. 11, p. 166.
Sandstones: Cedar Mountains, Cape Colony.
1841. *Atrypa flabellites.* Conrad, New York Geol. Survey Fifth Ann. Rept., p. 55.
Oriskany sandstone: Near Saugerties, N. Y.
1842. *Terebratula peruviana.*[3] D'Orbigny, Voyage dans l'Amérique méridionale, vol. 3, pt. 4, p. 56; Atlas, pl. 2, figs. 22–25.
Sandstone: Rio Chalhuani, Bolivia.
1846. *Atrypa palmata.* Morris and Sharpe, Geol. Soc. London Quart. Jour., vol. 2, p. 276, pl. 10, fig. 3.
Devonian: Falkland Islands.
1856. *Orthis palmata.* Sharpe and Salter, Geol. Soc. London Trans., 2d ser., vol. 7, p. 207, pl. 26, figs. 7–10.
Ferruginous rock: Cold Bokkeveld, South Africa.
Dark schists: Warm Bokkeveld, South Africa.
"With Conularia in the Cedarberg" (Cedar Mountains), South Africa.
Light-colored schists: Kokmans Kloof, South Africa.
1857. *Leptocœlia propria.* Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 108.
Oriskany sandstone: New York, Maryland, Canada.
1859. *Leptocœlia flabellites.* Hall, New York State Cab. Nat. Hist. Twelfth Ann. Rept., p. 33, figs. 1, 2, 4.
No formation or locality given.
1859. *Leptocœlia flabellites.* Hall, Paleontology of New York, vol. 3, p. 449, pl. 103B, fig. 1, pl. 106, fig. 1.
Oriskany sandstone: Albany, Schoharie, Greene, and Ulster counties, N. Y.; Cumberland, Md.; Virginia; Canada.
1861. *Leptocœlia flabellites.* Billings, Canadian Jour., vol. 6, p. 351, fig. 126.
Oriskany sandstone and Corniferous limestone: Haldimand, Canada West.
Oriskany: Gaspe, Quebec.
1861. *Orthis aymara.* Salter, Geol. Soc. London Quart. Jour., vol. 17, p. 68, pl. 4, fig. 14.
"Silurian:" Valley of Millepaya and other localities on the western side of the Andes Mountains, Bolivia.
Devonian: South Africa; Falkland Islands; Gaspe, Quebec.
1862. *Leptocoœlia flabellites.* Hitchcock, Portland Soc. Nat. Hist. Proc., vol. 1, pt. 1, p. 79.
Oriskany sandstone: In belt from Parlin Pond, Somerset County, to Aroostook River, Maine.
1863. *Leptocœlia flabellites.* Billings and Logan, Geology of Canada, p. 369, figs. 382, pp. 392, 393, 398, 439, 885.
Gaspé limestones Nos. 4 and 5 (Lower Helderberg-Oriskany transition): Cape Gaspe, Quebec.
Gaspé limestone No. 8, (Oriskany): Gaspe, White Head, Perce Rock, and Cape Barry, Quebec.
Gaspé sandstones: Patawegia Brook, near York River; north side of inner basin at Gaspe, and on Douglastown River; all on Gaspe Peninsula, Quebec.
Corniferous limestone: West of Grand River, in Haldimand and Norfolk counties, Canada West.
1867. *Leptocœlia acutiplicata* (pars). Hall, Paleontology of New York, vol. 4, p. 365, pl. 57, figs. 34, etc
Corniferous limestone: Waterloo, Seneca County, N. Y.
1868. *Leptocœlia flabellites.* Meek and Worthen, Illinois Geol. Survey, vol. 3, p. 397, pl. 8, fig. 3.
Oriskany cherty limestone: Dry Fork of Clear Creek, Union County, Ill.
1874. *Leptocœlia flabellites.* Billings, Paleozoic fossils, vol. 2, p. 42, pl. 3, figs. 5, 6.
Gaspe limestone No. 8, and lower part of overlying Gaspe sandstones: Gaspe Bay, Quebec.

[1] Hall, James, Paleontology of New York, vol. 3, p. 449, 1859.
[2] Idem, p. 450.
[3] As a result of the researches of Kayser, Ulrich, and Thomas, this name is generally regarded as a synonym of *Leptocœlia flabellites.* The fossil as figured by D'Orbigny shows a strongly convex brachial valve. Such strong biconvexity is not characteristic of Leptocœlia.

1879. *Leptocœlia flabellites.* Dawson, Canadian Naturalist, vol. 11, p. 7.
Nictau iron ore and dark slates (Oriskany): Nictau, Nova Scotia.
1882. *Leptocœlia flabellites.* Stevenson, Pennsylvania Second Geol. Survey Rept. T2, p. 104.
Lower Oriskany fine-grained dark-blue sandstone: Wills Creek, near Hyndman, Bedford County, Pa.
1882. *Leptocœlia flabellites.* I. C. White, Pennsylvania Second Geol. Survey Rept. G7, pp. 86, 297.
Oriskany cherty beds: Cooper Township, Montour County, Pa.
1883. *Leptocœlia flabellites.* Ells, Canada Geol. Survey Rept. Progress for 1880–1882, pp. 9DD, 13DD.
Upper Gaspe limestones (Oriskany): Perce Rock, Indian Cove, Grande Greve, and Little Gaspe, Quebec.
Gaspe sandstone (basal beds): York and Dartmouth rivers, and near Gaspe, Quebec.
?1884. Leptocœlia cf. *L. acutiplicata.* Walcott, U. S. Geol. Survey Mon. 8, p. 276.
Lower Devonian: Eureka district, Nev.
1885. *Leptocœlia flabellites.* Ells, Canada Geol. Survey Rept. Progress for 1882–1884, pp. 24E, 30E.
Gaspe Oriskany [whether sandstones or upper limestones not stated]: Hills in the rear of Gaspe village, Gaspe, Quebec.
Gaspe (lower ?) limestones (at contact with Ordovician): Cape Rosier Bay, Quebec.
1887. *Leptocœlia flabellites.* Ami, Canada Geol. Survey Ann. Rept., new ser., vol. 2, p. 9N.
Oriskany slates and sandstones: Campbell River, at junction with Don River, New Brunswick.
1891. *Leptocœlia flabellites.* Steinman, Am. Naturalist, vol. 25, p. 856.
Lower Devonian; North America, Bolivia, Falkland Islands, and South Africa.
1892. *Leptocœlia flabellites.* Clarke, Am. Jour. Sci., 3d ser., vol. 44, p. 415.
Oriskany dark siliceous limestone: Becraft Mountain, N. Y.
1892. *Leptocœlia flabellites.* A. Ulrich, Neues Jahrb., Beilage Band, vol. 8, p. 60, pl. 4, figs. 9–13.
Lower Devonian: Millepaya Valley, west slope of the Illampu Mountains, Bolivia, and elsewhere on the west slope of the Bolivian East Cordilleras.
Icla formation (calcareous or fine-grained rocks): Chahuarani, Icla, Huamampampa, Tarabuco, Chalhuani, Oconi, Pulquina, Agua Blanca, and Totora, Bolivia.
Icla formation (light-gray micaceous quartzitic sandstones): Chililaya, east side of Lake Titicaca.
Sandstone (Icla formation): Rio Chalhuani, Bolivia (D'Orbigny).
1893. *Leptocœlia flabellites.* Von Ammon, Gesell. Erdkunde Berlin Zeitschr., vol. 28, p. 363, fig. 7.
Lower Devonian: Taquarassu, Matto Grosso, Brazil.
1893–1895. *Leptocœlia flabellites.* Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, p. 137 (1893); pl. 53, figs. 40–46, 53 (1895).
Oriskany: Cumberland, Md.; Falkland Islands (as *Atrypa palmata* Morris and Sharpe); cordilleras of Bolivia (as *Orthis aymata* Salter); South Africa (as *Orthis palmata* Salter); Matto Grosso, Brazil.
1895. *Leptocœlia flabellites.* Ami, Canada Geol. Survey Ann. Rept., vol. 6, p. 15Q.
Nictau beds (Lower Devonian): Nictau, Nova Scotia.
1897. *Anoplotheca flabellites.* Schuchert, U. S. Geol. Survey Bull. 87, p. 144.
Oriskany and Corniferous: Schoharie and vicinity, N. Y.; Haldimand County, Ontario; Gaspe, Quebec; Cumberland, Md.; Union County, Ill.; Bolivia; Taquarassu, Matto Grosso, Brazil; Falkland Islands; South Africa.
1897. *Leptocœlia flabellites.* Kayser, Deutsch. Geol. Gesell. Zeitschr., vol. 49, p. 304, pl. 12, figs. 5–6.
Lower Devonian: Chilalaya, Lake Titicaca.
Devonian: Falkland Islands; Peru; Bolivia; Brazil; South Africa.
Oriskany: North America.
1899. *Leptocœlia flabellites.* Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), p. 342.
Oriskany calcareous quartzite: Countryman Hill, Albany County, N. Y.
1899. *Anoplotheca flabellites.* Schuchert, Am. Jour. Sci., 4th ser., vol. 7, p. 432.
Camden chert: Camden and vicinity, Benton County, Tenn.
1900. *Leptocœlia flabellites.* Clarke, Mus. Nac. Rio Janeiro Arch., vol. 10, 1899 (English ed., p. 99, 1900).
Icla shales (Lower Devonian): Icla, Bolivia.
1900. *Anoplotheca flabellites.* Schuchert, Geol. Soc. America Bull., vol. 11, pp. 271, 284, 313, 324.
Shales of the age of the New Scotland and Becraft: Devils Backbone, Kreighbaum station (Baltimore & Ohio Railroad), Md.
Lower Helderberg: Maryland-Virginia region; Gaspe and Nova Scotia.
Kingston beds (Port Ewen) below the Oriskany: Devils Backbone, near Cumberland, Md.
Oriskany: Oneida and North Cayuga townships, Ontario.
Monterey formation: About Cumberland, Md.
1900. *Leptocœlia flabellites.* Clarke, New York State Mus. Mem., vol. 3, No. 3, pp. 42, 73, 75, pl. 5, figs. 33–36.
Oriskany (dark siliceous limestone): Becraft Mountain; Glenerie; near Kingston, on the West Shore Railroad, one-half mile southeast of Rondout Creek, N. Y.
1903. *Anoplotheca flabellites.* Schuchert, U. S. Nat. Mus. Proc., vol. 26, p. 422.
Becraft limestone: Cherry Run, W. Va.
Oriskany siliceous shale: Bridge 21, Baltimore & Ohio Railroad, near Keyser, Mineral County, W. Va.

1903. *Anoplotheca flabellites.* Weller, New Jersey Geol. Survey, Paleontology, vol. 3, pp. 98–102, 357, pl. 49, figs. 1, 2.
Orbiculoidea jervisensis zone, or middle Oriskany (siliceous limestone): Wallpack Ridge, N. J., 5 miles from New York State line.
Spirifer murchisoni zone, or upper Oriskany (siliceous limestone): Werden Farm, Nearpass region; three-fourths of a mile west of Layton; three-fourths of a mile north of Peters Valley; 1½ miles east of Flatbrookville, all in New Jersey.
1903. *Leptocœlia flabellites.* Van Ingen and Clark, New York State Mus. Bull. 69, pp. 1203, 1207.
Oriskany (sandy and cherty beds): Glenerie and Rondout, N. Y.
1903. *Anoplotheca flabellites.* Katzer, Geologie des unteren Amazonasgebietes, p. 196, pl. 12, fig. 6.
Spirifer sandstone: Rio Maecuru, Para, Brazil.
1903. *Leptocœlia flabellites.* Reed, South African Mus. Annals, vol. 4, p. 189, pl. 23, fig. 10.
Bokkeveld series (Lower Devonian): Gydo Pass; just north of Stinkfontein; Ginka Poort; Ceres, South Africa.
Fossiliferous first or lowest sandstone: North of homestead, Uitkonist, South Africa.
Devonian: Argentina; Falkland Islands; Bolivia; Brazil; Cape Colony; North America.
1904. *Trigeria* (?) *oehlerti.* Drevermann, Palaeontographica, vol. 50, p. 260, pl. 30, fig. 23 (cet. excl., not fig. 24).
Siegen graywacke: Seifen, near Dierdorf, in the Westerwald, Germany (not Herdorf).
1905. *Leptocœlia flabellites.* Clarke, New York State Mus. Bull. 80, pp. 143, 146, 148, 149.
Grande Greve limestones: North side of Gaspe Bay.
Perce strata: Perce Rock, Gaspe, Quebec.
Gaspe sandstone: Gaspe, Quebec.
1905. *Leptocœlia flabellites.* Shimer, idem, pp. 206, 228, 229, 234, 253, 254, 264.
Middle Oriskany (zone with *Orbiculoidea jervisensis*) and upper Oriskany, or *Spirifer murchisoni* zone (both dense blue limestones): Trilobite Mountain, N. Y.
1905. *Leptocœlia flabellites.* Thomas, Deutsch. geol. Gesell. Zeitschr., vol. 57, p. 264, pl. 14, figs. 35a–c.
Devonian: Cerro del Agua Negra, Argentina.
1905. Anoplotheca cf. *A. flabellites.* Williams and Kindle, U. S. Geol. Survey Bull. 244, pp. 34, 43, 48.
"Oriskany" coarse sandstone: Rear of Alabama Row, White Sulphur Springs Hotel, W. Va. (as Leptocœlia sp., p. 34).
"Oriskany" soft coarse brown sandstone: Near Chesapeake & Ohio Railway bridge one-half mile west of Clifton Forge, Alleghany County, Va.

A small plano-convex shell of rounded outline with 10 to 14 simple ribs, having adductor muscular scars more prominent than the diductors, a massive bilobed cardinal process in the flat brachial valve, and a thin, low median septum or elevated line in each valve. Pedicle valve strongly convex throughout, commonly broadly inflated, rarely subcarinate; the greatest height, which is two-fifths the length from the beak, is equal to one-third the length of the shell; length occasionally equal to the width, but commonly less in the ratio 6 : 7. Greatest width near or slightly anterior to the middle. Hinge line short, curved. The posterior margin of the shell declines from the rounded beak at an angle of 105° to 135°, commonly nearer the latter; cardinal extremities rounded, forming with the lateral and front margins a deep curve of more than 180° and nearly 240°. Cardinal area practically lacking; delthyrium closed by deltidial plates. On the interior of the pedicle valve the most conspicuous features are the strong rounded teeth, unsupported by lamellæ; the unusual feature of the diductor cicatrix obscure and the adductor scars fairly conspicuous, much more so than the diductors; and the thin, low median septum extending one-half to three-fifths the length and apparently forking at the anterior end. In internal molds the two large, deep oval holes left by the teeth are very conspicuous; they are separated by a little more than their own width; the space between the outer margins of the teeth is equal to one-third the width of the shell, or a trifle more. The teeth appear to rise as thick, blunt processes from the base of the valve and are not supported by distinguishable lamellæ. The diductor cicatrix is rarely distinguishable but appears to be flabellate and a little wider than long. It extends the length of the median septum. The sides of the musculature diverge at an angle of about 90°. The pedicle cavity is large. The adductor scar is oval, is longer than wide, extends frequently as far forward as one-third the length from the beak, and is divided longitudinally by the median septum. The median septum is a narrow, sharply elevated line beginning at the forward end of the pedicle cavity, becoming conspicuous in passing through the adductor cicatrix, extending half or three-fifths the length and bifurcating in front into two short branches, which are extremely faint, rarely discernible, 1 to 2 millimeters long, and diverge at an angle of about 60° or more. These branches probably serve to limit the anterior end of the musculature.

The brachial valve is flat, sometimes slightly concave and sometimes (especially toward the front) slightly convex. The outline is rounded, the posterior margin diverging from the pointed beak at an angle of about 150° or 155°. The length is equal to or slightly less than the greatest width. On the interior of the brachial valve the most conspicuous features are the thick hinge plate and the massive lobed cardinal process. The mesial septum in the brachial valve is a low, narrow, sharp ridge extending about halfway to the front. It becomes thickened in front of the hinge plate where it halves the adductor scar longitudinally. The lateral and anterior margins of the scar are indefinable. The cardinal process is massive, occupying a large part of the umbo, and extends backward at an angle of 155° or slightly more with the plane of the margin. The lower and main mass of the process is undivided, but at the summit the process becomes lobed. There appear to be four small lobes in perfect specimens. In the molds each crural base leaves a sharp, deep pit at the base of the cardinal process. The umbonal region in such specimens presents an appearance similar to that of Megalanteris ("Beachia"), *Rensselaeria mainensis,* and *Nucleospira ventricosa.* This indicates that the cruræ extend directly into the body cavity of the animal as in the terebratulids, rather than diverging widely subparallel to the hinge, as in Spirifer and many spire-bearing shells, and suggests that *Leptocœlia flabellites* may after all prove to possess a terebratulid brachidium.

The surface is covered with 8, more frequently 10, or rarely 12, radiating ribs (10 to 14 are usually regarded as the limits in the species), which are strongly elevated, rounded to subangular, and separated by interspaces narrower than themselves. A sinus in the convex pedicle valve and a fold in the flat brachial valve are commonly but not invariably present. The sinus in the pedicle valve is produced most frequently by the disappearance of the median rib, but very commonly the bounding rib on each side is a little strengthened; the median rib may then also be present, but more or less obsolescent, appearing as a riblet in the sinus. The fold in the brachial valve is produced by the strengthening of the two median ribs. The groove or interspace between these two ribs is slightly wider and deeper than the grooves between the other ribs. One or two concentric varices of growth are commonly observable. No finer surface ornamentation has been seen. Shell structure finely fibrous; impunctate under a hand glass. The common size of the pedicle valve is 11 or 12 millimeters long and 13 or 14 millimeters wide. The largest specimen observed was 14 millimeters long and 17 millimeters wide.

Leptocœlia flabellites occurs in North America, South America, and South Africa in rocks of the age of the Oriskany sandstone and also in the younger "zone of *Spirifer hercyniæ.*" Apparently it extends upward into the "Corniferous" in Ontario. It is abundant and a dominant member of the fauna wherever it occurs; it is particularly so in the Moose River sandstone. It has been found in this formation at Parlin Pond (locality 1059 C^3), Moosehead Lake (locality 1076 E^3), and Detroit (locality 1100 A), all in Somerset County, Maine.

U. S. National Museum, catalogue No. 59756.

Comparisons.—The Maine specimens are distinguished for having the minimum number of plications, which are rounded. In Illinois, South America, and South Africa the species is represented by larger individuals with more angular ribs, the number of which is commonly the maximum for the species, 12 or 14. The Gaspe specimens also have 12 or 14 ribs.

The absence of *Leptocœlia flabellites* in Europe is worthy of special note. In the normal Oriskany fauna of New York, New Jersey, Pennsylvania, Maryland, and Virginia, as well as in such other faunas as seem to represent the younger "zone of *Spirifer hercyniæ*" (as at Gaspe, Quebec; in Nova Scotia; in Somerset County, Maine; in Appalachian Pennsylvania to Maryland; in Illinois and Tennessee; on Rio Maecuru, Para, Brazil; in Argentina; the Falkland Islands; and South Africa), Leptocœlia is one of the most abundant and dominant elements of the fauna. It seems therefore remarkable that this species, so abundant, very frequently forming of itself thick masses, in America and South Africa, should be unrecorded from rocks of similar age in Europe.

It is probable that in Europe the species is absent or extremely rare, else it would have been reported long ago. Only within the last few years have any fossils been reported from the European faunas that can be closely compared with *Leptocœlia flabellites.* One of these, which seems to be identical with this cosmopolitan species, is *Trigeria? oehlerti* Drevermann,[1] from the Siegen graywacke of Seifen, near Dierdorf, in the Westerwald. The fossil as figured by Drevermann has a depressed convex valve and is subcircular in outline, with a fold produced by two strong ribs, and on each side there are four slightly smaller rounded ribs. The internal mold figured by Drevermann has much the same aspect as the specimens of *Leptocœlia flabellites* occurring in the faunas of Somerset County, Maine, and his figure shows at the umbo a peculiar expression similar to that occurring in internal molds of *L. flabellites* and produced by the massive cardinal process. (Compare some of the figures in the present work.) Drevermann's species seem to represent the phase of *L. flabellites* represented by the Maine fossils—that is the pauciplicate type with small shell and only 8 or 10 rounded ribs. Drevermann gives a scanty description of the fossil, and though ordinarily I should feel much hesitancy in uniting with a transcontinental species a European fossil known practically only from a single figure of a fragmentary brachial valve, yet so peculiar are the features of *Leptocœlia flabellites* that it is safe to call attention to *Trigeria? oehlerti* Drevermann s. str. (not his fig. 24) as its possible European representative.

Drevermann illustrated in his figure 24 a form from the Siegen graywacke (Unter Coblenzian?) of Herdorf, in the Westerwald, which he provisionally regarded as cospecific with *Trigeria? oehlerti* from Seifen. The Herdorf fossils are, however, very distinct, having the fold in the pedicle valve and the sinus in the brachial valve and being in this respect similar to *Centronella* (*Trigeria*) *bergeroni* Oehlert from the French Eo-Devonian. In *Leptocœlia flabellites* and the Seifen fossils the fold is in the brachial valve. The Herdorf fossils also appear to have 16 or 18 ribs.

Genus **MERISTELLA** Hall, 1859.

MERISTELLA cf. M. BELLA Hall.

Plate VI, figures 16, 19, 20.

1857\. *Merista bella*. Hall, New York State Cab. Nat. Hist. Tenth Ann. Rept., p. 92, figs. 1–7.
Shaly limestone of the Lower Helderberg: Albany County, N. Y.

1859\. *Meristella bella*. Hall, Paleontology of New York, vol. 3, p. 248, pl. 40, fig. 1.
Shaly limestone of the Lower Helderberg: Helderberg Mountains, Schoharie, Carlisle, and elsewhere in New York.

?1891\. *Meristella bella*. Whitfield, New York Acad. Sci. Annals, vol. 5, p. 510, pl. 5, figs. 8–10.
Lower Helderberg hydraulic limestone: Greenfield, Ohio.

1895\. *Meristella bella*. Hall and Clarke, Paleontology of New York, vol. 8, pt. 2, pl. 43, figs. 7–9; pl. 44, figs. 1–3.
Lower Helderberg: Helderberg Mountains and Schoharie, N. Y.

?1895\. *Meristella bella*. Whitfield, Ohio Geol. Survey, vol. 7, p. 412, pl. 1, figs. 8–10.
Lower Helderberg (?)[2] hydraulic limestone: Greenfield, Ohio.

1897\. *Meristella bella*. Schuchert, U. S. Geol. Survey Bull. 87, p. 266.
Lower Helderberg: Albany and Schoharie counties, N. Y.; Greenfield, Ohio; Lake Temiscouata, New Brunswick.

1899\. *Meristella bella?* Prosser, New York State Geologist Seventeenth Ann. Rept. (for 1897), p. 350.
New Scotland shaly limestone: Oniskethau Creek section near Clarksville, Albany County, N. Y.

1900\. *Meristella bella*. Schuchert, Geol. Soc. America Bull., vol. 11, p. 284.
Lower Helderberg (New Scotland): New York, Maine, and New Brunswick.

1905\. Meristella cf. *M. bella*. Williams and Kindle, U. S. Geol. Survey Bull. 244, p. 48.
Sandy and cherty beds: Southern Railway, near Big Stone Gap, Wise County, Va.

Two gibbous pedicle valves in the collections of the Chapman fauna are referred with doubt to the genus Meristella and species *M. bella* Hall. They are of small size, ovate outline, and without any definable sinus in the pedicle valve, though the anterior margin is constricted for a short distance in the middle, indicating that a faint sinus may possibly exist in the brachial valve. The posterior margin is obtuse (95°–115°). The greatest width at the well-rounded shoulders is near the midlength of the shell and the length is equal to the width. The umbo is well inflated. On the interior of the pedicle valve the muscular scars are well developed. The oval pedicle musculature with a narrow impressed median line extends one-third the length

[1] Palaeontographica, vol. 50, p. 260, pl. 30, fig. 23, cet. excl., not fig. 24, 1904.
[2] This horizon appears to be about that of the Manlius limestone. Associated with several species of Helderbergian aspect are *Spirifer vanuxemi* and some Silurian fossils.

of the valve and is surrounded by a slightly elevated rim; from its front end the diductor scars extend in a triangular flabellate patch, strongly striate radially toward the front, with the sides diverging at an angle of 90°. The musculature extends three-fourths the length of the shell from the beak. In the musculature of *Meristella bella* figured by Hall and Clarke,[1] the front does not extend more than three-fifths the length from the beak, but the sides diverge at a right angle, as in the present specimen. In another individual of *M. bella* from the New Scotland limestone of Clarksville, in the Helderberg Mountains (Cornell University Museum collections No. 186), the musculature extends three-fourths the length or more, as in the Maine specimens, but the margins are acute, diverging at 60°.

In the small size, transverse outline, absence of a strong sinus in the pedicle valve, and probable occurrence of a slight sinus in the brachial valve,[2] the present forms approach *Meristella bella*, and the musculature is also similar. The sinus, which is generally present, though more or less obscure, in the anterior surface of the pedicle valve of *M. bella*, is not present in the two Chapman pedicle valves examined; it is also occasionally absent in New York specimens of Hall's species. The Maine specimens are provisionally referred to *M. bella* Hall.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59757.

Comparisons.—Meristella bella is a remarkable little species distinguished from the normal Meristellæ of the Silurian and Devonian by its smaller size and by the usual occurrence of a sinus in both valves at the front margin.[3] In these rather important respects, *M. bella* agrees with Hindella (Whitfieldella of authors). Superficially the species is similar to the *Merista* (*Whitfieldella*) *oblata* of Hall, the only distinction being that the insinuation is generally slightly deeper in *M. bella.*

In external appearance these species differ little from the European Silurian (Gothlandian) *Meristella* (*Whitfieldella* or *Hindella*[4]) *didyma* (Dalman) of Davidson and authors,[5] the external appearance, the musculature, and the septal feature being remarkably similar. However, in the genus Meristella the jugum has a circular loop on each side, but this circular loop is absent in Whitfieldella, where the jugum ends in a simple straight spur. Hall and Clarke[6] state definitely that the Meristella type of brachidium, with a circular loop added to each side of the jugum, has been observed in *M. bella*, so that this species is a true Meristella, whereas *Whitfieldella oblata* is a typical form of Hindella (Whitfieldella), as is also *Hindella* (*Whitfieldella*) *didyma* of authors.

Genus PENTAGONIA Cozzens, 1846.

PENTAGONIA (?) sp. indet.

Plate VI, figure 24.

cf. 1904. Athyris sp. nov. Drevermann, Palaeontographica, vol. 50, p. 259, pl. 30, figs. 20, 20a.
Siegen (?) graywacke: Unkel, Germany.
Lower Coblenzian (?) graywacke: Herdorf, Germany.

An internal mold which presents such interesting characters that, fragmentary and very imperfect as it is, it has been figured in this report. The remarkable feature is the low, broad,

[1] Paleontology of New York, vol. 8, pt. 2, pl. 44, fig. 1, 1895.

[2] A brachial valve (see Pl. VI, fig. 16) of a Meristella of the same size and proportions as the forms under discussion and probably representing the same species has since been found in the collections from the same locality (1099 M). It shows the front margin slightly insinuate, with a very faint short sinus and a depressed convexity of the anterior two-fifths of the valve. The specimen, which is an internal mold, shows a strong median septum extending three-fifths the length. The posterior margin diverges from the beak at an angle of 95°. The greatest width is distinctly well in front of the middle; width, 16 millimeters; length, 16 millimeters. Of the other specimens, one is 14.5 millimeters long and wide, and the other 16 millimeters.

[3] The little *Meristella meta* Hall and Clarke, from the Hamilton of New York, also has an insinuation at the front in both valves, thus agreeing with Whitfieldella.

[4] Whitfieldella and Hindella are now regarded as essentially identical. (See Schuchert, Charles, in Eastman's American edition of Zittel's Textbook of paleontology, vol. 1, p. 338, 1900.) Hindella is the older term and has priority. The Whitfieldellas may be distinguished superficially from Hindella in having the front margin insinuate, but no internal distinction is known. The insinuation of the margin is apparently a character variable in the same species.

[5] Probably not Dalman's species. In the Gotland Island Whitfieldellas which furnished Dalman's types the umbo in the pedicle valve is elevated above that of the brachial valve, thus entirely exposing the large delthyrium and the deltidial plates. (See Hall, James, and Clarke, J. M., Paleontology of New York, vol. 8, p. 60, pl. 40, figs. 14, 15, 1895.) Such a form does not occur in America, nor apparently in England.

[6] Op. cit., p. 78.

rounded fold which occupies most of the width of the valve. On each side near the lateral margin is a shallow sinus or flat area; the extreme lateral margin is ridgelike and abruptly inflected. This remarkable curvature recalls the form of *Pentagonia unisulcata*,[1] but the present specimen has a much lower and more rounded fold without any groove or sinus,[2] and the valve as a whole is very depressed convex. The figure shows the impressions of what appears to have been a simple spindle-like cardinal process, and no median septum is preserved. In these respects the shell seems distinct from Pentagonia. The figure also shows the impression of what seems to be the adductor musculature.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59758.

Comparisons.—The remarkable curvature of this fossil recalls, still more closely than it does *Pentagonia unisulcata*, the peculiar Athyris n. sp. of Drevermann, cited above, from the Lower Coblenzian (?) of Herdorf, and also his *Athyris aliena*[3] from the Siegen graywacke of Seifen. These Athyris species, characterized by a broad fold in the brachial valve and a broad distinct sinus on each side, form a natural, easily recognizable group ranging from the lowest Devonian to the Upper Devonian and occur throughout Europe. In America *Pentagonia unisulcata* and the present fossil are the only representatives of this interesting group, except, perhaps, the peculiar Atrypina sp. described by Clarke[4] from the St. Albans beds of Griffon Cove, Quebec.

MOLLUSCA.

Class PELECYPODA Goldfuss.

Order PRIONDESMACEA Dall.

Family SOLENOPSIDÆ Neumayr.

Genus ORTHODESMA Hall and Whitfield, 1875.

The genus Orthodesma was founded in 1875 by Hall and Whitfield[5] to include transversely elongated shells having typically the length equal to more than twice the height and resembling Orthonota Conrad and Palæosolen Hall in the subparallel ventral and dorsal margins. In the latter genera the hinge is continued in a straight line both behind and in front of the beaks, whereas in Orthodesma the hinge line is more or less interrupted and deflected in front of the beaks by a lunule. The original diagnosis of the genus follows:

> More or less elongate bivalve shells, having the hinge line straight and generally extended posterior to the beaks but contracted or bent beneath or anterior to them; hinge plate apparently edentulous; valves united by an external ligament extending to a greater or less distance along the posterior cardinal margin. Posterior muscular scar elongate ovate; anterior scar smaller; both faintly marked; pallial line simple. Shells thin, marked externally with irregular concentric plicæ. Type, *Orthodesma recta.*

In 1894 the genus was redefined and restricted by Ulrich,[6] who added as one of the generic characters a very slight gape anteriorly and posteriorly. The Chapman material is not well enough preserved to add to our knowledge of the structure of the genus, but the present species is the first recorded above the Ordovician in America.

ORTHODESMA CARINIFERA sp. nov.

Plate XIX, figure 2.

Outline transversely elongate, length about three times the height. Greatest length below the middle; greatest height at the posterior fifth or sixth. Beaks situated near the anterior

[1] See Paleontology of New York, vol. 8, pt. 2, pl. 42, figs. 22–32, 1895; also Schuchert, Charles, U. S. Geol. Survey Bull. 87, p. 302, 1897.

[2] Hall and Clarke (Paleontology of New York, vol. 8, pt. 2, figs. 25, 26, 1895) figure a specimen of *Pentagonia unisulcata* from the Hamilton of Centerfield, N. Y., which has a low rounded fold without any median sinus, but even this is much more gibbous than the specimen at hand.

[3] Drevermann, F., Palaeontographica, vol. 50, pl. 30, fig. 19, 1904.

[4] Clarke, J. M., Early Devonic history of New York and eastern North America: New York State Mus. Mem. 9, p. 109, pl. 29, fig. 18, 1908.

[5] Hall, James, and Whitfield, R. P., Paleontology of Ohio, vol. 2, p. 93, 1875.

[6] Ulrich, E. O., Paleontology of Minnesota, vol. 3, pt. 2, p. 516, 1894.

end, nearly but not quite terminal. In front of the beaks the anterior margin descends in a gently convex, almost vertical line, rounding off into the ventral margin. The latter is almost straight and descends as far as the postumbonal extremity, which is subangular. The posterior margin is slightly retrorse, nearly vertical, and gently convex. Hinge extremity obtusely subangular. The hinge line is straight and rigid, slightly less than the length of the shell, but longer than twice the height of the shell. The dorsal and ventral margins diverge posteriorly at an angle of less than 20°, so that the maximum height near the postventral extremity is equal to twice the height of the shell at the beaks. Beaks inconspicuous, depressed to the hinge line and not protruding beyond. A conspicuous feature of the shell is an elevated rounded carination recalling to some extent the genus Goniophora, extending from the beaks to the postventral extremity. This carination is sigmoidal, mostly convex, to the hinge line. The greatest depth of the valve is situated at the midheight on the carination, and at the anterior third of the length; the depth is equal to half the height of the valve. A very faint sinus or depression, not shown in the figure, extends from the beak ventrally and backward, at an angle of 45° with the hinge. Midway between the carination and the hinge line there is, in the right valve, a faint ridge, somewhat as in the genus Sphenotus. Ligament, external (?). Dentition and muscular scars not observed. The type specimen, a clean internal mold of the right valve, shows neither muscular scars nor any trace of posterior lateral teeth.

The surface ornamentation consists of extremely faint concentric lines of growth.

The type and only specimen, a right valve in internal mold, is 14.75 millimeters long, 5⅓ millimeters high, and nearly 3 millimeters deep.

Locality: Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59759.

Comparisons.—In the long, straight, rigid hinge line, transversely extended form, expanding height posteriorly, anterior beaks, and surface carination, the species bears a close resemblance to *Sphenotus? gorceixi* (Clarke),[1] but the Maine fossil is more rapidly contracted in height toward the front. The surface carinations and general outline of *Orthodesma carinifera* present superficially a resemblance to the genus Sphenotus Hall; but Sphenotus as described by Hall[2] has two cardinal teeth in the right valve, one or two posterior laterals, and a strong anterior muscular scar, agreeing in these respects as well as in superficial appearance with the Silurian to Permian genus Pleurophorus King. Most of the species of Sphenotus, however, show no trace of teeth or umbonal scars, but whether this is due to poor preservation can not be stated. Certainly *Orthodesma carinifera* appears superficially congeneric with those shells which have the typical surface carination and general superficial appearance of Sphenotus, but in which no teeth have been observed. These Sphenoti are very closely allied to the usually noncarinated Orthodesma; indeed the noncarinated, so-called *Sphenotus solenoides* Hall[3] appears to be a typical Orthodesma.

Family GRAMMYSIIDÆ Fischer.

The following genera and species of Grammysiidæ are recognized in the Chapman fauna:

Grammysia acadica Billings.
Grammysia (*Grammysioidea*) *modiomorphæ* Clarke.
G. (*Grammysioidea*) *elymelloides* sp. nov.
Elymella harrisii sp. nov.
Glossites barrandii sp. nov.
Glossites amnigenoides sp. nov.
Glossites sp. indet.

From the Moose River sandstone fauna an allied form is described as *Grammysia* (*Grammysioidea*) *princiana* sp. nov.

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[1] Clarke, J. M., The Paleozoic faunas of Para, Brazil; The Devonian Mollusca of the State of Para: Mus. nac. Rio de Janeiro Arch., vol. 10, 1899 (author's English ed., p. 59, 1900), pl. 5, figs. 14–16. The species is from the Éréré Meso-Devonian.

[2] Hall, James, Paleontology of New York, vol. 5, pt. 1, No. 2, p. 33, 1885. Type *S. contractus* (Hall). Hall mentions *S. arcæformis* and *S. contractus* as "examples of the genus," but only the latter shows the dentition described.

[3] Idem, p. 398, pl. 65, figs. 21–29; Hamilton group, New York.

Genus GRAMMYSIA De Verneuil.

History.—The lamellibranch genus Grammysia was founded by De Verneuil[1] in 1847. A translation from the French of the original description is as follows:

Grammysia hamiltonensis No. 6.—Being unable to neglect this species, which is of great importance on account of the extent of its distribution, and finding no genus into which it can conveniently enter, we have thought it necessary to establish for it the genus Grammysia, which we would characterize in the following manner: Shell equivalve, inequilateral, not gaping, furnished with two very unequal muscular impressions; pallial impression rounded posteriorly, terminating at the large muscular scar in such a way as to leave two-thirds of the latter outside [the pallial line]; ligament external, quite prolonged in the depression of the corselet; surface traversed by an oblique rib, which extends from the beak to the middle of the lower margin, and by several concentric rounded folds. Through the inequality of its muscular impressions and through the form of the pallial impression, this shell, it seems, ought to be placed near the Cypricardias and the Cyprinas. This genus, so well characterized by the median rib which traverses the valves, includes several species, of which one has been called *Nucula cingulata* by Hisinger.

The *Grammysia hamiltonensis* is distinguished from the *N. cingulata*, which is found in Gotland and at Dudley, by its less transverse form and by the position of its beaks farther removed from the external border [beaks more incurved]. It is abundant in the Hamilton group (New York) and is found in Europe in the Néhou limestone (Manche) and in the graywacke of Daun (in the Eifel).

Verneuil gives three figures of left valves from the localities indicated.

Type species.—The type species of Grammysia is universally recognized as the *Grammysia hamiltonensis* of De Verneuil and not *G. cingulata* Hisinger. This is made evident by the very words of De Verneuil: Being unable to neglect this species [*G. hamiltonensis*] * * * we have thought it necessary to establish for it the genus Grammysia." What the types of *Grammysia hamiltonensis* De Verneuil may have been, however, is another problem, which must be answered before the type species of De Verneuil's genus can be fixed. It is to be noted that De Verneuil regarded as representative of a single species, which he called *G. hamiltonensis*, shells from the Hamilton (Middle Devonian) of New York, from the Néhou (Lower Devonian) limestone of Normandy, and from the Daun graywacke (Lower Coblenzian or middle Eo-Devonian) of the Eifel.

These American, French, and German shells are now known to represent not a single species but certainly at least two, and probably three, distinct forms. The American form from the New York Hamilton had been previously described by Conrad[2] as *Pterinea bisulcata*, and in America Conrad's specific name has been adopted, so that the shell is here known as *Grammysia bisulcata* (Conrad). Among German paleontologists De Verneuil's name *Grammysia hamiltonensis* has been in general usage, particularly in the earlier decades; but Hall[3] showed that the German form of De Verneuil's *Grammysia hamiltonensis* is Goldfuss's old species *Pholadomya anomala*.[4] The shells which Beushausen[5] regards as identical with Goldfuss's species differ from the American *G. bisulcatus* in the more irregular and compressed ornamentation, and to emphasize this distinction Beushausen proposed for the Rhenish shells the name *Grammysia anomala* var. *rhenana*. Whether Beushausen's forms are really those included by De Verneuil under *G. hamiltonensis* is open to some doubt. De Verneuil's German form of *Grammysia hamiltonensis* came from the vicinity of Daun, in the Eifel—presumably from the Lower Coblenzian at Upper and Lower Stadtfeld, as these were the best-known Daun localities. Certainly De Verneuil's types came from the Daun district, whereas none of Beushausen's *Grammysia anomala* var. *rhenana* are recorded from Daun. Beushausen's form is described from the Upper Coblenzian at Daleiden and the Lower Coblenzian at Nellenköpfchen. Beushausen records from Daun (Gemünd) *Grammysia marginata* (Goldfuss), *G. nodocostata* var. *eifeliensis*, *G. ovata* (Sandberger), and *G. abbreviata* (Sandberger). Drevermann[6] records all these Daun species from Oberstadtfeld, near Daun, except *G. abbreviata* (Sandberger), and adds *G. irregularis* Beushausen (?) and *G. lævis* Drevermann nov. De Verneuil's Daun material seems to have

[1] Remarques sur les fossiles paléozoiques communs à l'Amérique et à l'Europe, et sur les rapports qu'ils offrent dans leur distribution: Soc. géol. France Bull., 2d ser., vol. 4, p. 696, 1847.

[2] Conrad, T. A., New York Geol. Survey First Ann. Rept., p. 116, 1838.

[3] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 359, 1885.

[4] Goldfuss, August, Petrefacta Germaniæ, p. 272, pl. 157, fig. 9, 1834–1840.

[5] Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 237, pl. 22, figs. 8–10, 1895.

[6] Palaeontographica, vol. 49, p. 93, 1902.

coincided rather with shells having more down-curved beaks, more retrorse posterior margin, and more regular concentric plication anterior to the cincture; in fact, the shells are identical with those figured by Beushausen as *Grammysia ovata* Sandberger,[1] from the Lower Coblenzian of Gemüd, near Daun, and as *G. irregularis* Beushausen nov.,[2] from the Lower Coblenzian of Nellenköpfchen, near Coblenz.

The French form of De Verneuil's *Grammysia hamiltonensis* has been separated by Oehlert as a distinct species under the name *Grammysia cotentina* Oehlert, 1881, so that we find to-day a general disagreement as to what forms, if any, should take the name *Grammysia hamiltonensis* De Verneuil (the consensus of opinion seems to be that the name should not be used), and what should be regarded as the types of *G. hamiltonensis*, either in the interpretation of De Verneuil or in a restricted use of De Verneuil's specific name.

The types of *Grammysia hamiltonensis* in the interpretation of De Verneuil were certainly from the Hamilton of New York, not from Néhou, in La Manche, nor from Daun, in the Eifel, as is proved first, by the name of the species; second, by the fact that the Hamilton of New York is the first locality cited, and a specimen from it is the first one figured; and third, by the fact that the paper in which the species is described is one treating of American fossils. It is, therefore, certain that the fossils which De Verneuil called *G. hamiltonensis* were lamellibranchs which are fairly abundant in the Hamilton of New York, and that for these New York shells the name was proposed and used. The Néhou and Daun Grammysias were regarded by De Verneuil as identical with the New York forms. Hence it follows that although *Grammysia hamiltonensis* De Verneuil, so far as the New York specimens are concerned, is a synonym of *G. bisulcata* (Conrad), De Verneuil's name need not be applied to either the French or the German forms if these are distinct. There is additional warrant for restricting the use of the specific name *hamiltonensis* in the fact that De Verneuil's species was not sufficiently described or figured to enable one to recognize the particular species intended. The names applied by the German paleontologists and by Oehlert in France will, therefore, hold good for the European shells regarded by De Verneuil as identical with the New York Hamilton forms.

Another preliminary difficulty which must be overcome before fixing the type of Grammysia is the fact that although *Grammysia hamiltonensis* De Verneuil may be, and in fact is, admitted to be identical with the common Hamilton *Grammysia bisulcata* of Conrad, the shells which Hall calls *Grammysia bisulcata* are quite evidently not all cospecific.[3] As has been pointed out by Beushausen,[3] if we were to consider, as Hall did, that figures 6, 7, 15, and 16 on his plate 54 [4] represent a single species, then the advance made in the last two score years in our conception of a species must be abandoned. If a typical form of *Grammysia bisulcata* (Conrad) is to be selected it will have to be that represented by Hall's figure 7, plate 54, and with it might be included under the same specific name the specimens represented in his figures 10, 11 (a crushed specimen), 12, 13, and possibly a few others, but not that shown in figures 5, 6, 15, and 16. The typical forms of *Grammysia bisulcata* as thus selected are not only the commonest types of the species in the Hamilton, but they also include the form figured by De Verneuil as *Grammysia hamiltonensis*, for it must be apparent to the bluntest discernment that De Verneuil's figure 1 is indistinguishable specifically from Hall's figure 7. Finally they conform with Conrad's diagnosis of the species. The distinguishing features of the species are the strong cincture which distorts the basal margin; the long hinge line, which is only slightly reclining; the retrorse posterior margin; the transversely extended outline; the concentric striæ covering the entire surface and raised into distinct concentric folds; and the obliquity of the shell.

In lack of any other known information as to the types, the specimens shown in Hall's plate 54, figures 7, 10, 12, and 13, may be taken as the types of *Grammysia bisulcata* (Conrad), 1838 (= *G. hamiltonensis* De Verneuil, 1847), and therefore as the types of the genus Grammysia De Verneuil, 1847. With the types thus definitely and precisely fixed we can draw up the following revised description of Grammysia De Verneuil:

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[1] Beushausen, Louis, op. cit., pl. 19, fig. 2.
[2] Idem, pl. 20, fig. 2.
[3] Idem. p. 227.
[4] Paleontology of New York, vol. 5, pt. 1.

Lamellibranch shells of rather large size, equivalve except for the alternation of a fold and sulcus in each valve, sometimes duplicated. Frequently, on account of compression in the rock, apparently inequivalve, but that this inequality is not real and is due to posthumous pressure is indicated by the facts that uncrushed specimens are equivalve and that in crushed material sometimes one valve is the larger and sometimes the other. Fold and sulcus pass from the beak nearly to the middle of the basal margin; very strongly inequilateral, oblique, transversely, or obliquely ovate. Margins not gaping, though on account of the strong ligament, many shells have been pulled open after the death of the animals and have been fossilized in this condition, so that they appear to be open behind, but this gaping is more apparent than real, for specimens may be found entirely closed. Beaks anterior, prominent, incurved, directed forward. Cardinal line distinct, straight, or slightly arcuate, reclining or nearly horizontal; posterior margin retrorse; basal margin arcuate, more or less constricted near the middle or post-ventrally by the fold and sulcus, as already indicated; anterior portion of the shell distinct; lunule very well developed. Apparently edentulous, or with an obscure obsolescent fold under the beak. Muscular scars rarely retained; the anterior one situated under the lunule, fairly large, though only about half the width of the posterior scar, or slightly more. Pallial line simple; beginning at the anterior third of the large scar, it extends downward and backward, then curves parallel to the basal margin, reaches upward and forward to about the middle of the anterior muscular scar; pallial impression radially striate when well preserved. Surface features comprise concentric folds, more or less irregular posterior to the sulcus, less irregular anteriorly and on the umbones; covered with more or less obsolescent concentric striæ.

Limits of Grammysia.—The general configuration of these shells is well known, but owing to the unrestricted use of the generic name in Hall's more advanced work some misconceptions as to the limits of the genus may arise. In the first place, the radial fold and sulcus furnish one of the most important features of the genus, as was noted by De Verneuil [1] when he used the expression "This genus, so well characterized by the median rib which traverses the valves." De Verneuil, in fact, included in his genus only those Silurian and Devonian forms which have a well-developed fold and sulcus, and the name Grammysia will have to be restricted to grammysioid shells having this feature. Although the radial fold and sulcus are represented by nearly all stages of development, from the well-developed type of De Verneuil's form to that shown in *Grammysia circularis* Hall,[2] in which the fold and sulcus are with difficulty apparent, it is nevertheless true that the name Grammysia can be and really ought to be restricted to those shells in which the fold and sulcus are developed, at least in some stage of the life history; and it is obvious that those so-called "Grammysias"[3] which have no indication whatever of the fold and sulcus or of any strictly corresponding structures at any period of their existence can not be included in Grammysia—particularly as several well-defined genera already exist in which these shells may very well be included. A few of these genera are mentioned below, but as the present work is not intended as a monograph on Paleozoic lamellibranchs, only the briefest mention will be made of the forms that do not occur in the Chapman fauna.

In the first place, we may separate from Grammysia those genera usually confounded with it, such as Allorisma or Allerisma King and Chænomya Meek (Carboniferous, Permian), Pholadomya Sowerby (Mesozoic and Cenozoic), Pleuromya Agassiz or Myacites of authors (Triassic to Lower Cretaceous), and Sanguinolaria Lamarck (Cenozoic)—shells which are both gaping and sinupalliate. Leptodomus McCoy, 1844, differs from Grammysia in the gaping anterior and posterior extremities (the posterior gape is especially well defined), and in the absence of the radial fold and sulcus, which are, however, represented by a radial undefined sinus extending from the beak obliquely to the basal margin.

Sedgwickia McCoy, 1844, is like Leptodomus but has no radial sinus, and the beaks are usually directed less anteriorly, more vertically.

Sanguinolites McCoy, 1844 (not De Koninck, 1885 = Sphenotus Hall, mostly), is like Sedgwickia but very long drawn out transversely; gaping behind, not in front, and with a distinct retractor muscular impression above the strongly marked anterior cicatrix.

[1] Op. cit., p. 696. [2] Paleontology of New York, vol. 5, pt. 1, pl. 57, figs. 3, 4, 1885. [3] Idem, pls. 59–62.

Cimitaria Hall, 1869–70, is apparently gaping only behind, like Sanguinolites; it has a very long drawn out transverse outline; musculature not strongly impressed, character unknown. The shells are distinguished superficially by the curved Solen-like or cimitar-like form and by the presence of a posterior carination and distinctly demarcated postumbonal slope, somewhat as in Goniophora.

Distinct from the gaping shells of the above types is a second strongly marked group separated from Grammysia by Hall and Whitfield[1] in 1875 under the name Cuneamya. Cuneamya includes closed grammysioid shells without indications of radial sulcus, having the umbones tumid, terminal or nearly so, and directed strongly forward. The shells are transversely elongated or oblong. A lunule is present but not well developed. The ligamental groove is well developed. There are no teeth or hinge plate, according to Ulrich.[2] A large number of Upper Ordovician species are included in this genus. It may continue higher into the Silurian[3] and possibly into the Lower Devonian or even higher.

Sphenomya Hall, 1883, resembles Cuneamya in general expression but has no ligamental groove. The typical species is *G.* (*S.*) *cuneata* Hall from the Hamilton of New York. *Leptodomus truncata* McCoy, from the Upper Ludlow of Westmoreland, is congeneric.[4] A few species described by De Koninck[5] under Edmondia, and Sanguinolites may possibly belong here, as well as *Grammysia præcursor* Hall, from the Schoharie grit.

Protomya Hall,[6] 1885, is like Cuneamya, but its beaks are more nearly central and more vertical (less prosogyrate). It has no lunette or lunule and only a weakly developed ligamental groove. It is of Devonian age.

Cardiomorpha De Koninck, 1842,[7] has a large shell, without radial fold or sulcus; smooth or with concentric striæ; inflated; oviform; beaks depressed, twisted spirally; ligamental groove well developed, but no anterior lunule; obscure indications of an internal ligamental furrow. Well developed in the middle Carboniferous, less so in the lower and upper Carboniferous; one species in uppermost Carboniferous (Permian). Similar shells occur in the Silurian, but the Silurian and Devonian forms usually called Cardiomorpha belong elsewhere. In the Bohemia Silurian (étage E) occur some apparently typical forms of Cardiomorpha—large, smooth, oval shells with more or less strongly and spirally twisted beaks, including *Isocardia pollens* Barrande, *Isocardia elongata* Barrande, *Isocardia incumbens* Barrande, etc.[8] Like typical Cardiomorpha these shells have a posterior ligamental groove[9] and no very well defined lunule, and from present knowledge of these forms they may be referred to Cardiomorpha. This occurrence indicates the appearance of Carboniferous Cardiomorpha as early as the Silurian (étage E) of Bohemia, equivalent to the English Wenlock-Aymestry, or to the American Guelph.

Broeckia de Koninck,[10] 1885, resembles Cardiomorpha in its large size, inflated aspect, and smooth oval surface, but has the beaks more depressed and not so strongly or spirally twisted as in Cardiomorpha. It occurs in the middle Carboniferous. Some Silurian shells from Bohemia agree with this type in visible features, and a few Devonian species may be referred to it.

Isoculia McCoy, 1884, emend. De Koninck,[11] 1885, resembles Cardiomorpha in its inflated oval expression, but the beak is not at all spirally twisted; the surface is covered with concentric folds, not smooth, and the lunule is well developed in the type species. The typical forms are middle Carboniferous, but the genus evidently extends down to the Middle Devonian

[1] Hall, James, and Whitfield, R. P., Fossils of the Hudson River group: Paleontology of Ohio, vol. 2, p. 90, pl. 2, figs. 9, 10, 12. Type *C. miamiensus* Hall and Whitfield, "Hudson River group" (Upper Ordovician), Waynesville, Ohio.

[2] Ulrich, E. O., Paleontology of Minnesota, vol. 3, pt 2, p. 620, 1894.

[3] Compare *Leptodomus mainensis*, from Pembroke, Maine (Billings, Elkanah, Portland Soc. Nat. Hist. Proc., vol. 1, pt. 2, p. 118, pl., 1869). The shell occurs in a series of gray shales and volcanic rocks in the Eastport quadrangle, which have been named Pembroke formation.

[4] See McCoy, Frederick, British Paleozoic fossils, p. 279, pl. 1K, figs. 21–24, 1854.

[5] De Koninck, L. G., Faune du calcaire carbonifère de la Belgique, p. 66, 1885.

[6] Paleontology of New York, vol. 5, pt. 1, p. lii, 1885.

[7] De Koninck, L. G., Descriptions des animaux fossiles du terrain carbonifère de la Belgique, p. 101, 1842; Faune du calcaire carbonifère de la Belgique, p. 9, 1885. Not Beushausen, L., Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 276, 1895.

[8] Barrande, Joachim, Système silurien du centre de la Bohême, vol. 6, pl. 250, figs. 19–21; pl. 251, 1881.

[9] Idem, pl. 251, fig. 10.

[10] De Koninck, L. G., Faune du calcaire carbonifère de la Belgique, p. 19, 1885.

[11] Idem, p. 17.

if not lower. *Grammysia obsoleta* Hall[1] seems to be a typical form of Isoculia, and in the same group may be included *Grammysia arcuata* Hall[2] and several other members of "Hall's section *C. undulata*" under Grammysia.

Finally, as possibly among the grammysioids may be mentioned Pholadella Hall,[3] 1869 (including Cercomyopsis Sandberger, 1887 = Physetomya Ulrich).

The term Cercomyopsis might possibly be retained for the very finely striated Pholadellas called Leptodomus by Beushausen and for such similar American species as *Grammysia constricta* Hall, but the Ordovician Physetomya,[4] founded on *P. acuminata* Ulrich, from the "middle Cincinnati beds," appears to be synonymous with Cercomyopsis and the term Cercomyopsis is preoccupied for a different Mesozoic shell so called by Meek, so that Ulrich's name, Physetomya, may stand for the Devonian shells above included in Cercomyopsis Sandberger. Should the posterior margin in Pholadella and in Physetomya (Cercomyopsis) prove to be gaping, these shells might have to be affiliated with Cimitaria rather than with Grammysia. Some species of Pholadella approach Cimitaria in the elongated posterior portion, which is not, however, nearly so elongated as in normal Cimitaria. Other species approach Grammysia, but none have a radial fold or sulcus structure. The margins are closed (?). The lunette and posterior ligamental groove (external) are well developed. The distinguishing feature of the genus is the presence of more or less well developed radiating striæ marking the central part of the body from beak to margin, but absent on the anterior portion and posterior slope. Concentric ornamentation is also developed as usual. The Pholadellas are mostly Devonian. They are rare in the Carboniferous but range down to the Ordovician.

Geologic range of Grammysia.—The genera above discussed include most of the shells erroneously identified with Grammysia.[5] Grammysia thus restricted, as it should be, to the closed, edentulous or practically edentulous grammysioids having a well-developed lunette and posterior ligamental groove, and (most particularly) with indications, at least in some part of their life history, of the characteristic radial fold and sulcus structure, ranges from the Upper Ordovician to the Upper Devonian.

It seems to be very rare in the Ordovician, though Cuneamya is abundant. Beushausen[6] recognizes forms of Grammysia s. str. from the Ordovician of Russia. The particular forms referred to are not indicated, but they are probably *Grammysia avus* Eichwald and *G. macroderma* Eichwald,[7] species also mentioned by Barrande[8] in his note on geologic range of Grammysia. Eichwald's paper is not at hand, so that it can not be stated whether the Russian species named are really Grammysia. Barrande's *Grammysia? præcox*, from étage E, is not a grammysioid, as has been pointed out by Beushausen. In America typical Grammysia is represented in the Upper Ordovician by "*Cuneamya*" *coriformis* Miller.[9] A typical Grammysia in the Cornell University (Jewett) collection appears to come from the St. Peter sandstone of Minnesota, but unfortunately it is insufficiently labeled.

In the Silurian Grammysia occurs particularly in the Upper Ludlowian faunas of Russia, Sweden, Great Britain, Nova Scotia (*Grammysia remota, rustica,* and *acadica* Billings[10]), and the Eastport or Cobscock Bay region. It is extremely rare in the Appalachian Helderberg or Oriskany. A new species of Grammysia is indicated by Schuchert[11] in his list of the Helderberg fauna of New York, but whether this is a Grammysia s. str. is unknown. A new species of

[1] Paleontology of New York, vol. 5, pt. 1, pl. 59, figs. 26, 27, 1885.

[2] Idem, pl. 61, figs. 1-5, etc.

[3] Compare Leptodomus Beushausen (op. cit.), not McCoy. Beushausen has applied McCoy's generic name Leptodomus to some Lower Devonian apparently closed grammysioids of the typical Pholadella aspect superficially. The following, illustrated by Beushausen (op. cit., pl. 24) are typical Pholadella: *Leptodomus securiformis* (Sandberger), *L. acutirostris* Sandberger, *L. medius* Beushausen, nov., *L. striatulus* (F. Roemer), whereas "*Leptodomus*" *latus* Krantz, *L. posterus* Beushausen, nov., and *L. barroisi* Beushausen, nov., are typical Goniophora (Phillips) Hall.

[4] Ulrich, E. O., Geology of Ohio, vol. 7, p. 693, pl. 49, figs. 12-14, 1894.

[5] Prosocœlus Keyserling (Deutsch. geol. Gesell. Zeitschr., vol. 9, 1857; Tripleura Sandberger, 1889), Sphenolium Miller (North American geology and paleontology, p. 513, 1889; Ordovician), Sphenotus Hall (Paleontology of New York, vol. 5, pt. 1, p. xxxiii, 1885; Devonian to Carboniferous), Spathella Hall (idem, p. xxxv; Devonian to Carboniferous), Vlasta Barrande, 1882 (in part), and a few other genera are sometimes confused with Grammysia or, more commonly, with some of the grammysioid genera mentioned above.

[6] Beushausen, Louis, op. cit., p. 229.

[7] Lethæa rossica, pt. 7, p. 1015, 1860.

[8] Système silurien du centre de la Bohême, vol. 6, p. 87, 1881.

[9] North American geology and paleontology, p. 474, figs. 805, 806, 1889.

[10] Paleozoic fossils, vol. 2, pt. 1, pl. 11, 1874.

[11] Geol. Soc. America Bull., vol. 11, p. 286, 1900.

Grammysia s. str. is meagerly described by Shimer[1] from the Oriskany of Trilobite Mountain, N. Y. The genus is well represented in the Grande Greve fauna of Gaspe, both *Grammysia canadensis* Billings and *Leptodomus canadensis* Billings appearing to be true Grammysias. It is also abundant in the European Lower Devonian, particularly in the arenaceous deposits. It is rare in the American Lower Devonian but is well represented in the Middle Devonian and the Ithaca shale member of the Portage formation of the Upper Devonian, though rare except locally in the Upper Devonian in general. In the Cayuta shale member of the Chemung formation of south-central New York calcareo-arenaceous banks have been observed which are a mass of shells of a large Grammysia, but in the general body of the Chemung formation Grammysia is exceedingly rare.

The genus is unknown in the Carboniferous. All the American Carboniferous "Grammysias" listed by Weller[2] are not only without the radial fold and sulcus or any strictly corresponding structure, but most of the species are gaping posteriorly. (See, for instance, "*Grammysia*" *hannibalensis* as figured by Miller,[3] also "*Grammysia*" *famelica* Herrick.[4] These will have to be included in the Leptodomus-Sedgwickia-Sanguinolites groups. Sinupalliate and gaping shells of the Sanguinolaria and Allorisma groups are confined to the Permian rocks or higher. The merely gaping Leptodomus, Sedgwickia, and Sanguinolites apparently begin with the Carboniferous, for no gaping shells of these types are actually known in the lower rocks. Devonian gaping shells like Cimitaria are, of course, easily distinguished from the grammysioid Leptodomus, Sedgwickia, etc. The genus Rhytimya was founded by E. O. Ulrich[5] for some Ordovician gaping shells the species of which had been previously described.[6] Rhytimya has been regarded by Ulrich as closely allied to Pholadella, but its affinities are apparently not with the grammysioids but rather with the Ordovician orthodesmoids.

Subgenus GRAMMYSIOIDEA subgen. nov.

The new subgenus Grammysioidea comprises grammysioids differing from Grammysia essentially in the absence of the radial fold and sulcus, from Isoculia in the presence of a posterior rounded carination and distinct posterior slope, and from Cuneamya in the last-mentioned respect, in being larger and less elongated, and in having beaks less nearly terminal.

Closed edentulous shells of medium to large size, transversely and obliquely ovate to subcircular, not elongate; equivalve, inequilateral; beaks fairly prominent, incurved, directed forward, and situated in the anterior half, but not terminal, leaving a distinct anterior portion of the shells separated from the beak by a concave lunule. Hinge line fairly long but much less than the length of the shell, straight or slightly arcuate, and reclining posteriorly, rarely horizontal. Posterior edge retrorse. A well-defined carination extends from the beak to the posterior basal angle, producing a distinctly flattened posterior slope. Posterior to the beak the cardinal margin is strongly inflected, producing a conspicuous escutcheon for the reception of the ligament. Anteriorly the lunule is deeply excavated for the ligament. On the interior of the hinge there are apparently no teeth. Muscular impressions and pallial line as in typical Grammysia, except that the pallial impression has not been observed to be radially striate. Surface covered with concentric striæ and more or less irregular concentric folds; sometimes with an obscure, very slight insinuation in the middle, but never, in any stage of development, with any pronounced radial fold or sulcus structure corresponding to that of Grammysia.

The type is *Grammysioidea princiana* sp. nov. The subgenus also includes the species listed below, though some of the Upper Devonian forms may possibly prove to be gaping shells and hence distinct.[7]

Cypricardites caswelli. Foerste, Denison Univ. Sci. Lab. Bull., vol. 1, p. 92, pl. 14, figs. 12a, 12b, 1885.
Clinton group: Ohio.

Megalodon curvatus. Krantz, Naturhist. Verein preuss. Rheinlände Verh., vol. 14, p. 161, pl. 11, fig. 4, 1857.
Siegen graywacke: Menzenberg.

[1] New York State Mus. Bull. 80, pp. 261, 267, 1905.
[2] U. S. Geol. Survey Bull. 153, 1898.
[3] Op. cit., p. 483, fig. 831.
[4] Ohio Geol. Survey, vol. 7, pl. 17, fig. 5 (lower figure), 1893.
[5] Paleontology of Minnesota, vol. 3, pt. 2, p. 618, 1894.
[6] Ohio Geol. Survey, vol. 7, pp. 688 et seq., 1893.
[7] See Paleontology of New York, vol. 5, pt. 1, pl. 59, figs. 6–12; pl. 60, 1885.

Allorisma plicatella. Oehlert, Soc. géol. France Mém., 3d ser., vol. 8, p. 34, pl. 6, figs. 3, 3a, 3b, 1881.
Eo-Devonian: Nehou, Normandy.
Grammysia sp. indet. Reed, South African Mus. Annals, vol. 4, pt. 6, p. 252, pl. 31, fig. 3.
Bokkeveld series: Ezel-fontein, Ceres, Cape Colony.
Grammysia lundi. Clarke, Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 6, figs. 11, 12, 13, 1899 (author's English ed., p. 66, 1900).
Eo-Devonian: Rio Maecuru, Para, Brazil.
Grammysia ulrichi. Clarke, idem, p. 67 (not pl. 7, fig. 12).
Meso-Devonian: Erere, Para, Brazil.
Grammysia alveata (Conrad) and *G. lirata.* Hall, Paleontology of New York, vol. 5, pt. 1, pl. 59, figs. 6–12; pl. 60, 1885.
Hamilton group: New York.
Leptodomus interplicatus. Clarke, New York State Mus. Mem., 6 (Naples fauna, pt. 2), p. 315, pl. 12, figs. 32–34, 1903.
Middle Portage: Naples, N. Y.
Grammysia minor. Walcott, U. S. Geol. Survey Mon. 8, p. 174, pl. 15, figs. 15, 15a, 1884.
Upper Devonian limestone: Rescue Hill, west of Rescue Hill, and at gate northwest of Eureka, Nev.
Grammysia undata. Hall, Paleontology of New York, vol. 5, pt. 1, p. 379, pl. 93, fig. 21, etc., 1885.
Panama conglomerate and upper Chemung sandstone: Panama, Portville, and Salamanca, N. Y.; Warren County, Pa.
Grammysia duplicata. Hall, idem, p. 380, pl. 93, fig. 23.
Chemung group: Warren, Pa.
Grammysia glabra. Hall, idem, p. 369, pl. 93, fig. 24.
Chemung group: Warren, Pa.

As already indicated, these shells suggest the typical large Grammysia but differ in the complete absence of the radial fold or sulcus developed in Grammysia. The species of Grammysia most nearly approaching Grammysioidea are *Grammysia inequalis* Beushausen[1] and "*Leptodomus*" *canadensis* Billings,[2] especially the former, but in these there is a well-defined sulcus, at least in the younger stages of the shell. In some forms of *Grammysia triangulata* Salter, from the late Silurian of the Eastport quadrangle, Maine, one valve is occasionally devoid of fold and sulcus, this structure appearing only in the umbonal portion of the opposite valve.

As to the subgeneric importance of the complete absence of the radial fold and sulcus structure in shells to be dissociated from Grammysia, it may be stated that the presence of the radial fold and sulcus was regarded by De Verneuil, the founder of the genus, as the distinguishing characteristic of Grammysia. Not only was the genus thus restricted by De Verneuil himself to shells with this characteristic feature, but subsequent descriptive paleontologists[3] have, with exceptions,[4] used the term Grammysia in the strict sense of De Verneuil, the founder. Billings does not describe Grammysia generically, but indicates perfectly by his use of the terms Grammysia, Leptodomus, and Sanguinolites that he limits the use of Grammysia to the strict sense. Beushausen most emphatically restricts Grammysia to the shells having the fold and sulcus structure. Hall himself was at first also inclined to the restricted use of the term Grammysia, as is indicated by his use of the term "Leptodomus" (in his preliminary report, 1883) for several species not strictly Grammysia.

If Hall's expansion of the genus Grammysia to include as strictly congeneric with the type species *G. bisulcata* (Conrad) such shells as *G. globosa* Hall and *G. obsoleta* Hall, which have no indication whatever of radial fold and sulcus, is to be accepted, it will be necessary to expunge the genus Grammysia from the literature altogether for the *globosa* and *obsoleta* types are congeneric with Isoculia McCoy, which has several years' priority over Grammysia. Grammysia would then be merely a synonym of Isoculia. Even a very slight study, however, would show the unreasonableness of adopting the conclusion just indicated; but it must be emphasized that if the term Grammysia is to be used at all, it must be restricted to shells having the characteristic radial fold and sulcus in at least some stage of development. Shells com-

[1] Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, pl. 21, figs. 1a, 1b, 1895; Siegen graywacke.

[2] Billings, Elkanah, Paleozoic fossils of Canada, vol. 2, pt. 1, p. 54, pl. 5, fig. 1; Gaspe limestone No. 8 (Oriskanian), Indian Cove, Gaspe, Quebec.

[3] McCoy, Frederick, British Paleozoic rocks and fossils, pp. 280 et seq., 1885. Billings, Elkanah, Paleozoic fossils of Canada, p. 51, etc., 1874. Lindström, G., in Angelin, N. P., Fragmenta silurica, p. 20, 1880.

[4] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 1885.

pletely lacking all traces of such radial fold or sulcus can not, therefore, be included in Grammysia, so that we are quite justified in erecting the subgenus Grammysioidea for the species indicated. As a matter of fact, some paleontologists may prefer to consider Grammysioidea as worthy of full generic rank. Grammysioidea is intermediate between Grammysia and Cuneamya, having the size and proportions of the former but being, like the latter, without radial sulcus. It is also intermediate between Isoculia and Grammysia, lacking radial sulcus, like the former, and having the less evenly rounded or less globular aspect of the latter.

GRAMMYSIA ACADICA Billings, var.

Plate XXIV, figure 12.

cf. 1874. *Grammysia acadica.* Billings, Paleozoic fossils of Canada, vol. 2, p. 140, pl. 9, figs. 4, 4a.
Upper Arisaig series [with Upper Ludlow fauna]: Arisaig, Nova Scotia.
1909. *Grammysia acadica.* Twenhofel, Am. Jour. Sci., 4th ser., vol. 28, pp. 155–158.
Moydart and Stonehouse formations [Aymestrian and Upper Ludlow faunas]: Arisaig, Nova Scotia.

A single poorly preserved internal mold of a left valve, the only specimen of Grammysia in the Chapman fauna collections, is characterized by having the radial sulcus unaccompanied by any fold and reaching the basal margin posterior to the middle (at the posterior fourth or fifth). The length is a trifle less than twice the height; cardinal and basal margins subparallel; posterior margin retrorse, with the most posterior point near the midheight. Greatest height well in front of the middle, somewhere near the anterior two-fifths; greatest length only slightly below the midheight; height 24 millimeters, length 45 millimeters. Umbones broad, incurved, directed forward; beaks at the anterior sixth. Cardinal line parallel to the longitudinal axis; very gently convex, a little greater than the height of the shell, the highest point being back of the beak at about the anterior third or two-fifths. Cardinal extremity angular, obtuse; posterior margin in the upper half retrorse, straight, or hardly appreciably convex; lower half of the posterior margin rounding into the basal margin. At the posterior end the basal margin is slightly insinuated by the radial sulcus, immediately back of which begins the curve of the posterior-basal margin. Anterior to the sulcus the basal margin has not been observed, but to judge from the direction of the very faint lines of growth it appears to have been convex—strongly so just in front of the sulcus—rising upward and forward in the anterior portion and rounding into the anterior end, which is distinct. The most protruding point of the anterior extremity is near the midheight. The lunule, which occupies the upper third or fourth of the height, is very distinct, but the specimen is too poor to show the lunette. The point of greatest depth of the valve is on the rounded umbonal "ridge" back of the radial sulcus, near (commonly slightly above) the midheight and at the posterior third of the length of the shell. The depth of the valve is 6 millimeters, or one-fourth the height. Except for the concave radial sulcus the surface is rounded throughout. The umbonal ridge is broadly rounded, forming part of the general convexity of the shell. The slope is very steep and convex to the cardinal line, less steep over the anterior portion in front of and below the umbo, and still less steep over the general surface. In fact, between the convex anterior end and the convex posterior slope, the general surface over the central regions is depressed convex or almost flat. The radial sulcus is slightly concave, very shallow, and hardly discernible on the internal mold, unless oriented at the proper angle to the light; it is extremely faint over the umbones, but expands slightly and becomes more prominent lower in the mold. It forms an angle of about 45° with the cardinal line and terminates on the basal margin at about one-third or one-fourth of the length in front of the posterior extremity. There are no radial folds.

The surface ornamentation consists of obsolescent growth lines with irregular obsolescent concentric wrinkles; the ornamentation is more pronounced on the posterior slope, but is very obscure on the specimen at hand.

Length 45 millimeters, height 23.5 or 24 millimeters, depth of the valve nearly 6 millimeters.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59760.

Comparisons.—In the transverse outline and radial sulcus reaching nearly to the posterior instead of anterior or central basal margin, this Grammysia resembles *G. ovata* (Sandberger) from the lowest or Singhofen Coblenzian; but *Grammysia ovata* and most of the Devonian Grammysias have a radial fold and sulcus on each side, whereas in the present form there is no radial fold and only one radial sulcus.

The Devonian Grammysias [1] with only one radial sulcus have the base of the sulcus rarely at and generally in front of the middle, never near the posterior extremity, as in the present form. Grammysias having only a single well-defined sulcus reaching nearly to the posterior basal margin, as in the type at hand, have been confined, so far as hitherto known, to pre-Devonian rocks, in which occur a few forms that are very closely related to *G. acadica* var., namely, *Grammysia cingulata* (not Hisinger) (Salter),[2] in part, from the tilestones of Llangadoc, in the Usk region; and *Grammysia acadica* Billings,[3] from the upper faunas of Arisaig, Nova Scotia. These two forms may be the same species. *Grammysia exarata* Lindström,[4] from the late Silurian oolite at Bursvik, Gotland, is also similar. The Chapman shell differs from both *G. acadica* and Salter's form in two respects. First, in the present specimen the umbones are less nearly terminal, being one-sixth the length from the anterior margin, and there is consequently a more pronounced anterior portion of the shell; second, in both the European and Acadian fossils there is a second more or less definite concave depression in front of the radial sulcus, but no trace of such a depression is present in the specimen at hand, whose surface is convex throughout except for the radial sulcus. Because of the differences indicated I refrain from identifying the Chapman shell with the late Silurian *Grammysia acadica* Billings (or with Salter's "*Orthonota*" *cingulata* (not Hisinger), 1848, which is presumably cospecific with Billings's species) with any greater degree of definiteness than to call it *G. acadica* var.

GRAMMYSIA (GRAMMYSIOIDEA) PRINCIANA sp. and subgen. nov.

Plate XX, figure 8.

Shell large, closed, equivalve, very inequilateral, transversely and obliquely subovate. (The particular specimen figured is inequivalve, but this is due to posthumous crushing in the rock during fossilization.) Greatest height one-third the length from the front; height about eleven-twentieths of the length; greatest length two-fifths the height from the base. Beaks incurved, directed forward, situated one-fifth the length from the anterior extremity. Hinge line posterior to the beak, equal in length to the height of the shell, straight or nearly so, and declining so that the posterior extremity of the hinge is one-fourth or one-fifth the height below the beaks. Postero-cardinal region angular, obtuse; posterior margin retrorse, straight, or very slightly convex from cardinal extremity to point of maximum length, which includes a distance equal to about three-fifths the length of the cardinal line. Postero-basal region rounded-angular, the posterior margin and posterior basal margin forming an angle of about 95°. Basal margin nearly straight to the point at the base of the maximum height, whence it arches upward to the anterior extremity. The anterior portion of the shell is unsymmetrically rounded, the upper portion having a shorter radius of curvature than the lower. At midheight the anterior extremity is abruptly recurved, producing a long, concave lunule in front of the beaks. Depth of both valves in conjunction probably about half the height. The specimen as preserved is crushed and flattened and only 20 millimeters thick, but it seems originally to have had a thickness of 26 or 28 millimeters and a height of 55 millimeters. The thickness is therefore certainly not less than one-third nor more than one-half the height. Point of greatest convexity on the line of maximum height, about a third below the cardinal line; the shell is equally deep on the posterior carination three-sevenths of the distance from the umbones. The umbo is convex but not tumid; incurved; the beaks almost on the hinge line. The general surface of the shell

[1] Compare *G. abbreviata* Sandberger, *G. prumiensis* Beushausen, *G. inæqualis* Beushausen, *G. taunica* (Kayser), and *G. obscura* Beushausen (Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, pp. 243–249, pls. 19–22, pars, 1895), which range from lower to highest Eo-Devonian.

[2] Phillips, John, and Salter, J. W., The Malvern Hills: Geol. Survey Great Britain Mem., vol. 2, pt. 1, p. 360, pl. 17, fig. 2 (cet. excl.), 1848.

[3] Paleozoic fossils of Canada, vol. 2, pt. 1, p. 140, pl. 9, figs. 4, 4a, 1874.

[4] Angelin, N. P., Fragmenta silurica, p. 20, pl. 19, fig. 33, 1880.

is very gently convex, except for a rounded carination extending from the beak to the postero-basal angle, on which the convexity is more pronounced. Posterior to this carination the surface is flat or very slightly, almost imperceptibly, concave to the cardinal line. The general surface over the greater part of the shell anterior to the carination is depressed-convex or almost flat, except the anterior end, which is more distinctly convex. In front of the beak there is a concave lunette. Posterior to the beak the cardinal line is abruptly inflected to form a large, deep ligamental groove.

The surface is covered with very low concentric folds which are fairly even and regular on the umbones but become irregular and obsolescent over the general area of the shell, producing a concentrically striate, faintly undulose surface. There is no indication of any radial fold or sinus comparable with the cincture in the Grammysia, nor is there any abrupt insinuation or interruption of the continuity of the concentric markings. There is, however, an extremely faint undefined sinus which causes the flattening of the general central surface and also produces a very feeble, scarcely perceptible long constriction of the basal margin. Posterior to the carination the striæ are recurved parallel with the margin, the carination serving as the angle. The lunette is smooth, concave, equal in length to more than one-third the height of the shell, and very wide.

Except for the presence of a long, deep posterior ligamental groove and a conspicuous anterior lunule and well-developed lunette the hinge features are unknown. The muscular scars are distinctly developed. The anterior adductor is oval or semicircular, situated just under the anterior half of the lunule. The posterior adductor scar is suboval or obtusely triangular, about twice as long as the anterior scar; it is situated on and just in front of the posterior carination but does not extend back of it. There are no discernible pedal, retractor, or other accessory muscular scars. The pallial line reaches the anterior third or half of the posterior scar, thus leaving the posterior half or two-thirds of the scar outside. The posterior portion of the pallial impression has not been very clearly preserved, but it appears to be simple (noninsinuated) and, as in Grammysia,[1] extends from the posterior scar backward and downward, then curving forward, nearly straight and parallel with the basal margin, then reaches upward and forward to the anterior scar, near the forward basal extremity of which the pallial line ends. No radial striations or pits have been observed along the pallial impression, which is, indeed, very obscure in the specimen at hand, but whether this absence is due to imperfect preservation of the present specimen or to the real tenuity of the pallial impression can not be stated.

As already indicated, the specimen is 100 millimeters long, 55 millimeters high, and, as restored from its crushed condition, between 26 and 28 millimeters thick. These dimensions indicate the large size of the species.

Locality.—Moose River sandstone, Detroit, Maine.

Comparisons.—This species resembles very closely *Grammysia canadensis* Billings,[2] from the lower part of the Gaspe sandstone at Gaspe, but *G. canadensis* has a rather longer and less declining hinge line, a slightly more nasute postbasal extremity, a more arcuate basal line, and, most important of all, has a distinct fold and two sulci in the left valve and corresponding structures in the right valve. In *Grammysioidea princiana* there is of course no indication whatever of fold or sulcus.

Another remarkably close ally of *Grammysioidea princiana* is *Grammysia inæqualis* Beushausen,[3] from the Siegen graywacke of Ysenberg, a species which has no appreciable indication of the radial fold in the right valve, and only obscure traces of a radial sulcus, accentuated by an abrupt interruption of the ornamentation, in the left valve. The differences between these two species are very slight; they include a more pronounced posterior

[1] See De Verneuil, Edouard, Soc. géol. France Bull., 2d ser., vol. 4, p. 697, fig. 2, 1847 (*G. "hamiltonensis,"* from Nehou, Normandy); also Hall, James, Paleontology of New York, vol. 5, pt. 1, pl. 54, fig. 8 (*G. bisulcata*), pl. 57, figs. 3–4, 1885 (*G. circularis*), both species from the Hamilton of New York. See also Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, pl. 23, fig. 1, 1895 (*G. marginata* Goldfuss, from the upper Eo-Devonian of Lahnstein, in the Rhenish province).

[2] Billings, Elkanah, Paleozoic fossils of Canada, vol. 2, pt. 1, p. 51, pl. 4, fig. 3, 1874 (not *Leptodomus canadensis* Billings, idem, p. 54, pl. 5, fig. 1, which is also apparently a Grammysia).

[3] Beushausen, Louis, op. cit., p. 245, pl. 21, figs. 1a, 1b.

carination, more retrorse posterior margin, larger posterior slope, and weaker concentric ornamentation in the American species. The left valve is too poorly preserved in *G. princiana* for comparisons with reference to the radial sulcus structure, but in the right valve of the specimen at hand there is no trace whatever of such structure.

Perhaps the closest resemblance is to *Megalodon* (*Grammysioidea*) *curvatus* Krantz,[1] in which the beak is more anterior and the ornamentation more obsolescent. Beushausen regards this species as possibly cospecific with his *Grammysia inæqualis*.

Grammysioidea alveata (Conrad), *G. lirata* (Hall), and *G. interplicatus* (Clarke) are easily distinguished from *G. princiana* by their more nearly circular or less transverse outline, comparatively shorter hinge, and stronger markings.

Grammysia (? Grammysioidea) modiomorphæ (Clarke).

Plate XXIII, figures 16, 17.

1907. *Grammysia modiomorphæ*. Clarke, New York State Mus. Bull. 107, p. 221, two lower figures (not upper figure). Lower Devonic [Chapman sandstone]: Edmunds Hill, Chapman Township, Aroostook County, Maine.

A large species of Grammysia which seems to be very common in the Chapman sandstone of Edmunds Hill (locality 1099 C) is represented in the collections by about half a dozen poorly preserved specimens. In this species the length is less than twice the height, the ratio of length to height varying from 12:7 to 3:2. The greatest height is slightly in advance of the midlength. The umbones are broad, incurved, directed forward; the beaks are at the anterior fifth. The cardinal line is nearly straight, very slightly reclining, and equal in length to the height of the shell. The posterior margin is retrorse, the upper part nearly straight, the most projecting point at the lower fourth or third. The basal margin is straight or broadly insinuated for a distance about equal to the length of the cardinal line, whence the basal margin rises forward and upward in a broad curve which rounds off into the anterior margin. The anterior portion of the shell is very distinct, with the most projecting point near or slightly below the midheight. The lunule is well defined and begins at about the upper third of the height. With regard to convexity, the distinguishing feature is a broad, persistent sinus over the central part of the shell becoming more pronounced toward the base, where it produces a more or less distinct concavity of the surface and broad constriction of the margin. The umbonal ridge is broadly rounded, undefined.

The surface ornamentation consists of concentric obsolescent growth lines irregularly aggregated into concentric obsolescent ridges or undulations. Three specimens have, respectively, the following dimensions: Length (in millimeters), 61, 68, 57; height (in millimeters), 36, 40, 33.

Locality.—Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59761.

Comparisons.—The species is very closely allied to *G. princiana*, from which it differs in the conspicuous broad sinus, the proportionally somewhat greater height, and in the smaller size. There is also a close relationship with *Orthonotus semisulcatus* McCoy[2] (not Sowerby) from the Upper Ludlow green quartzite of Kirkby Moor, near Kendal, Westmoreland, in the general expression produced by the similar outline and convexity and the broad sinus, but the English shell is smaller, the beaks slightly more anterior, and the posterior margin less straight.

Grammysioidea elymelloides sp. nov.

Plate XXIV, figure 10.

Transversely ovoid, widest in front; length twice the height; maximum length at the midheight; greatest height at the anterior third, back of the beak. The dimensions of the two

[1] Krantz, A., Ueber ein neues bei Menzenberg aufgeschlossenes Petrefakten Lager in den devonischen schichten (Siegen graywacke): Naturhist. Ver. preuss. Rheinlände Verh., vol. 14, p. 161, pl. 11, figs. 4a, 4b, 1857.

[2] McCoy, Frederick, British Paleozoic rocks and fossils, p. 275, pl. 1 K, fig. 25, 1855. The *Modiola* (?) *semisulcata* Sowerby (Silurian system, pl. 8, fig. 6) with which McCoy considered his shells identical is very distinct specifically, and apparently also generically.

specimens are 46 by 24.5 millimeters (type) and 37 by 16 millimeters. Both specimens are somewhat crushed; the second is incomplete ventrally. Umbones broad, incurved, arching only slightly beyond the hinge line; prosogyrate, beaks at the anterior seventh. Hinge line long, from $1\frac{1}{6}$ to $1\frac{2}{5}$ times the height of the shell; nearly straight, very slightly convex, descending so that the postcardinal extremity is one-eighth the height below the umbones. Postcardinal region obtusely rounded. Posterior margin very gibbously arched, convex throughout, very retrorse in the upper third; posterior extremity at the midheight; lower portion curving into the ventral margin. Ventral margin convex throughout, strongly bellied down, nowhere insinuated or constricted; the extreme lowest point is at the anterior two-fifths, whence the ventral margin ascends only very slightly posteriorly but rises very strongly anteriorly into the well-developed, rounded, distinct anterior end, which includes one-eighth the length of the shell and two-thirds the height, and which is separated from the umbones by a strong, well-developed lunule. Anterior extremity at the midheight. Rather gibbous, especially over the region of the umbonal ridge, which is rounded and undefined, except by the retral curve of the ornamentation. The posterior slope is convex throughout, as is the entire shell, including the infraumbonal region, which is nowhere insinuated. The umbones are gibbous, inflated, incurved, not elevated. The greatest depth of the valve is in the region of the rounded umbonal ridge, a trifle above the midheight and three-fifths the length from the front. The depth of the single valve is equal to one-third its height or a trifle less, though the specimens are crushed and the original depth may have been half the height.

A long, well-developed inflection of the cardinal line produces a very pronounced and conspicuous escutcheon. The lunule and lunette are also very well developed. There do not appear to be any posterior lateral teeth; the strongly incurved beak prevented any observations as to the presence of cardinal teeth. The anterior muscular scar is broadly oval, situated below the lunule, rather faintly impressed. What seems to be a posterior muscular scar is very faintly discernible, subcircular, twice as long as the anterior scar; it fills the space between the umbonal ridge and hinge line and is separated by twice its length from the beak. Pallial line simple, distant from the ventral margin. Beginning at the base of the anterior adductor scar, it curves strongly downward and backward, is nearly horizontal over the middle of the shell, and ascends very slightly to the umbonal ridge. At the respiratory angle it is abruptly deflected forward and upward, making an angle of less than 45° with the horizontal axis and terminating at the inner third of the posterior adductor scar, leaving most of the posterior muscular scar outside of and above the pallial line.

There are no discernible undulations; the surface is smooth, marked only by obsolescent faint tenuistriate lines of growth. The internal mold is smooth and devoid of ornamentation.

The distinguishing features of the fossil are the transversely ovoid outline, wider in front; small size; rounded, nonconstricted basal margin; long tapering and rounded posterior end; smooth surface; and absence of ventral insinuation or restriction.

Locality: Chapman sandstone; both specimens from Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59762.

Comparisons.—The species is nearly related to *Grammysia undata* Hall,[1] of the New York highest Devonian (Panama conglomerate), but is quite distinct, lacking the ventral constriction, having the umbones more anterior and being somewhat less strongly marked. *Grammysia glabra* Hall[2] is also similar, but has a ventral sinus and more protuberant umbones.

Genus PHYSETOMYA Ulrich, 1893.

The generic name Physetomya Ulrich has been discussed on page 132, where its relations to Cercomyopsis Sandberger, Pholadella Hall, and Grammysia De Verneuil have been indicated.

[1] Paleontology of New York, vol. 5, pt. 1, 1885, p. 379, pl. 61, fig. 23; pl. 64, fig. 30; pl. 93, fig. 21. If Hall's species is a closed, nongaping, shell it apparently belongs to the subgenus *Grammysioidea*.

[2] Idem, p. 369, pl. 93, fig. 24; Chemung group, Warren County, Pa.

PHYSETOMYA sp. indet.

Plate XXVI, figure 4.

This specimen of a left valve is incomplete on the anterior, but indicates a Grammysia-like shell of the usual transverse outline common to the species of Cercomyopsis Sandberger (=Physetomya Ulrich). On the external mold there were observed traces of fine, continuous radial striæ below and just back of the beaks and crossing the concentric undulations. The body of the shell is covered with coarse concentric wrinkles, which fade out on the posterior slope. The imperfection of the specimen anteriorly makes comparisons with allied species unfeasible. The portion of the shell preserved recalls in outline and ornamentation (on the internal mold) the British Upper Ludlow *Leptodomus truncatus* McCoy,[1] which is a Sphenomya.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59763.

Genus ELYMELLA Hall.

The genus Elymella was founded by Hall for some small ventricose Middle Devonian shells of uncertain hinge characters, but easily recognizable by their external aspect, which is characterized by strong convexity; transversely elliptical-ovoid outline without insinuation; incurved beaks anterior and directed forward, and cardinal line fairly long, convex, and slightly reclining posteriorly; both anterior and posterior extremities rounded (as is, indeed, the entire shell) and the short anterior extremity narrower dorso-ventrally than the posterior extremity. The ornamentation consists of concentric lines of growth, sometimes elevated into uneven concentric ridges.

Hall's original diagnosis [2] of the genus is as follows:

> Elymella n. gen. (Type, *Elymella nuculoides* Hall.) Shell equivalve, inequilateral, ovate elliptical. Anterior end very short and the margin rounded. Posterior end narrower [3] and rounded at the extremity. Beaks closely incurved; umbo prominent. Cardinal line short. Umbonal slope prominent in the upper part, not confined, and merging into the general convexity of the shell. Surface marked by fine concentric striæ of growth, which are sometimes lamellose and elevated into concentric ridges. Hinge line short, the internal characters undetermined. Muscular impressions unknown. The small group of shells here termed Elymella can not with propriety be referred to any established genus, and therefore this name has been chosen in reference to the form and expression of the fossils. The form of the shell and the direction and character of the concentric striæ resemble some species of Nucula; but although occurring with specimens of the latter genus, showing the hinge teeth, none of the specimens of Elymella have preserved any indications of such characters.
>
> Examples: *Elymella fabalis*, Plate XL, figures 5, 9; *Elymella nuculoides*, Plate XL, figures 6, 7, 8.

As to the hinge, it may be safely stated that these shells are edentulous, for no indications of teeth have ever been observed.

Allied genera.—Figures of species of Elymella resemble very much forms of Glossites, as can be seen by comparing the respective species of the two genera figured on Hall's Plate XL. Glossites is, however, a flattened lamellibranch; Elymella is gibbous.

Elymella is closely related to the Upper Devonian and Mississippian Spathella Hall,[4] but Spathella is somewhat more elongated than Elymella and widens posteriorly instead of narrowing. Elymella is also very closely allied to the gigantic Carboniferous Broeckia De Koninck,[5] from which it differs practically only in being smaller. Broeckia may occur in the Silurian (étage E^2) of Bohemia. (Compare *Astarte primula* Barrande and the gigantic *Isocardia? latissima* Barrande,[6] which appear to be typical Broeckias.) The genus is unknown in the

[1] McCoy, Frederick, in Sedgwick, Adam, and McCoy, Frederick, British Paleozoic rocks and fossils, p. 279, pl. 1 K, figs. 21-24, 1854. The species is from the Upper Ludlow quartzites of Westmoreland.

[2] Hall, James, Paleontology of New York, vol. 5, pt. 1 (Lamellibranchiata II), p. 1, 1885.

[3] Hall's wording is ambiguous here, and might, by one not acquainted with the shells, be taken to mean that the posterior end is narrower than the anterior end. This is distinctly not the case. Hall evidently meant that the posterior portion is narrower at the extremity than farther forward.

[4] Op. cit., p. xxxiii, pl. 66, figs. 36-42.

[5] De Koninck, L. G., Faune du calcaire carbonifère de la Belgique, pt. 5, Lamellibranches: Mus. roy. hist. nat. Belgique Annales, vol. 11, p. 19, 1885.

[6] Barrande, Joachim, Système silurien du centre de la Bohême, vol. 6, pl. 190, 1881.

Devonian. It should be borne in mind, however, that the large typical Broeckias occur in limestone lamellibranch faunas, whereas in the Devonian lamellibranch faunas are confined to arenaceous and shaly deposits. Typical Broeckia, besides being of relatively gigantic size, also differs from Elymella in having the anterior end wider dorso-ventrally than the posterior end (for instance, *B. prisca* McCoy and *B. latissima* De Koninck [1] (not Barrande); also *B. mutica* [2]), while in Elymella the reverse is of course always the case. However, a few forms of Broeckia, such as *B. subequalis* De Koninck,[3] have the anterior end narrower, as in Elymella.

When the minute known Devonian Elymellas, whose length does not exceed 3 centimeters, are compared with the relatively gigantic Carboniferous Broeckias, which commonly attain a length of 9, 10, or even 12 centimeters, very little genetic connection or relationship between the two is at first apparent. But in the Belgian Carboniferous occur several Elymellas somewhat larger than the Devonian types, and between these Belgian Carboniferous Elymellas and typical Broeckia are several transitional forms. The minute Devonian Elymella and the typically gigantic Silurian and Carboniferous Broeckia are therefore connected in the Belgian Carboniferous by intermediate types, and it seems possible that Elymella is only a minute Silurian-Devonian representative of the Silurian-Carboniferous Broeckia which has become adapted to conditions adverse to the typical development of the gigantic forms. This hypothesis is borne out by the thin shell of Elymella and seems to afford the best explanation of the occurrence of large typical Broeckia in the Carboniferous and ?Silurian, its absence in the Devonian, the substantial identity in structural features of Broeckia and the small Devonian Elymella, and the occurrence of both types and intermediate forms in the Belgian Carboniferous.

These Belgian Carboniferous Elymellas and transitional Elymella-Broeckia forms have been doubtfully referred by De Koninck to Edmondia, a genus that has become well known through its characteristic superficial strongly convex, smooth, quadrate, oval expression, on the basis of which various Silurian and Devonian fossils have been referred to it. The essential feature of the genus is, however, the presence of an internal septum underneath the cardinal line for the reception of an internal (?) ligament. De Koninck divided the 67 Belgian Carboniferous species of Edmondia into two groups, one group characterized by the globular or orbicular expression with lengths approximately equal to the height, and the other group transversely elongated. The species with the diagnostic internal ligamental septum are almost entirely confined to the first group; the elongated species of the second group, lacking this internal ligamental septum, were only doubtfully referred to Edmondia by De Koninck. The genus Pseudedmondia Fischer, 1887, is founded on some of De Koninck's Edmondias that lack the internal septum and have an apparently external ligament, but the species of Pseudedmondia are globular shells representing the first group of De Koninck. The true classification of De Koninck's second group of Edmondias is therefore still uncertain, but many of the species can be placed under Broeckia, Elymella, and probably Isoculia. Among the species that can be referred to Broeckia and Elymella are *Edmondia? pulchella* De Koninck [4] (a very typical Elymella), *Edmondia amydalina* De Koninck,[5] *Edmondia? debilis* De Koninck,[6] *Edmondia? elliptica* De Koninck,[7] and *Edmondia? prælonga* De Koninck,[8] all of which are referable to the genus Elymella, as is also De Koninck's *Broeckia dorsata*,[9] the only small form admitted by De Koninck into Broeckia; and *Edmondia grælata* De Koninck, *Edmondia? nobilis* De Koninck [10] (a typical Broeckia), *Edmondia? decorata* De Koninck,[11] *Edmondia? præcox* De Koninck,[12] which have the Broeckia aspect but are transitional in size from the typical large Broeckia to the small Elymella.

There is, then, a much closer relationship between Elymella and Broeckia than is at first sight apparent. It must be remembered, however, that little is known of the hinge structure of these fossils. The term Elymella has been applied only to the smaller broeckioids having

[1] De Koninck, L. G., op. cit., pl. 2, figs. 13, 14.
[2] Idem, pl. 3, fig. 18, etc.
[3] Idem, pl. 3, fig. 19, etc.
[4] Idem, pl. 10, figs. 21, 22.
[5] Idem, pl. 13, figs. 30, 31.
[6] Idem, pl. 7, figs. 17, 18.
[7] Idem, pl. 7, figs. 19, 20.
[8] Idem, pl. 7, figs. 21,
[9] Idem, pl. 6, figs. 11, 12.
[10] Idem, pl. 10, figs. 33, 34.
[11] Idem, pl. 10, figs. 31, 32.
[12] Idem, pl. 10, figs. 15–20.

the anterior end narrower dorso-ventrally than the posterior end. As thus defined Elymella is a valid group of characteristic expression.

Geologic range of Elymella.—Hall[1] described two species of Elymella (*E. nuculoides* and *E. fabalis* Hall) from the calcareous shales of the Hamilton (Middle Devonian of central and western New York, and a slightly larger species (*E. patula*) from the Mississippian shales, at Medina, Ohio. Miller and Gurley[2] have described *Elymella missouriensis*, from the Chouteau limestone (Mississippian) near Sedalia, Mo. The Belgian Carboniferous Elymellas already mentioned are from étages I and II. No forms of Elymella have been recognized in the étage III or Viséan Carboniferous. Elymella thus ranges through the lower part of the Mississippian (lower Carboniferous), Upper and Middle Devonian, and apparently Lower Devonian. The species from the Chapman fauna described below is therefore the oldest Elymella known.

Elymella harrisi sp. nov.

Plate XXIV, figure 11.

Shells small, ventricose; closed, equivalve; transversely elliptical; margin rounded throughout, not sinuated. Maximum height at the midlength; maximum length at or just below the midheight; length twice the height. Umbones small, narrow, incurved, directed forward at a very acute angle with the transverse axis of the shell. Beaks about one-seventh the length from the anterior extremity. Cardinal line evenly convex throughout, horizontally or nearly so as far as a point two-thirds the length of the shell from the front, thence rounding off into the symmetrical, semielliptical, or parabolic posterior end. (Parabolic is here used in the sense opposed to catenaric, to apply to a curve more ventricose than a circular arc; the term catenaric is applied to a curve flatter than a circular arc.) There is no discernible demarcation between the cardinal and posterior margins above nor between the posterior and basal margins below. The posterior extremity is at the midheight. The basal margin is a convex, evenly rounded curve of slightly deeper convexity than the dorsal line. The basal extremity is opposite the midlength; the anterior basal line rises more rapidly than the posterior, and merges into the small but distinct symmetrically rounded anterior portion of the shell, which includes one-eighth or one-tenth of the length. The depth of the single valve is three-thirteenths of the height. The point of maximum depth of the valve is on the rounded umbonal "ridge" opposite the midlength of the shell and one-third the height below the cardinal line. The surface is evenly rounded throughout except for the umbo, which is marked by a short carinate ridge from which the surface slope is almost perpendicular to the cardinal line. The nearly perpendicular postumbonal slope and umbonal ridge are very short, extending only to a point one-third or two-fifths the length of the shell from the anterior extremity, beyond which the surface slopes in a descent evenly convex in all directions, with only a faint indication of concavity in the longitudinal profile just in front of and under the beak.

The surface ornamentation consists of unequal, obsolescent, concentric lines of growth, an occasional stronger line becoming almost lamellose. There are no ridges or plications. The striæ have the same uniformly convex elliptical curve as the margin. In the specimen figured the ornamentation is strongest in the posterior portions of the shell and faintest in the anterior end.

In the single specimen at hand, an internal mold of the left valve, there are no indications of the existence of any teeth or ligamental structures, nor are there discernible muscular impressions. There are faint markings comparable with an anterior muscular scar, which, if really such, is obliquely ovoid, 4 millimeters long and horizontally striate on the posterior or narrower end. From the anterior upper part of the scar a low clavicle septal ridge extends upward and backward to the beak. It is possible that these markings, thus anatomically interpreted, may prove to be merely accidental grooves or scratches on the specimen.

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, pp. 502–505, 1885. Hall's *Elymella levata*, from the Hamilton of eastern New York, has a sinuated basal margin and flattened middle surface and can not be included in Elymella. It is possibly a modimorphid or grammysioid.

[2] Miller, S. A., and Gurley, W. F. E., New species of Paleozoic invertebrata from Illinois and other States: Illinois State Mus. Nat. Hist. Bull. 11, p. 15, pl. 2, figs. 11, 12, 1896.

The type and only specimen is 25 millimeters long, 13 millimeters high, and 3 millimeters deep.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59764.

Comparisons.—*Elymella harrisi* is very similar in appearance to *Edmondia? debilis* [1] and *Edmondia? prælonga* [2] De Koninck, from the "sub-Carboniferous" étage II, of Pauquys and Waulsort, Belgium.

Both these species are Elymellas, as has already been indicated. In *Edmondia? prælonga* the anterior end is much shorter and in *E. debilis* it is slightly longer than in *E. harrisi*. *E. harrisi* has a more arcuate cardinal line and is somewhat less gibbous than either of the Belgian species. From Hall's three species of Elymella, *E. harrisi* differs in being slightly more elongated transversely, and in having a narrower, sharper, and less elevated umbo.

Genus GLOSSITES Hall.

Glossites Hall is another of the several Paleozoic lamellibranch genera founded on external characters. The form is easily recognizable by the transversely elliptical outline and characteristic very depressed convexity. Hall's original diagnosis [3] of the genus is as follows:

> Glossites n. gen. (Type, *Glossites lingualis* Hall). Shell equivalve, inequilateral, narrowly or broadly elliptical in outline. Anterior end short, margin declining from beak and curving below. Posterior end large, narrowly or broadly rounded at the extremity. Beaks small and appressed, subanterior, or in advance of the anterior third. Cardinal line long, gently arcuate. Umbonal slope not defined, prominent above and usually merging into the general convexity of the surface about the middle of the length. Surface marked by fine concentric striæ of growth, which are often raised into sharp, sublamellose elevations or more rarely by stronger concentric ridges. Obscure radiating striæ are rarely observed. Hinge-line characters undetermined. There is evidence of an elongate lateral tooth or fold, and the valves are joined by a strong external ligament. Lunule distinct. Muscular impressions shallow.
>
> The species of this genus apparently constitute a very natural group, since they present such characteristic features of form and surface characters. These shells have sometimes been referred to Modiomorpha and to Sanguinolites, but they are clearly distinct from either and can not be properly referred to any previously established genus. Some of the species in their natural condition have had considerable convexity, or even gibbosity, in the umbonal region; but they are evidently thin shells and much compressed. The shell rarely preserves evidence of radiating striæ, which are scarcely superficial.
>
> Examples: *Glossites teretis*, Plate XCVI, figure 15. *Glossites lingualis*, Plate XL, figures 16, 17; Plate XCVI, figures 9–11. *Glossites ellipticus*, Plate XCVI, figure 8.

In the New York rocks a single extremely rare species (*G. teretis* Hall) occurs in the Onondaga ("Corniferous") limestone, but this is probably not a Glossites but a Modiomorpha, for it has a ventral constriction which does not appear normally in Glossites, where the ventral margin is convex throughout. If it is a Modiomorpha the genus Glossites is unknown in New York in beds below the Hamilton. In the Hamilton of eastern, central, and western New York several species occur, by no means rarely, especially in the coarse arenaceous beds of extreme eastern New York, though *Glossites subtenuis* Hall is the only form described by Hall from the Hamilton. In eastern New York Glossites is occasionally found in the Ithaca shale member of the Portage formation, though Hall does not describe any species of the genus from that member. Hall described seven species from the sandstones of the Chemung of New York, in which the genus occurs from the eastern to the western part of the State, though it is nowhere abundant, nor, indeed, even common. One species, *Glossites amygdalinus* (Winchell),[4] appears in the lower Mississippian. In North America, therefore, Glossites has hitherto been unknown below the "Corniferous" but has been questionably recognized in the "Corniferous." It is occasional in the Hamilton formation, the Ithaca shale member of the Portage formation, and the Chemung formation where it attains its greatest development, continuing into the Mississippian.

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[1] De Koninck, L. G., op. cit., p. 50, pl. 7, figs. 17, 18.

[2] Idem, p. 51, pl. 7, figs.

[3] Hall, James, Paleontology of New York, vol. 5, pt. 1, div. 2, pp. xlix–l, 1885.

[4] *Sanguinolites amygdalinus* Winchell (Acad. Nat. Sci. Philadelphia Proc., 1863, p. 13) and *Glossites amygdalinus* Hall (op. cit., p. 501, pl. 40, figs. 13, 14), from the "Yellow sandstone" at Burlington, Iowa; also recorded from the Mississippian sandstone of Licking County, Ohio (Herrick, C. L., Denison Univ. Sci. Lab. Bull., vol. 3, p. 69, 1888).

In Europe Glossites is represented by *Sanguinolaria concentrica* Goldfuss,[1] 1832, from the Middle Devonian of Gerolstein, in the Eifel, and by *Orthonata? solenopsis* Barrande.[2]

In South Africa the genus Glossites has been recognized by Reed [3] in the Lowest Fossiliferous or First sandstone, now regarded as of the age of the Lower Coblenzian, or the zone of *Spirifer hercyniæ* (=*S. gaspensis*) (middle Eo-Devonian). Reed describes and figures a very large Glossites which he regards as somewhat similar to *Glossites depressus* Hall, from the New York Chemung.

In the Chapman faunas, Glossites is represented by three distinct species which are therefore the oldest forms of the genus described.

GLOSSITES BARRANDII sp. nov.

Plate XIX, figures 14, 17.

cf. 1881. *Orthonata* (?) *solenopsis*. Barrande, Système silurien du centre de la Bohême (Acéphales), pl. 258, case 2, figs. 8, 9.
Étage G: Tetin, Bohemia.

The Chapman species is very similar to the fragmentary Devonian fossil from Bohemia figured by Barrande under the above name. The form is peculiar in its narrow elliptical outline, which does not widen, but instead slightly contracts posteriorly; in the umbones, which are far removed from the forward end, being situated at the anterior third; and in the strongly pronounced concentric striation. The Chapman species shows a peculiar flattening just below the hinge line; this area is broken off in the Bohemian shell, where a similar structure appears to have been present.

Outline transversely narrow elliptical; length (33.5 millimeters) a little over twice the height (15.5 millimeters); greatest height slightly in advance of the midlength, at about the anterior three-sevenths; greatest length about two-fifths the height above the base. Umbones very broad, obtuse, compressed, situated at the anterior third; not protruding beyond and indeed hardly reaching the hinge line; directly upward, very faintly prosogyrate. Cardinal line long, equal in length to 1⅓ times the height; nearly straight, very slightly convex; descending posteriorly so that the posterior extremity is two-fifteenths the height below the umbo. Cardinal extremity angular, obtuse, about 110° to 115°. Posterior margin truncate; retrorse above, where it is straight or very slightly concave. Posterior extremity at the rounded respiratory angle a trifle less than one-third the height above the base. Ventral margin arched, convex throughout, nowhere insinuated or constricted, nearly horizontal in the middle; ascending into the rounded forward end only very slightly more strongly than into the posterior end. Extreme lowest point at the midlength. Anterior end well developed, rounded in a nearly symmetrical deep parabola; anterior extremity three-sevenths the height above the base. No concavity in front of the beak.

The shell is very depressed convex; the greatest depth, 2.2 millimeters, is equal to about one-seventh the height of the valve or one-fifteenth the length, and is situated at the midheight or a trifle above, and at the anterior three-sevenths the length. The postumbonal ridge is very depressed, broadly rounded, nondefinable; in front of it the surface is evenly and very gently convex, the umbones depressed. Between the region of the umbonal ridge and the hinge line, nearer the latter, is a radial sulcus which produces an abrupt flattening of the surface as far as the hinge line. This flattening below the hinge line is well indicated in the figures. In front of the umbones there appears in the specimen a faint furrow extending horizontally forward and slightly downward, subparallel to the upper anterior margin and approaching the front margin. There is no flattening above it. This may indicate a lunette, or it may be merely an accidental feature. The hinge line appears to have been occupied by a very narrow, almost linear ligamental groove, but whether this was internal or external can not be ascertained. There are no indications of teeth, unless the radial furrows in front of and behind the beak are

[1] See Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 288, pl. 26, figs. 10, 11, 1895.

[2] Système silurien du centre de la Bohême, pl. 258, case 2, figs. 8, 9. From étage G'[Devonian]: Tetin, Bohemia.

[3] Reed, F. R. C., Mollusca from the Bokkeveld beds: South African Mus. Annals, vol. 4, pt. 6, No. 11, p. 254, pl. 31, fig. 5, 1904. First sandstone, near Klein Straat Siding.

considered as such, but that these furrows really indicate teeth is highly improbable. Muscular scars or pallial line not impressed. Shell structure unknown, but the shell was apparently extremely thin, for the surface striations and the flattening and furrows below the hinge are preserved on the internal mold or "sculpture cast" nearly as strongly as on the external mold.

The surface and the "sculpture cast" are covered with strongly pronounced concentric striæ, which are strongest in the region of the postumbonal ridge; behind this they become rather retrorse, and at the posterior radial sulcus they are slightly insinuated. Varices are only obscurely developed by an occasional concentric line, becoming a trifle stronger for a short distance in crossing the region of the umbonal ridge. The striation continues to the upper anterior margin.

The type and only specimen, an internal mold or "sculpture cast," and an external mold of the same shell (a left valve) is 33.5 millimeters long, 15.5 millimeters high, and 2.2 millimeters thick.

The principal distinguishing features of the species are the strong concentric ornamentation; the large anterior end, with the beaks far back, at the anterior third and only slightly prosogyrate; the narrow, transversely elliptical outline, with hinge line slightly descending, not ascending; and the posterior margin retrorse, nearly straight or slightly concave.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59765.

Comparisons.—The large anterior end with the beaks far back at the anterior third will distinguish the Chapman species from any other known form of Glossites except the Devonian fossil from Bohemia already mentioned. In the strong concentric striation there is an approach to *G. depressus* Hall, but the New York species may be easily distinguished by its ascending hinge line, rounded posterior end, and shorter anterior end. A still closer approach to the Chapman species is made by *Glossites lingualis* Hall,[1] which occurs in the Chemung at Belmont, N. Y. This form has similar striation and a nonascending hinge line, but its posterior end is rounded, not straight, or retrorse, nor with angular hinge extremity, and the beaks are much more anterior.

In the strong striation, narrow elliptical outline, beaks far back at the anterior third, and truncate posterior margin, *Glossites barrandii* apparently very closely resembles Barrande's *Orthonata? solenopsis*, from the Devonian of Tetin, Bohemia (étage G′), but unfortunately Barrande's fossil is only fragmentary. It is incomplete near the hinge line, and its real features in this unknown region may ultimately prove it to be distinct. The Bohemian shell may be distinguished for the present by its being much shorter in height than *G. barrandii.*

GLOSSITES AMNIGENOIDES sp. nov.

Plate XIX, figure 20.

Outline transversely ovoid or spatuloid, widest behind; length (52 millimeters) a trifle over twice the height (24 millimeters); greatest height at the posterior end of the hinge at the posterior third; greatest length at the ventral fourth. Umbones gibbous, depressed to and not protruding beyond the hinge line; broad, prosogyrate; beaks at the anterior sixth. Hinge line very slightly convex, nearly straight, equal in length to the height of the shell; ascending markedly toward the rear, so that the greatest height of the shell is at the hinge extremity. Posterior margin long, slightly convex, very retrorse, forming an angle of 45° with the height of the shell; posterior extremity at the respiratory angle very near the base (one-fifth or one-sixth the height above the base). Ventral margin depressed arcuate, convex throughout; nowhere insinuated nor constricted; nearly horizontal for the posterior three-fifths. The lowest point of the shell is below the hinge extremity at the posterior third, whence the ventral margin ascends very slightly to the respiratory angle, extends horizontally forward for one-third the length, and then

[1] Hall, James, op. cit., p. 497, pl. 40, figs. 16, 19; not pl. 96, which represents a different species from Mansfield, Pa.

ascends strongly into the narrow, rounded anterior end, which includes half the height of the shell and one-sixth or one-seventh the length. Anterior extremity at the lower two-fifths of the height. The shell is convex throughout, depressed over most of the surface, but a little more inflated-convex below the umbones in the anterior half of the shell. Point of greatest depth situated a trifle in front of and above the middle; depth of the single right valve 4.2 millimeters, or a little less than one-sixth the height and less than one-twelfth the length. There is no umbonal ridge, its space being flattened. Hinge features unknown. The anterior muscular scar is broadly reniform, of moderate size, situated close to the upper margin of the anterior end; no retractile scar discernible. The posterior adductor is much more feebly impressed and is very much larger, being at least twice as long as the anterior scar and broadly oval in outline. Pallial line extremely obscure, but simple.

The specimen, an internal mold of the right valve, is marked by obsolescent concentric striæ of growth, which leave it almost smooth except for an occasional thin wrinkle or varex. The ornamentation, very faint everywhere, is most conspicuous near the region of the umbonal ridge. Length, 52 millimeters; height, 24 millimeters; depth, 4.2 millimeters.

The distinguishing features of this species are the strongly ascending hinge line (equal to the height) and the long retrorse posterior margin, causing the greatest height of the shell, which is at the hinge extremity, to be at the posterior third. The length is only twice the height. This is the only species of Glossites in which the characters of the muscular scars and pallial line are known.

Locality: Chapman sandstone, Edmunds Hill, Chapman Plantation, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59766.

Comparisons.—In the distinguishing features indicated above *Glossites amnigenoides* seems to be very closely allied to Hall's *Glossites teretis*,[1] from the Onondaga ("Corniferous") limestone at Littleville, near Avon, Livingston County, N. Y., but *G. teretis*, besides having the beaks more nearly terminal, also differs in having an insinuation or constriction below the umbones, which suggests its relationship to the genus Modiomorpha rather than to Glossites.

Glossites amnigenoides is in general intermediate between *G. patulus* Hall,[2] from micaceous red sandstones above (?) the Chemung at Mansfield, Pa., and *G. procerus* Hall,[3] from the higher beds of the Chemung at Mansfield, Pa., and Rockville, N. Y., being more elongated than the former and shorter than the latter and also differing from both in some minor features. It bears a close superficial resemblance, particularly in outline, to *Modiomorpha rigida* Hall,[4] from the Chemung formation of Allegany County, N. Y. That species has a much more conspicuous umbonal ridge but is a moderately convex species without ventral insinuation or constriction and is therefore presumptively not a Modiomorpha; it may possibly be a Glossites.

As is indicated by the name, the Chapman fossil bears a strong resemblance to the well-known *Amnigenia catskillensis* (Vanuxem),[5] a characteristic form of the Upper Devonian fresh-water or estuarine beds, particularly in the large size, ascending hinge line equal in length to the height, and long, very retrorse posterior margin; but the Amnigenia is somewhat larger and more elongate, and, what is still more important, it has a modiolopsoid ventral insinuation and occurs with a nonmarine fauna; *Glossites amnigenoides* occurs with a marine fauna.

GLOSSITES cf. G. DEPRESSUS Reed (not Hall).

cf. 1904. Glossites aff.? *G. depressus* (not Hall). Reed, South African Mus. Annals, vol. 4, p. 254, pl. 31, fig. 5. Bokkeveld series, First sandstone (zone of *Spirifer hercyniæ*): Near Klein Straat Siding.

A third species of Glossites is represented in the collections from the Chapman sandstone by a specimen which looks as if it might have been the original of Reed's figure cited above and is possibly the same species. The Chapman fossil is unfortunately too poorly preserved to warrant an extended description or figure, being even more fragmentary than the South

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 494, pl. 96, fig. 18, 1885.
[2] Idem, p. 499, pl. 96, fig. 13.
[3] Idem, p. 501, pl. 96, figs. 15, 16.
[4] Idem, p. 287, pl. 41, figs. 14-16 (not fig. 17).
[5] Idem, p. 516, pl. 40, figs. 1-4; pl. 80, fig. 12.

African shell referred to. The species of Glossites represented is characterized by its large size; length a little more than twice the height; dorsal margin convex, horizontal; posterior margin very retrorse with the posterior extremity near the base; umbones well back, at the anterior quarter, with a faint, low, subangular umbonal ridge. Height 27 millimeters; length unknown, but well over 53 millimeters.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59767.

Family CYRTODONTIDÆ Ulrich.

Genus CYPRICARDITES Conrad.

In establishing the family Cyrtodontidæ, Ulrich [1] adopted Cyrtodonta Billings as the type genus and cited the genera Palæarca Hall, Angellum S. A. Miller, and "Cypricardites Hall and most American authors (not of Conrad)" as synonyms. The family was regarded by him as essentially Ordovician, becoming practically extinct with the close of the Silurian. The genus Cypricardites Conrad, with *C. curtus* as type species, was regarded as not synonymous with Cyrtodonta Billings, and Ulrich suggested that "Cypricardites may for a long time to come serve as a convenient temporary receptacle for those species which, because they are insufficiently known, can not be definitely placed in other genera."[2]

The search for an appropriate genus in which to place a species of the Moose River sandstone fauna has emphasized the confusion of usage into which Conrad's generic name Cypricardites has fallen. My study of the subject leads to conclusions somewhat different from those of Ulrich, which were based chiefly on Silurian rather than Devonian material. The following discussion may save others the trouble of going over again the tangled evidence by which the several related genera of the family are supposed to be distinguished. These genera include Cypricardites Conrad, Palæarca Hall, Ptychodesma Hall, Cyrtodonta Billings, Vanuxemia Billings, and Cyrtodontopsis Frech.

In the early part of 1841 Conrad [3] proposed the new genus Cypricardites, which he characterized as follows:

> Genus Cypricardites. Equivalve, profoundly inequilateral; hinge with four or five unequal cardinal teeth; anterior one largest and most prominent, oblique; lateral teeth short and very remote from the cardinal teeth. This genus is allied to Pterinea of Goldfuss, but it is never properly alated, nor has it the very large muscular impressions of that genus; the cardinal lateral teeth are also different; the anterior cicatrix is often deeply impressed; the posterior one not visible in casts of the interior. This genus abounds in the Silurian[4] rocks, but I have not seen a species from any other recent formation.

No genotype was designated. Conrad described 16 heterogeneric species from the Ordovician and Devonian. (Hamilton and Portage); but these are now distributed among the genera Modiolopsis, Modiomorpha, Grammysia, Pholadella, Goniophora, Cimitaria, and others. The first species described is Conrad's *Cypricardites elongatus*, from the Hamilton fauna at Smyrna, N. Y., a species now referred to the genus Cimitaria Hall. In most of the copies of the work of Conrad under discussion there are no accompanying figures, but in 1859 Hall stated that some of the copies of Conrad's paper were accompanied by a lithographed plate of illustrations, and a plate purporting to be a reproduction of Conrad's plate is inserted in the Fifteenth Annual Report of the New York State Museum (1862). Upon this plate two species of Cypricardites are figured. One of the figures, No. 4, which is labeled only "Cypricardites," shows the hinge structure of a typical Cypricardites-Cyrtodonta shell. The other figure represents an external view of the Devonian *Cypricardites* (now *Goniophora*) *carinata* Conrad. If the plate subsequently resurrected really accompanied some copies of Conrad's work, the inference is that the shell figured as No. 4 was intended by Conrad himself as the type of the genus

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[1] Ulrich, E. O., Geology of Minnesota, vol. 3, pt. 2, Paleontology, p. 583, 1897.
[2] Idem, p. 536.
[3] Conrad, T. A., New York Geol. Survey Fifth Ann. Rept., p. 51, 1841.
[4] Conrad's "Silurian" included the Cambrian, Ordovician, Silurian, and the Devonian below the Catskill.

Cypricardites. Moreover, it appears that of the 16 so-called species of Cypricardites Conrad the one illustrated on the plate as figure 4 is the only one which expresses the characteristics of the genus. The form shown in the figure 4 cited, which is *Cypricardites curta* Conrad, a species occurring in the Ordovician of Richmond, Ind., and near Rome, N. Y., must therefore be taken as the genotype of Cypricardites Conrad.

In 1847 Hall[1] founded the genus Modiolopsis for Conrad's *Cypricardites modiolaris*, from the beds of Utica and Lorraine age in New York, Ohio, and Indiana. Curiously enough, in this work Hall, in citing the species described by Conrad in 1841, makes no reference whatever to any published illustrations or plate supposed to have accompanied Conrad's paper, though other published figures are accurately cited. Hall's genus Modiolopsis included not only the modioliform shells to which the name Modiolopsis is now restricted, but also all the Ordovician shells described by Conrad under Cypricardites, including *Cypricardites curta* Conrad, which Hall himself 12 years later recognized as the genotype of Cypricardites Conrad, 1841. That the now well-known dimyarian and edentulous Modiolopsis was originally intended by Hall to be coextensive with Conrad's concisely characterized genus Cypricardites is indicated by his inclusion in Modiolopsis of the various Ordovician Cypricardites described by Conrad. Moreover, in a footnote, Hall[2] proposes the substitution of Modiolopsis for Cypricardites, saying:

I find myself compelled to abandon the use of the name Cypricardites as applied to shells differing so widely as these do from the Cypricardia and belonging apparently to the Monomyaria and not Dimyaria. So far as it is possible to ascertain, none of the species of the older strata possess two muscular impressions, and therefore do not strictly fall under the genus Cypricardites of Conrad.

The following is Hall's original diagnosis[2] of the genus Modiolopsis:

Equivalve, inequilateral, elongated, becoming broader posteriorly, umbones near the anterior extremity, which is marked by a single strong muscular impression, as in Modiola. A sinus often extends from the anterior side of the umbones obliquely backwards, leaving the anterior portion separated as a kind of lobe. Surface marked by fine concentric striæ; shell thin.

This genus, as defined, includes a very natural group of shells found in the older Silurian strata, some of which have been referred to Cypricardia, Modiola, Pterinea, and other genera. One of the most prominent characters is the strong muscular impression which is close to the anterior margin; this is often visible in the shell, forming a little circumscribed elevation, and more conspicuous in the cast, where it is usually well preserved. There is often a slight contraction or sinus below or posterior to the umbones, but this is not always conspicuous. The shells of this genus are for the most part smooth or marked only by fine concentric lines, indicating the laminæ of the shell, and they are generally free from angular ridges. *Cypricardites modiolaris* (Conrad)?

This description is much less concise than that of Cypricardites Conrad, 1841; all the features recognized by Hall were equally well or better recognized by Conrad, and whereas Hall erroneously regarded the shells as monomyarian, Conrad correctly understood their real nature. Hall indicated no characters which would separate these shells from Cypricardites as he then understood the genus, so that it seems quite evident that Hall either intended to suppress Cypricardites and substitute Modiolopsis in its place, or else he regarded Conrad's genus as founded on some Devonian shells of a different nature. Modiolopsis is now restricted to such edentulous dimyarian modioliform shells as are congeneric with *M. modiolaris* (Conrad), which, of course, are very distinct from Cypricardites-Cyrtodonta.

On March 1, 1858, Elkanah Billings,[3] paleontologist of the Geological Survey of Canada, communicated to the Director of the Survey his report for the year 1857 including the description of the new genus Cyrtodonta for certain Ordovician forms, which since 1859 have been generally regarded as identical with Cypricardites Conrad. The date of publication is not certainly known. Billings's report for 1857 was transmitted to the director of the Geological Survey of Canada, W. E. Logan, March 1, 1858, and the entire Annual Report of Progress for

[1] Hall, James, Paleontology of New York, vol. 1, pp. 157, 294, 1847.

[2] Idem, p. 157.

[3] Canada Geol. Survey Rept. Progress for 1857, p. 179, figs. 1-14 (*Cyrtodonta rugosa* Billings is described on p. 179 and shown in figs. 1, 2. The species is from the "Fourth Chute of the Bonne Chere, Pauquettes Rapids, and at La Petite Chaudiere Rapids near the city of Ottawa, north side, associated with numerous fossils of the Trenton and Black River formations").

1857 was transmitted by Logan to the lieutenant governor March 31, 1858, so that the publication appeared some time in 1858 later than March 31. However, the portion of the paleontologic report containing the description of the fossils, including the description of the new genus Cyrtodonta Billings, was published at Montreal as a separate pamphlet of 31 pages with the title "Canadian fossils, containing description of new genera and species, from the Silurian and Devonian formations of Canada, etc." The date of this pamphlet is unknown, but it may have been March, 1858, the date given by B. E. Walker in his "List of the published writings of Elkanah Billings, F. G. S."[1] This portion of Billings's report was again published in December, 1858, under the title "New genera and species of fossils from the Silurian and Devonian formations of Canada."[2] In this article Cyrtodonta is described on page 431 and this description is commonly regarded as the original diagnosis of the genus; but apparently both the Report of Progress for 1857 and the separate pamphlet mentioned above antedate the article in the Canadian Naturalist.[3]

Three years later Billings[4] said of the genus Cypricardites:

As for myself, I must say that when I described the genus Cyrtodonta, I was aware of Conrad's description, but considered, as I do now, that the genus, having been suppressed by Prof. Hall and never acknowledged by paleontologists or quoted by them except as a synonym, was perfectly obsolete.

So far as Billings was aware, no figures of the real Cypricardites had ever been published; and seven species of Cypricardites figured and described by Conrad in 1842[5] all represented entirely different shells which would now be included in Cypricardinia, Cimitaria, Goniophora, Plithonia, etc. Besides, Billings considered the name Cypricardites inappropriate, the shells having, in his opinion, no resemblance to Cypricardia.

The following is Billings's diagnosis of the genus Cyrtodonta:

Equivalve, inequilateral; umbones near the anterior end; general form obliquely tumid, transversely subrhomboidal or ovate, posterior extremity larger than the anterior and usually broadly rounded; two muscular impressions, of which the posterior is superficial and the anterior sometimes deeply excavated; three oblique, often more or less curved, anterior teeth situated either beneath or a little in front of the umbones; two or three remote posterior lateral teeth parallel with the hinge line; pallial line simple; ligament external; some of the species have a narrow area (escutcheon) between or behind the beaks.

Billings did not emphatically designate any particular genotype but described ten species (giving figures of most of them) from Ordovician rocks throughout Canada from Anticosti to Lake Huron and called attention to a few also occurring in the New York Ordovician. The first species described and figured by Billings, *C. rugosa* Billings, well illustrates the generic features described and what would be considered a normal expression of Cyrtodonta and may be taken as the genotype.

While Billings was working on these widespread and important Ordovician lamellibranchs in Canada, Hall was working on the American species of Conrad's Cypricardites s. str. In 1857 Hall prepared a paper in which he promulgated the new genus Palæarca to include *Palæarca* (formerly *Edmondia*) *ventricosa* Hall and *Palæarca saffordi* Hall, from the Ordovician of Tennessee, and *Ambonychia obtusa, Cardiomorpha vetusta, Edmondia subtruncata, E. subangulata, E. ventricosa, Modiolopsis latus,* and *M. subspatulus*, from the Trenton limestone, all described in "Paleontology of New York," volume 1, 1847. Conrad's *Cypricardites curta*, the genotype of Cypricardites, which Hall in 1847 included in Modiolopsis, is not included in Palæarca, but in a later report[6] Hall says: "This species is probably distinct from Modiolopsis."

Hall's paper on the genus Palæarca was not published, however, until 1859, when, according to Billings, it was issued in a small 18-page pamphlet as an advance extract from the Twelfth Annual Report of the New York State Museum. This pamphlet appeared probably in May or June, as it is noticed in the July number of the American Journal of Science, under the title

[1] Canadian Rec. Sci., vol. 8, No. 6, p. 372, 1901.
[2] Canadian Naturalist and Geologist, vol. 3, pp. 419-444, 1858.
[3] Fischer, Paul (Manuel de conchyliologie, 1887, p. 992), cites the genus Cyrtodonta Billings as of date 1853.
[4] Canadian Jour., July, 1861.
[5] Acad. Nat. Sci. Philadelphia, Jour., vol. 8, pp. 244-246, pls. 12, 13, 15, 1842.
[6] New York State Mus. Twelfth Ann. Rept., p. 71, 1859.

"Contributions to the paleontology of New York; being some of the results of investigations made during the years 1855–1858, by James Hall, Albany, N. Y., 18 pages, 8°, 1859." The paper reappeared in the Twelfth Annual Report of the State Museum, pages 8 et seq. (1859), and in "Paleontology of New York," volume 3, pages 271, 523, etc. (1860, according to Billings). I have not seen the original pamphlet and the following description of Palæarca is reproduced from the museum report:

Shell equivalve, very inequilateral, ovoid or rhomboid-ovate, gibbous or ventricose; umbones subanterior; anterior extremity abruptly rounded or sometimes obliquely subtruncate; anterior muscular impression very strongly marked (usually a deep round pit); the posterior impression obscurely defined; anterior teeth three, four, or five oblique, placed beneath or in advance of the umbones with two or three remote oblique posterior or lateral teeth; pallial line simple; ligament external; ligamental area often deep and wide, striated. The shells of this genus vary in the development of the ligamental area and in the teeth of the hinge line, the latter often becoming much thickened, and some of them obsolete with age; the anterior muscular impression is very deep and strong, while the posterior one is superficial, though the shell is always thinner at that point, as frequently observed in worn specimens.

Hall figures *Palæarca ventricosa* and *P. saffordi*, showing the hinge and internal features, and gives the list of species from the Trenton limestone of New York already cited as included in Palæarca. He states that "this genus was proposed in 1847, and the description has been printed in the Paleontology of New York, volume 3, with the accompanying illustrations." I can find no trace of any mention of Palæarca in 1847, and that date is evidently a misprint for 1857.

In the works cited Hall states that Cypricardites Conrad, 1841, and Palæarca Hall, 1859, appear to be identical, and that heretofore the genus Cypricardites had been almost entirely overlooked. He reproduces the original description of Conrad's genus, and says:[1]

The description corresponds in many respects with that of Palæarca, and the illustration given by Mr. Conrad likewise resembles that genus. Should an examination of the typical species prove the two identical, the latter name will give place to that of Cypricardites.

Hall thus suggests that his generic name Palæarca should perhaps be abandoned. In this quotation is the first direct reference to the illustration given by Conrad of the generic characters of Cypricardites. Hall introduces an outline sketch of a figure showing these characters and states:

This figure is copied from the original figure of Mr. Conrad, accompanying the description of the genus in 1841. The plate upon which this occurs was engraved to accompany the Annual Report of 1841; but unfortunately only a small number were ever distributed so far as known to the writer. * * * At the time I proposed the generic name Palæarca in 1847 [? misprint for 1857], I had overlooked the description and figures of Cypricardites, and it is only since the printing of that part of volume 3, Paleontology of New York, that my attention has been directed to the subject of the preceding note.

The reviewer[2] of Hall's advance pamphlet states that the genus described by Hall, Palæarca—

is the same that was called Cyrtodonta by Billings in the Canada Geol. Rep. for 1857, p. 179; and Billings's name therefore has the priority. Mr. Hall states that the genus is in the third volume of his Paleontology. Unfortunately the volume is not published, and much more may yet be lost to the author, as priority of publication is the only just basis for any claim. Mr. Hall at the same time observed that the genus Cypricardites of Conrad was based on a shell probably of similar character.

The reviewer adds that, as Palæarca is not related to Arca, nor Cypricardites to Cypricardia, "both the names Palæarca and Cypricardites are objectionable."

In an article in the Canadian Journal of Industry, Science, and Art for July, 1861, Billings gives a short history of the generic names Cyrtodonta, Palæarca, and Cypricardites, in which he reiterates the literary objection to the name Cypricardites and says that Cyrtodonta therefore ought to be retained. Moreover, he adds, Conrad's genus was heterogeneous, and no type was designated. With regard to the figures supposed to have accompanied Conrad's paper of 1841, Billings states that "he [Conrad] did not give any illustrations" and practically accuses Hall of having suppressed Conrad's generic name Cypricardites in order that he might apply his own generic name Palæarca to these shells. Billings goes on to say that when Hall discovered that

[1] New York State Mus. Twelfth Ann. Rept., p. 14, 1859.

[2] Am. Jour. Sci., 2d ser., vol. 28, p. 149, 1859.

Cyrtodonta Billings antedated Palæarca Hall, the New York savant resurrected and published Conrad's supposed figure in order to suppress Cyrtodonta by reviving Cypricardites.

In reply to this article Hall published a short "Note on the genus Cypricardites," [1] in which he stated that the slight zoologic error suggested by the name Cypricardites hardly warranted expunging the name, citing other names, such as Athyris, which are commonly accepted, though much more glaringly inappropriate. Hall appended to this note a reproduction [2] of the plate which is stated to have accompanied Conrad's paper of 1841 and on which is figured the hinge structure of Cypricardites.

Was this plate really published in 1841? The general trend of the facts of the case and, especially, the peculiar circumstances that Hall in his work before 1859 makes no reference whatever to these illustrations, lend ground to the suspicion that this plate was not really published before 1859. This suspicion is accentuated by Billings's remark [3] that "he [Conrad] did not give any illustrations." Again, as late as 1894, Ulrich [4] says that in 1859 "Hall reproduced a sketch of the things that had been overlooked among the manuscript left by Conrad."

The importance of determining whether or not a plate accompanied Conrad's work lies in the fact that if Cypricardites was illustrated, as is alleged, in 1841, then the genus Cypricardites is valid beyond question; whereas if the genus was not illustrated in the manner alleged, then the heterogeneity of the assemblage included by Conrad under Cypricardites and the absence of any genotype might leave room to argue against the assumption of priority for the name Cypricardites over that of any related group dissociated therefrom prior to 1859.

Evidence that the plate was published in 1841 is given in the assertion by Hall,[5] previously cited, that the figure of Cypricardites under discussion "is copied from the original figure of Mr. Conrad accompanying his description of the genus in 1841. The plate upon which this occurs was engraved to accompany the annual report of 1841; but unfortunately only a small number were ever distributed, so far as known to the writer." The only other proof that any of these plates were ever "distributed" is given in a later statement by Hall,[6] in which he says:

> I [Hall] inferred that only a small number of the copies of the plate were published with the report [of Conrad, 1841]; but it may have been more extensively distributed than I supposed, for I have found five copies among my own volumes.

The plate of illustrations certainly resembles the work of Conrad, but there is no reference to these illustrations in geologic literature prior to 1859, by Billings, Hall, or Conrad himself, or by Salter, McCoy, or other European paleontologists. Search among public and private libraries would clear this point, but such a stupendous task is not fundamentally necessary, chiefly because of the fact that, of the 16 species of Cypricardites described in 1841 by Conrad, *C. curta*, whether a figure was published or not, is the only one which really possesses the type of dentition mentioned by Conrad, the other 15 species being generically decidedly different shells.

Since 1859 Cypricardites Conrad, 1841, Cyrtodonta Billings, 1853, and Palæarca Hall, 1859, have been commonly regarded as indicating the same genus, the controversy being as to which name should be used.

Salter [7] regards Cypricardites Conrad as an illegitimate name and adopts Palæarca Hall in preference to Cyrtodonta. He retains this name in other works but is the only paleontologist who adopts it, the reason lying in his assumption that the genus Palæarca was founded in 1847, as stated by Hall, so that it would have priority over Cyrtodonta Billings, 1858. In the text above referred to (p. 546) Salter cites the genus Cyrtodonta Billings as having "appeared in 1848 beautifully illustrated," but as Palæarca was not published or even otherwise disseminated until 1859, it must be abandoned.

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1 New York State Mus. Fifteenth Ann. Rept., pp. 192-193, 1862.
2 Idem, pl. 11.
3 Canadian Jour., July, 1861.
4 Paleontology of Minnesota, vol. 3, p. 535, 1894.
5 New York State Mus. Twelfth Ann. Rept., p. 14, footnote, 1859.
6 New York State Mus. Fifteenth Ann. Rept., p. 192, 1862.
7 Mem. Geol. Survey Great Britain, vol. 3, p. 546; also see Bigsby, J. J., Thesaurus Siluricus, p. 139, 1868.

Cyrtodonta is used by Safford,[1] who figures several species, but otherwise in the United States Cypricardites Conrad has been used in preference to Cyrtodonta, largely because of the adoption of Conrad's name by Hall and by Miller.[2]

In 1884 shells of this type were for the first time certainly recognized in rocks higher than the Ordovician, when Beushausen[3] described three species from the Lower Devonian of the Harz Mountains under the name Cyrtodonta—*C. beyrichi* Beushausen, *C. kayseri* Beushausen, and *C. declivis* (Roemer).[4]

Beushausen, like the Canadian and British paleontologists, regards Cypricardites Conrad, 1841, as less valid than Cyrtodonta Billings, 1858, chiefly because of the heterogeneity of the species included by Conrad in Cypricardites. In 1891 Frech[5] adopted Cyrtodonta for the same reason. He described and figured *C. declivis* (Roemer) and a new species, *C. orbicularis*, both from the Harz Eo-Devonian. Frech[6] also described a new genus or subgenus, Cyrtodontopsis, for cyrtodontiform shells having five or six crenulated[7] cardinal teeth, of which the first and third in the right valve join above, forming an inverted V within which is the second tooth. The ligamental area is strongly striated. The genus is restricted to the Lower Devonian, three species being described from the Rhine district and one from the Harz Mountains. Frech considers Cyrtodontopsis a subgenus of Gosseletia.

Beushausen[8] recognized neither Cyrtodonta nor Cyrtodontopsis in the Rhenish Province.

Ulrich,[9] working on the American Ordovician shells of the Cypricardites-Cyrtodonta group, was the first to suggest that Cypricardites Conrad might not be identical with Cyrtodonta Billings, of which Palæarca Hall is a synonym. Ulrich called attention to the fact that in Cypricardites, according to Conrad, there are five cardinal teeth, whereas in all the Ordovician shells of this type which have been since examined and referred to Cyrtodonta or Palæarca, the usual number is three. Two teeth are not uncommon, but four are very rare. According to Conrad, also, the anterior cardinal tooth is the "largest and most prominent," but this is not the case in the Ordovician shells examined by Ulrich, nor in those figured by Hall as Palæarca or by Billings as Cyrtodonta. Moreover, the figure of Cypricardites credited to Conrad represents the cardinal teeth as radiating downward from the beak, whereas in all the shells of this type subsequently examined the teeth are subparallel and more nearly horizontal than vertical or radial

Ulrich thus raises the question whether Conrad correctly described and illustrated the hinge of the genus Cypricardites (*C. curta* Conrad); but in the absence of definite knowledge to the contrary it must be assumed for the present that Conrad's diagnosis is correct, and hence that Cypricardites represents a different type of shell from that called Cyrtodonta Billings, 1858 (Palæarca Hall, 1859). As all the Ordovician shells examined exhibit a type of structure conformable with that of Cyrtodonta, that name is applied to them.

Ulrich makes it quite clear, however, that if *Cypricardites curta* Conrad is congeneric with Cyrtodonta, Conrad's name ought to have priority. That they may be congeneric is suggested by Ulrich's proposed retention of Cypricardites Conrad for *C. curta* Conrad and *incertæ sedis* of this type, and by the suspicion that Conrad's diagnosis and figure were incorrect. Ulrich seems to overlook the well-known variability in dentition of these schizodontic shells and the

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1 Geology of Tennessee, p. 287, pls. e, f, 1869.

2 American Paleozoic fossils, 1877; North American geology and paleontology, 1889.

3 Beushausen, Louis, Beiträge zur Kenntniss des Oberharzer Spiriferensandsteins und seiner Fauna: Abh. geol. Specialkarte von Preussen, etc., vol. 6, Heft 1, pp. 67 et seq., pl. 3, figs. 2–5.

4 *Lucina declivis* Roemer, C. F., Die Versteinerungen des Harzgebirges, p. 25, pl. 6, fig. 19, 1843; *Megalodon declivis* D'Orbigny, Prodrome de paléontologie, vol. 1, p. 75; *Pterinea declivis* Roemer, Beiträge zur geologischen Kenntniss des nortwestlichen Harzgebirges, pt. 3, p. 123, pl. 18, fig. 5, 1855.

5 Frech, F., Die devonischen Aviculiden Deutschlands; ein Beitrag zur Systematik und Stammgeschichte der Zweischaler: Abh. geol. Specialkarte von Preussen, etc., vol. 9, Heft 3, pp. 130 et seq., pl. 4, figs. 2, 3, 1891.

6 Idem, p. 125, pl. 13.

7 In the genotype, *Gosseletia* (*Cyrtodontopsis*) *kayseri* Frech, the teeth are not crenulated; in *G.* (*C.*) *quarzitica* Frech they are crenulated. Of the four species of Cyrtodontopsis described by Frech these two are the only really cyrtodontiform shells. (See Drevermann, F., Die Fauna der Unter Coblenz Schichten von Oberstadtfeld bei Daun in der Eifel: Palaeontographica, vol. 49, pp. 84, 85, pl. 10, figs. 4–9, 1902.

8 Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon mit Ausschluss der Aviculiden: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, 1894.

9 Ulrich, E. O., The lower Silurian Lamellibranchiata of Minnesota: Geology of Minnesota, vol. 3, pt. 2, Paleontology, pp. 534–536, June 16, 1894.

consequent possibility that Conrad's diagnosis, from a fortuitous specimen may illustrate a rarer type of tooth structure. This point is of greater importance than has hitherto been recognized and possibly involves the consideration which induced authors to regard Cypricardites as identical with Cyrtodonta or Palæarca, although from the descriptions given above it is evident that these genera are quite distinct.

Drevermann,[1] in 1902, gave some good illustrations showing variations in the dentition of shells referred to Cyrtodonta and Cyrtodontopsis. The latter genus Drevermann affiliates with Cyrtodonta rather than with Gosseletia, where it had been placed by Frech. Cyrtodontopsis, according to Drevermann, differs from Cyrtodonta (or, rather, from the German Eo-Devonian shells referred by authors to Cyrtodonta) in having an oblique outline, and particularly in having all the teeth directed strongly backward, whereas in Cyrtodonta the front cardinal teeth are directed obliquely forward. On this distinction in the direction of the cardinal teeth Drevermann includes in the genus Cyrtodonta a new species, *Cyrtodonta dunensis*, the first Cyrtodonta proper described from the Rhine province. This species, originally described by Drevermann from the Lower Coblenzian of Oberstadtfeld, near Daun, in the Eifel, has been recorded by the same author [2] as apparently occurring in the Siegen graywacke of Seifen, near Dierdorf, in the Westerwald. Drevermann shows that *Modiomorpha follmanni* (Beushausen) is congeneric with *Cyrtodontopsis kayseri* Frech and, as in that species, its teeth are not crenulated.

The distinction between Cyrtodontopsis and Cyrtodonta indicated by Drevermann, that in Cyrtodontopsis the teeth are directed backward, whereas in Cyrtodonta the front cardinals are directed obliquely forward—can not hold, for, on account of the variability in dentition of these schizodontic shells, it sometimes happens that the front cardinals are directed forward in Cyrtodontopsis, as in *C. follmanni* (Beushausen),[3] and vice versa in Cyrtodonta.

Of course the European Devonian shells referred to the genera Cyrtodontopsis and Cyrtodonta are all distinct from Cyrtodonta Billings in several important and interesting respects. In Cyrtodonta Billings (and, according to Ulrich, in all the Ordovician Cyrtodonta-Cypricardites shells hitherto examined except *Cypricardites curta* Conrad), there are commonly only two cardinal teeth, sometimes three, rarely four; the teeth are directed backward, almost horizontally, and the forward teeth are the weakest. In the European Devonian shells, on the other hand, there are five cardinal teeth, rarely four, and commonly six or seven; the teeth are obliquely radial, and commonly the front one or two cardinals are nearly horizontal, but if so are directed forward, and the front teeth are the strongest.

It is of interest to note that these German Devonian shells are the only Devonian forms which really answer to the generic description of the Ordovician Cypricardites Conrad s. str., 1841 (*C. curta* Conrad). As for the present, Conrad's description must be considered authentic and illustrative of the real and normal dental structure of *Cypricardites curta*, it follows that the Eo-Devonian shells commonly referred to Cyrtodonta and Cyrtodontopsis are at least approximately congeneric with Cypricardites. The name Cyrtodontopsis Frech will have to be restricted to shells which have crenulated teeth. Those Ordovician shells which have the cardinal teeth horizontal, only three in number, and the strongest one not in front, and which have been commonly regarded by Hall, Miller, Billings, and others as identical with Cypricardites, Cyrtodonta, and Palæarca, will have to be called Cyrtodonta Billings, of which Palæarca Hall is a synonym, but which is quite distinct from Cypricardites so far as is at present apparent or ascertainable.

The genus Ptychodesma Hall and Whitfield[4] was founded upon *P. knappianum* Hall and Whitfield, a Middle Devonian shell having the aspect of the more depressed-convex Cypricardites or Palæarca types; but the nature of its hinge teeth is unknown, and it has what was regarded as a characteristic ligamental structure. The escutcheon is very strongly pronounced, deepen-

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[1] Drevermann, F., Die Fauna der Unter Coblenz Schichten von Oberstadtfeld bei Daun in der Eifel: Palaeontographica, vol. 49, pp. 84, 85, pl. 10, figs. 4–9, 1902.

[2] Palaeontographica, vol. 50, p. 241, 1904.

[3] See Drevermann, F., op. cit., fig. 5.

[4] Hall, James, and Whitfield, R. P., Description of new species of fossils from the vicinity of Louisville, Ky., and the Falls of the Ohio: New York State Mus. Twenty-fourth Ann. Rept., pl. 12, figs. 1–6, 1875.

ing and widening with the growth of the shell, and it is strongly striated or ridged longitudinally. The ligamental striæ or ridges arch over the umbo and are straight posteriorly, but, instead of being parallel to the hinge line, are slightly inclined or oblique to it and parallel with the cardinal margin. A similar ligament occurs in the late Silurian shells referred by Lindström[1] to "*Ptychodesma*" *nilssoni* Hisinger, a species from the later Silurian limestones at Djupvik, Gotland. The Gotland shells seem to differ from Ptychodesma in being apparently edentulous and in possessing an internal cartilage pit. The species is represented in England, according to Lindström and McCoy, by *Modiola? antiqua* Sowerby and *Mytilus* (*Modiolopsis*) *gradatus* Salter, from the Upper Ludlow. The occurrence of hinge teeth was noticed in 1885 by Hall,[2] who mentions the existence of "two or more cardinal teeth." Nettelroth[3] repeats the description of Ptychodesma given by Hall and Whitfield, but adds nothing new. Ulrich[4] places the genus Ptychodesma in the family Cyrtodontidæ, regarding it as the last surviving member of the family. The real tooth structure in Ptychodesma was described and figured for the first time in 1900, when Kindle[5] showed that there are two long posterior laterals near the posterior end of the hinge line and parallel to it; and, under the umbones, there are "about three" short oblique radial cardinal teeth. Kindle gave a good figure[6] of the interior of a silicified left valve showing four cardinal teeth and five sockets, indicating the existence of five cardinals in the right valve. The second and third cardinals in the left valve unite above, forming the inverted V (Λ) which is so common in the German Eo-Devonian "Cyrtodonta" and "Cyrtodontopsis" and which also, as in the German shells, incloses the third socket in the left valve, corresponding to the third or middle tooth of the right valve. Kindle's figures indicate that the ligamental characteristics noted by Hall and Whitfield are of less importance and constancy than had been previously supposed. There can be no doubt of the relationship of Ptychodesma to the Cyrtodontidæ or the Cypricardites; indeed, *P. knappianum* is remarkably similar to *Cypricardites curta* in having four or five cardinal teeth, as described for Cypricardites by Conrad, and not six or seven; moreover, these teeth are radial, not horizontal, and the longest one is in front. Ptychodesma agrees more nearly with Cypricardites than do the German Eo-Devonian shells previously mentioned, and with present knowledge Ptychodesma must be considered a synonym of Cypricardites Conrad s. str.

In conclusion it seems necessary, therefore, to restrict the term Cypricardites to such cyrtodontiform shells as are congeneric with *C. curta* Conrad, in having the cardinal teeth radial, not horizontal, and five in number, sometimes six or seven, rarely four. The forward one or two are the stronger, and may be in some specimens horizontal, but if so are directed forward. In the Devonian members of this group (the shells usually called Cyrtodonta and Cyrtodontopsis by Beushausen, Frech, and Drevermann, and Ptychodesma by Hall and Whitfield) the second or third cardinal tooth is usually inclosed in an inverted V or horseshoe-shaped loop formed by the union dorsally of the cardinal tooth in front and behind. The teeth are variable in their development, even in the same species.

The term Cyrtodontopsis Frech will have to be restricted to those forms of Cypricardites which have crenulated teeth. Cyrtodonta Billings will be retained for shells differing from Cypricardites as here limited in having commonly only three cardinal teeth, frequently only two, rarely four. The teeth are directed backward, are horizontal or nearly so, and not essentially radial, and the front one or two are not the stronger. Palæarca Hall is a synonym.

Vanuxemia Billings, which has frequently been confused with Cyrtodonta and Cypricardites, is a vertical Ambonychia-like or Megambonia-like shell. As no fossil has been found in the Maine faunas comparable with this type, I do not feel at liberty to enter here into any discussion of the genus.

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1 Angelin, N. P., and Lindström, G., Fragmenta silurica, p. 18, pl. 2, figs. 21–22; pl. 19, figs. 5–6, 1880.

2 Hall, James, Paleontology of New York, vol. 5, pt. 1, pp. xxix, 352, 1885.

3 Nettelroth, Henry, Kentucky fossil shells; a monograph of the fossil shells of the Silurian and Devonian rocks of Kentucky, pp. 201–202, pl. 11, figs. 13–18, 1889.

4 Ulrich, E. O., Paleontology of Minnesota, vol. 3, pt. 2, pp. 486, 533, 1894.

5 Kindle, E. M., The Devonian fossils and stratigraphy of Indiana: Indiana Dept. of Geology and Nat. Res. Twenty-seventh Ann. Rept., pp. 671–672, pl. 15, figs. 2–2c, 1901.

6 Idem, pl. 15, fig. 2c.

The Cypricardites-Cyrtodonta group are among the dominant fossils of the Ordovician in America and Europe, but are exceedingly rare, if, indeed, they have been recorded at all, in the Silurian. In the Lower Devonian they have already been indicated from the Rhenish and Hercynian strata. *Modiomorpha sellowi* Clarke,[1] from the Devonian fauna of the Rio Maecuru, Para, Brazil, appears to be a member of this group, rather than of Modiomorpha. It is apparently congeneric with "*Modiomorpha*" *follmanni* (Beushausen). In the Middle Devonian no fossils of this group have hitherto been recorded, but *Nyassa subalata* Hall,[2] from the New York Hamilton, is very probably a member of the assemblage, for it is closely related to Cypricardites, particularly to the German Eo-Devonian fossils here referred to that genus, differing chiefly in having the cardinal teeth more numerous and more irregular.

Finally, *Ptychodesma knappianum* appears to be a typical Cypricardites. The species is from the Hamilton of New York and beds of similar age in Kentucky, Ohio, and Indiana.

Hall[3] also describes *Ptychodesma nanum* and *P. minor*, from the Upper Devonian, the former from the lower half of the Ithaca shale member of the Portage formation, the latter from the Cayuta shale member of the Chemung formation. In both of these species the dentition is unknown; hence it can not be definitely stated that they belong to the group under discussion.

Cypricardites detroitense sp. nov.

Plate XXIII, figures 14, 15.

Shell transversely oblique, equivalve; very inequilateral. Rhombic, obliquely extended at an angle of about 35° with the hinge line. Length (35 millimeters) very nearly one and one-half times the height (24 millimeters), widening posteriorly, so that the greatest height is at the posterior third, which is one and one-half times as high as the height of the shell under the beaks. Greatest length at or above the midheight. Umbones anterior but not terminal; situated between one-fourth and one-fifth the length from the front; prosogyrate. Cardinal line straight, very slightly ascending, equal in length to three-fourths the height of the shell. Cardinal extremity obtuse. Posterior margin strongly arcuate and evenly rounded, forming a semicircle as far as the ventral extremity at the midheight. Postventral region broadly rounded. Ventral margin rounded, with the lowest point at the posterior third or two-sevenths, whence the margin ascends forward into a depressed curve, causing a marked diminution of the height toward the front and causing the forward extremity of the shell to be opposite the upper third of the height. There is no ventral insinuation nor constriction. The anterior end is very short and narrow, evenly rounded. There is no discernible lunule in front of the beak. The shells are of moderate or depressed convexity. The depth of the single valve is 5 millimeters, approximately one-fifth the height or one-seventh the length. The point of greatest depth is at the upper third, two-fifths the length of the shell from the front, whence the surface dips into an evenly convex slope in all directions. The beaks are depressed convex, incurved, hardly protruding beyond the cardinal line. There is no umbonal ridge. There is evidence suggesting the presence of an external ligament in a long escutcheon, which appears to be striated, the striæ arching over the region of the cardinal teeth, as in *Ptychodesma knappianum*, but not so strongly developed. There are two posterior long, narrow, linear laterals in each valve, those of the left valve being above those of the right. These teeth are more clearly discernible near the distal end of the hinge line, the portion just back of the umbones appearing almost edentulous. The lower posterior lateral is a little shorter than the upper one. Of cardinal teeth the only one preserved in the specimen at hand is one extending forward from the beak, almost horizontal and fairly strong, very similar to the anterior cardinal of *Cyrtodonta dunensis*, from the Lower Coblenzian fauna of Oberstadtfeld, near Daun, in the Eifel, figured by Drevermann.[4] Whether any other teeth are present can not be stated.

[1] Clarke, J. M., The Paleozoic faunas of Para, Brazil; Devonian Mollusca: Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 6, figs. 14-16, 1899 (author's English ed., p. 51, 1900).
[2] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 355, pl. 53, figs. 21-26, 1885.
[3] Idem, pp. 353-354.
[4] Palaeontographica, vol. 49, pl. 10, fig. 7a, 1902.

Muscular scars and pallial line unknown. The surface appears to have been covered with obsolescent concentric striæ of growth, or was very nearly smooth. A few distant, somewhat stronger striæ of growth or varices are apparent. No concentric ridges or radial markings. Length of type and only specimen 35 millimeters, height 24 millimeters, depth of single valve 5 millimeters.

The fossil is easily recognized among the collections by the characteristic cyrtodontiform outline. It is longer than high, and the length is less than twice the height. Shell widens posteriorly; anterior end narrow; ventral extremity at the posterior third; posterior margin semicircular; cardinal line straight, less than the height, and very slightly ascending; umbones between the anterior fourth and fifth; convexity moderate; strong ligamental groove; posterior laterals distant; surface smooth or tenuistriate, with a few distant varices.

Locality: Moose River sandstone, Detroit, Somerset County, Maine (locality 1100A). Not in the Chapman fauna.

U. S. National Museum, catalogue No. 59780.

Comparisons.—This is one of the very few species in the Cypricardites group which lack the ventral insinuation below the beaks. The shell bears some relation to *Ptychodesma knappianum* Hall and Whitfield and has, like that species, the peculiar arching of the striæ of the ligamental groove over the region of the cardinal teeth. *Cypricardites detroitense* differs from the Ohio shell in having the anterior end much better developed, so that the beaks are not terminal. The front cardinal tooth is also more nearly horizontal rather than radial. *Cypricardites detroitense* is very closely related to *Modiomorpha sellowi* Clarke, previously referred to, but the Maecuru shell is larger, more nearly quadrate in outline, has a much wider anterior end and a consequently less rapid widening posteriorly, and the umbo is a trifle more protruding. Clarke [1] shows, just in front of the beak, a nearly horizontal line which has some resemblance to the linear front cardinal tooth in *Cypricardites detroitense*.

Superfamily NUCULACEA Dall.

Families ?CTENODONTIDÆ Dall, NUCULIDÆ Adams, and LEDIDÆ Adams.

The superfamily Nuculacea Dall [2] constitutes a natural evolutional group whose beginnings were in the early Paleozoic (the family "?Ctenodontidæ Dall"), and from later Paleozoic to recent times the group has been represented by the two families Nuculidæ and Ledidæ of Adams. Verrill and Bush [3] group the Nucula-like shells in the two families Ledidæ and Nuculidæ and include the Paleozoic forms in a subfamily, Tindarina,[4] of the family Ledidæ. These authors say of the family Ctenodontidæ:

> Mr. Dall has proposed the family Ctenodontidæ to include the extinct genera above named [Palæoneilo, Nuculites] and others, but it is doubtful whether Ctenodonta itself belongs here. Zittel and others refer it to Arcidæ.

Dall [5] remarks that this statement expresses complete misconception of the arrangement proposed by him and states, further, that he includes none of the members of Tindarinæ Verrill in his group "Family ?Ctenodontidæ." He continues:

> I have preferred to avoid attempting a revision of the Paleozoic genera, which comprise the beginning of so many groups and require for adequate comprehension a truly monographic treatment.

Without proposing a solution of the difficulties in the case I present the following notes, brought together in the process of distributing the species here described into appropriate generic groups, in the hope that they may be useful to those who may make a serious attempt to treat this group monographically.

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[1] Clarke, J. M., op. cit., fig. 14.

[2] Dall, W. H., Tertiary mollusks of Florida, pt. 3—A new classification of the Pelecypoda, etc.: Wagner Free Inst. Sci. Trans., vol. 3, pt. 3, p. 515, 1895.

[3] Verrill, A. E., and Bush, K. J., Revision of the genera of Ledidæ and Nuculidæ of the Atlantic coast of the United States: Am. Jour. Sci., 4th ser., vol. 3, p. 51, 1897.

[4] Idem, p. 58.

[5] Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 583, 1898.

Considerable discussion has arisen over the definition and proper application of the names Tellinomya Hall and Ctenodonta Salter, 1851, and to pave the way toward a proper generic classification some historical notice of these names becomes necessary.

The genus Tellinomya was founded by Hall[1] in 1847 with the following diagnosis:

Equivalve, inequilateral, somewhat compressed below but becoming gibbous at the umbones; umbones not angular; outline of the shell curved, without angular ridges; shell thin, closely laminated; hinge without visible teeth crenulations; muscular impressions two in each valve, near the dorsal margin; often apparently gaping at the posterior extremity. Type, *T. nasuta*.

Continuing, Hall emphasized the difficulty of elucidating the real generic or hinge characters in such poorly and imperfectly preserved Paleozoic shells. He pointed out that some of these shells have, however, a characteristic form, saying:

I am well aware of the difficulty, not to say impossibility, of properly characterizing a genus where the specimens are in the condition of these ancient fossils; and therefore general external form and the structure of the shell must be allowed some weight. In the present instance the form of the shell and some other characters in the typical series are so widely different that they can not fail to attract attention.

At the twenty-first meeting of the British Association for the Advancement of Science, held at Ipswich in July, 1851, Logan[2] read a paper "On the age of the copper-bearing rocks of Lakes Superior and Huron, and various facts relating to the physical structure of Canada." To this paper, as published, Salter[3] added as an appendix a "Note on the fossils above mentioned, from the Ottawa River." The fossils referred to are from the Trenton limestone at the southeast end of Allumette Island, on Ottawa River. Salter says:

Among bivalve shells, which chiefly belong to the Arcacidæ, a very interesting new genus has rewarded examination. It was found that two species resembling Nucula in every general character differed from it importantly by having no internal ligament, but a very manifest exterior one.[4] One of these shells measures 3 inches across, and from the general analogy of several accompanying species it is believed that the genus will be found common in the Silurian rocks and will include many species now referred to Nucula. It might be called Ctenodonta.

No species are named, nor is any reference made to Nuculites Conrad or to Tellinomya Hall.

In 1856 Hall[5] noted the finding of good specimens, preserving the hinge, of six species of Tellinomya, mostly from the Trenton limestone of Ottawa River, and pointed out the error in his description of the hinge in 1847, which was drawn up from imperfect material. The hinge, according to Hall's later description, shows a series of numerous small teeth or crenulations as in Nucula, but the teeth are continuous and not interrupted by a cartilage pit, the ligament being external. Hall, in this paper, abandons the earlier restriction of Tellinomya to the characteristic form typified by the *T. nasuta* group and expands it to include all the Paleozoic shells with nuculoid dentition which differ from Nucula in lacking the cartilage pit, from Nuculites Conrad and Cuculella McCoy in lacking the muscular clavicle or septum, and from Isoarca Münster in not having the umbones spirally enrolled. Tellinomya as thus expanded is coextensive with Salter's Ctenodonta; Hall, in fact, mentions Ctenodonta Salter but does not give it any rank. He states that the type species of Tellinomya Hall, 1847, *T. nasuta*, has a hinge identical with that proposed as characteristic of Ctenodonta Salter, 1851, and that the type species of Salter, as ascertained by Hall, is closely allied specifically to *Tellinomya nasuta* Hall.

In S. P. Woodward's manual of the Mollusca, first edition, Ctenodonta is given as a synonym of Isoarca Münster.

In the first edition of Murchison's Siluria (1854) Salter does not mention Ctenodonta, but uses Nucula for the Paleozoic taxodonts.

In 1859 Salter[6] for the first time described and illustrated the material on which he founded his genus Ctenodonta. He stated,[7] with reference to Ctenodonta:

I was not aware, when I proposed the above generic term for a group of Paleozoic Nuculæ, that the principal species had been previously published under the name of Tellinomya by Hall * * * and if the name (Tellinomya) did not convey an entirely erroneous view of the affinities, I should be glad to restore it.

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[1] Hall, James, Paleontology of New York, vol. 1, p. 151, 1847.
[2] Logan, W. E., British Assoc. Adv. Sci. Twenty-first Meeting, Trans. Sections, pp. 59–62, 1852.
[3] Salter, J. W., idem, pp. 63–65.
[4] Mr. S. P. Woodward, of the British Museum, suggests that Solenella may contain these species.
[5] Hall, James, Canadian Naturalist and Geologist, vol. 1, pp. 390–395, December, 1856.
[6] Murchison, R. I., Siluria, 3d ed., pp. 213, 859, 1859.
[7] Salter, J. W., Figures and descriptions of Canadian organic remains, decade 1, p. 34, 1859.

Salter gives, as an additional reason for retaining Ctenodonta Salter, 1851, in preference to Tellinomya Hall, 1847, the fact that the essential feature of the shells, the ligament and hinge teeth, was overlooked and misrepresented in Hall's original diagnosis of Tellinomya in 1847. However, Salter does not mention in this connection the fact that not a single species of Ctenodonta had been described or figured or really known to anyone except Salter himself prior to 1859, whereas Tellinomya was sufficiently corrected and revised and well figured and described by Hall in 1856.

The *Ctenodonta logani* of Salter, which had appeared by name without specific description or illustration in Woodward's "Manual," and which was regarded as the type of Ctenodonta, was shown by Hall and by Salter to be identical with *Tellinomya nasuta* Hall. A new complication thus arose, both Tellinomya and Ctenodonta being founded on the same species, as Salter fully admitted. Salter described, in addition to *Ctenodonta nasuta*, two closely allied species—*C. logani* Salter, 1859 olim (*T. dubia* Hall, pars), and *C. contracta* Salter—as well as two other species—*C. gibberula* (genus Glyptarca Beushausen, s. str.) and *C. astartæformis* (genus Ctenodonta Salter, emend. s. str.).

The principal arguments against the use of Tellinomya are these: (1) The name Tellinomya proposed by Hall in 1847 may be regarded as preoccupied, having been suggested by Agassiz in 1846 as the corrected orthography of Tellimya Brown, 1827. (2) The description of the genus Tellinomya Hall, 1847, was imperfect and misleading with regard to the essential feature, the hinge characters. (3) The name conveys a suggestion of relationship which is erroneous when the hinge is considered.

The name Ctenodonta, however, was proposed in 1851 (published 1852), over four years later than the publication of Tellinomya Hall, 1847. Moreover, if the description of Tellinomya Hall, 1847, is regarded as invalid, the fact still remains that Tellinomya was completely described and illustrated by Hall in 1856, whereas not a single species of Ctenodonta was known by name or specifically referable to Ctenodonta before 1859, except the nude specific name *Ctenodonta logani*, which appeared in Woodward's "Manual." Again, the type species of Ctenodonta, *C. logani* Salter, is identical with the type species of Tellinomya, and Salter himself united his types with Hall's species *Tellinomya nasuta* and accepted Hall's specific name, but refused to accept Hall's generic name Tellinomya, calling his shells *Ctenodonta nasuta* (Hall).

As will be more fully shown, both Tellinomya and Ctenodonta ought to be retained. The principal argument against the name Tellinomya Hall is, of course, its supposed preoccupancy. The genus Tellimya was founded by Brown in 1827 for some different bivalve shells. In 1846 Agassiz undertook in his "Nomenclator zoologicus" to correct the name to Tellinomya on the assumption that, based on Tellina and Mya, the spelling Tellimya was improper, Tellinomya being the correct form. Agassiz did not propose a new genus or a new generic name, but merely corrected the orthography of Tellimya Brown. I am not aware of any definite rule on this point, but modern usage among biologists appears to tend to the preservation of the original orthography of a generic name, provided, of course, the name is Latin or latinized. It is obvious that endless confusion would result if each biologist were allowed to alter a name according to what he thought to be the proper orthography. Imagine the chaos, to put it mildly, if the same organism might be called Arthroacantha, Arthroacanthia, Arthroacanthus, Arthracantha, Arthrocanthus, or Arthracanthus, according to different persons' ideas of correct orthography; or take Aviculopecten, Aviculipecten, Aviculapecten, Aviculæpecten; or Pachyrisma, Pachyorisma, Pachyerisma; or Paleoneilo, Palæoneilo, Palæaneilo, Paleaneilo; or Tellimya, Tellomya, Tellinamya, Tellinæmya, Tellinomya, Tellinimya; or, finally, suppose the individual caprice for correct orthography should cause someone to change a commonly accepted name like Allorisma to Allerisma, at the same time stating that Allœerisma is really the proper form but is "unbeautiful and impractical!" Manifestly Tellimya Brown, 1827, even if derived from Tellina and Mya, is as beautiful and, it might even be argued, technically as correct as Tellinomya Agassiz, 1846; moreover, it has the further advantage of being brief and practical, in addition to being the original name. Besides, not having seen Brown's work and not actually knowing that Brown really did form Tellimya from Tellina and Mya, I might argue, as do Miller and Faber,[1] that Tellimya might have been derived from the Greek word τελλω and Mya, meaning "dawn of Mya," or possibly Brown may have prefixed to Mya the name of a man called Tell, producing a name analogous with Barrandeoceras, Agassizodus, Collettosaurus, Millericrinus, and Worthenopora. Agassiz's work, being merely a nondescriptive catalogue, has no effect in fixing priority in nomenclature, and as a matter of fact his name Tellinomya has never been used by conchologists. Fischer in his "Manual" considers Tellimya a synonym of Montacuta, but more recently Brown's genus has been separated, and modern authors[2] use the word Tellimya in its original form. Tellinomya Agassiz, 1846, must therefore be expunged from nomenclature as a dead word, and the argument that its use causes Tellinomya Hall, 1847, to be preoccupied therefore falls to the ground.

The second argument against Tellinomya is that the description of Tellinomya in 1847 was imperfect and misleading with regard to the essential hinge features; but the genus was fully redescribed and corrected (and incidentally expanded by Hall) in 1856. Even without this redefinition the peculiar form of the *nasuta* group, which was characterized as being diagnostic of the genus, is sufficiently pronounced to permit Tellinomya to stand on external features.

The third argument against Tellinomya, that the name conveys an erroneous suggestion of the affinities of the fossil, even if true, would have no value according to modern usage. As a matter of fact, however, the genus Tellinomya ought to be returned to its original limits to include only the *T. nasuta* group, and for this group the name is eminently fitting in that the form really does recall Tellina and Mya.

The name Ctenodonta in the strict sense would be a synonym of Tellinomya, but in the expanded usage of Ctenodonta adopted by Salter and other authors various heterogeneric species were included. The first of these species described and figured, *Ctenodonta astartæformis* Salter, is readily separable from *Tellinomya nasuta* and its allies and is capable of standing as a nucleus of a separate genus.

Expansion of Tellinomya or Ctenodonta to include under one name or the other all the Paleozoic and early Mesozoic nuculoids devoid of cartilage pit seems inappropriate, for if all these shells are to be included under one generic name the earlier and well-known name Isoarca Münster, 1842, might be adopted as was done in Woodward's "Manual," and more recently by Tate.[3] Indeed, the still earlier name Nuculites Conrad, 1841, might be adopted, for Conrad recognized the importance in these nuculoid shells of the absence of a cartilage pit and the uninterrupted continuation of the teeth beneath the beaks.

The species of Nuculacea discovered in the Chapman fauna are placed in the following genera: Cleidophorus Hall, Myoplusia Neumayr, Tellinites McCoy, and Paleoneilo Hall.

Genus CLEIDOPHORUS Hall.

The genus Cleidophorus was founded by Hall[4] in 1847 for *Nuculites planulata* Conrad, of the Upper Ordovician. The genus was supposed to be characterized, like Conrad's genus Nuculites, by the development of a persistent, conspicuous, anterior muscular septum, but Hall did not observe any hinge crenulations. However, in all the shells of this type where the hinge structure has been observed the hinge is taxodontic, as in Nuculites. The generic name Cucullella was applied by McCoy[5] four years later for the same group of shells as represented in Great Britain, where the hinge crenulations were observed.

Specimens of *Cleidophorus planulatus* (Conrad) are rather uncommon, so that taxodontic dentition in this species can not be absolutely demonstrated. The strongest evidence in favor of assuming taxodontic dentition in the type species of Cleidophorus is the fact that the species

[1] Miller, S. A., and Faber, C. L., Cincinnati Soc. Nat. Hist. Jour., vol. 17, pp. 149-151, 1894.

[2] The eminent British conchologist, E. A. Smith (On a collection of marine shells from Port Alfred, Cape Colony: Jour. Malacology, vol. 11, p. 41, London, 1904), describes and figures a bivalve shell as *Tellimya similis*.

[3] Tate, Ralph, Fossils of the Larapintine series (Ordovician): Report on the work of the Horn scientific expedition to central Australia, vol. 3, Geology and botany, pp. 97-116, 3 pls., London and Melbourne, March, 1896.

[4] Hall, James, Paleontology of New York, vol. 1, p. 300, 1847.

[5] McCoy, Frederick, Annals and Mag. Nat. Hist., 2d ser., vol. 7, p. 50, 1851.

was included in the taxodont genus Nuculites by Conrad in his original diagnosis in 1841, and the other eight of the nine species of "Nuculites" there described by Conrad are taxodontic. In the second place, as has already been pointed out, whenever the hinge of similar Paleozoic shells has been exposed to view it has revealed a taxodontic dentition. In this connection it may be noted that the taxodont Tellinomya was likewise originally described by Hall (in the same work in which Cleidophorus was described) as being devoid of hinge crenulations.

The taxodont Cucullella therefore appears to be strictly synonymous with the imperfectly described Cleidophorus, but comparison of the shells of the group of *Cleidophorus planulatus* with typical *Nuculites triqueter* shows a ready and important distinction. In *Nuculites triqueter* and several other species, to which the name Nuculites ought to be restricted, there is a well-developed posterior ridge which seems to have been associated with a well-developed siphon or anal tube in the animal. This significance of the posterior ridge is suggested by the fact that some specimens of *Nuculites triqueter* Conrad and the similar Silurian *N. coarctata* Phillips become emarginate, as in Paleoneïlo, Koenenia, and Tellinites (Tellinopsis). In the typical Ordovician and Silurian, as well as in most Devonian forms to which the name Cleidophorus ought to be applied, the surface is smoothly oval without trace of any definable postumbonal ridge. If I am correct, in associating the development of a postumbonal ridge in Nuculites s. str. with the occurrence of a well-developed siphon or anal tube, then the persistent absence of such a ridge in a large number of widely distributed species deserves some notice; and for such oval forms devoid of postumbonal ridge the name Cleidophorus Hall may well be retained.

CLEIDOPHORUS CURTUS sp. nov.

Plate XIX, figure 1.

Small, moderately convex shells of transversely ovate outline, widest in front, tapering behind. Proportion of height to length, 7:10. Greatest height at the midlength or just in front; greatest length at the inferior two-fifths. Beaks inconspicuous, not protruding above the hinge line; situated at the anterior two-fifths or third; slightly prosogyrate, nearly vertical. The anterior end is high and symmetrically rounded, with the forward extremity at the mid-height rounding into the ventral margin, which is symmetrically bellied down; ventral extremity at the midlength. The postventral "angle" is rounded, obscurely discernible; between this and a distinct hinge extremity is demarcated a posterior margin which is retrorse and equal in length to half the height of the shell. The posterior extremity is just above the postventral "angle," at the inferior third of the height of the shell. The hinge extremity is obtusely sub-angular. The hinge line is declining, faintly convex, nearly straight, and slightly longer than half the height of the shell. The valves are evenly rounded throughout except that below the hinge line the surface is more nearly plane, though highly inclined. The point of maximum depth is a trifle above the middle of the shell. There is neither a postumbonal nor a preumbonal ridge, nor any trace of the posterior sinus. The depth of the single valve is equal to a little more than one-fourth, perhaps one-third the height. Ligament and teeth unknown. Muscular scars moderately impressed, each strongly delineated on its umbonal side by a curved septal ridge. The septum bounding the anterior scar extends from a point immediately in front of the umbo downward and forward about to the midheight. The posterior septum is blunter and more oblique than that bounding the anterior scar. The muscular scars are of about equal size and their distal margins are indistinct. No umbonal scars were observed. Pallial line not observed. Shell thin, except where thickened on the interior by the septal ridges.

The internal mold is smooth, and fragments of the surface also appear smooth, disclosing under a hand magnifier, however, extremely fine, tenuous lines of growth. Length 10 millimeters, width 7 millimeters.

Locality: The type and only specimen is a left valve from the Chapman sandstone of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59768.

The species is distinguished from the other Cleidophori by the occurrence of two muscular septa, the nearly central position of the beaks, the subangular hinge extremity, and the high form, the height being equal to seven-tenths the length. The posterior margin is nearly equal to the length of the hinge line.

Comparisons.—The fossil has almost precisely the size, shape, and outline of *Nucula* (*Nuculites* s. str.) *coarctata* Phillips,[1] but Phillips's species has a well-developed posterior ridge (sometimes accompanied, as in a few rare specimens of *Nuculites triqueter*, by an emargination and sinus), which places it in the genus Nuculites. *N. coarctata* also lacks the posterior septum.

Cleidophorus curtus also resembles the short forms of the Neo-Ordovician *Cleidophorus* (*Nuculites*) *neglectus* Hall figured by Ulrich,[2] but the latter are distinguished by having the muscular septum longer and vertical, and by having a faint postumbonal ridge.

CLEIDOPHORUS PEROVALIS sp. nov.

Plate XXV, figures 2, 10.

A second species of Cleidophorus is represented in the Chapman collections by a couple of specimens from Edmunds Hill (locality 1099 M). The form is of the smoothly rounded, subsymmetrically oval type of Cleidophorus characteristic of most of the Ordovician, Silurian, and early Devonian species of the genus. Outline transversely oval, margin nearly symmetrically rounded; proportion of height to length, 3:5. Greatest height at the midlength; greatest length at the midheight. Umbones inconspicuous, small, depressed to the hinge line; directed forward, and situated at the anterior fourth of the length. Anterior end short, though fairly high; forward extremity at the midheight, the margin rounding into the ventral margin, which is a symmetrical, strongly bellied-down arch, ascending markedly to the ill-defined respiratory (postventral) angle. The posterior margin is similar to the anterior, and rounds into the hinge line, which is gently convex, horizontal to a point just back of the midlength of the shell, thence descending and rounding into the posterior margin. The dorsal and ventral extremities are both at the midlength. The surface is smoothly and evenly rounded throughout, except near the postdorsal region, where there is a narrow, somewhat flattened strip. The shell is of moderate convexity, and the depth of the single valve is equal to about one-fourth its height. The point of greatest depth is at the anterior two-fifths of the length and at, or only slightly above, the midheight. Ligamental structure and teeth unknown. Muscular scars not impressed. There is no posterior muscular septum or ridge. The anterior septum is very narrow and thin; from a point immediately in front of the umbo it extends downward, slightly backward from the vertical, to the inferior third of the height of the shell.

The sculpture casts are nearly smooth, but show very faint tenuistriate lines of growth. The type specimen, a right valve, has a length of 21 millimeters, a height of 12.75 millimeters, and a depth of 3 millimeters. A second fragment, vertically compressed, is 22 millimeters long and 12.5 millimeters high.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59769.

Comparisons.—The species closely resembles the large uniseptate species of Cleidophorus described and figured by Beushausen[3] as *Cucullella elliptica* Maurer, but is more symmetrical, tapers less posteriorly, and, unlike the German shell, which is described as being strongly inflated, is only moderately convex.

Nuculites branneri Clarke,[4] from the Brazilian Lower Coblenzian fauna of Rio Maecuru, is somewhat similar, but has more protuberant and conspicuous umbones, a lower anterior end, and the dorsal margin more rapidly descending from the beaks, with the uppermost extremity of the shell in advance of the midlength.

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[1] Geol. Survey Great Britain Mem., vol. 2, pt. 1, p. 366, pl. 22, figs. 2, 3 (not figs. 1, 4), 1848; British Upper Ludlow-Downtonian sandstones of Freshwater Bay.

[2] Geology of Minnesota, vol. 3, pt. 2 (Paleontology), pl., figs. 20-23 (not fig. 25, which represents the elongate form), 1894.

[3] Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 104, pl. 5 (pars), figs. 9, 10, 11 (not figs. 12-15), 1895. Lower Coblenzian of Nellenkopfchen, Rhenish Prussia.

[4] Clarke, J. M., The Paleozoic faunas of Para, Brazil, pt. 2, Devonian Mollusca: Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 8, figs. 6-8, 1899 (author's English ed., p. 73, 1900).

The Silurian *Cleidophorus brasilianus* Clarke [1] is also similar, but has more protruding umbones, and tapers more posteriorly.

Cleidophorus perovalis sp. nov. is very similar to the transversely oval Ordovician shell figured and described by Ulrich [2] as *Cleidophorus neglectus* Hall, but differs from the Ordovician species in having a proportionately greater height and in being more gibbous.

Genus **MYOPLUSIA** Neumayr, 1883.

The ctenodontoid shells to which Neumayr applied the generic name Myoplusia are transversely elongated, with a high but short rounded anterior end and a lower, more elongated, and tapering posterior end; beaks directed forward; outline entire, not emarginate; without posterior surface sinus and ridge.

Myoplusia was actually founded on the character of the muscular scars, but the name may be applied, pending a thorough revision of these Paleozoic shells, to the type of outline described above. This outline is typically expressed in "*Paleoneilo*" *sulcatina* (Conrad)[3] and similar nonemarginate shells. Myoplusia appears to be most nearly related to the transversely elongate Paleoneilos of the "'*Ctenodonta*' *dalleidense* Beushausen group." These transversely elongated Paleoneilos have essentially the outline of Myoplusia described above, but have a more or less faint sinus or emargination postventrally. In some specimens of a few such species of Paleoneilo the postventral emargination becomes obsolescent, and such specimens appear to conform with Myoplusia. Myoplusia, however, represents persistently nonemarginate shells.

MYOPLUSIA CHAPMANI sp. nov.

Plate XXV, figure 7.

A small, incomplete, fractured specimen of a Myoplusia occurs in the Chapman sandstone on Presque Isle Stream. The shell does not appear to belong to any known species. Because of the imperfection of the type specimen it is with reluctance that I apply to it a specific name. Length, 10 millimeters; height, 6½ millimeters. Greatest length at about the midheight; greatest height in front of the middle. Beaks slightly protruding, prosogyrate, situated at the anterior fifth or sixth. Anterior end short but fairly high. A faint lunule is developed in front of the beaks, where the anterior margin is abruptly curved downward, rounding into the strongly arched ventral margin. Ventral extremity at the midlength. Posterior end tapering, elliptically rounded; no definable postventral extremity nor hinge extremity nor posterior margin. Hinge line gently convex, ascending from the rear to the umbones, with the highest point at the anterior fourth. Shell strongly convex; inflated below the umbones, which are incurved to the hinge line. The surface is evenly rounded, except for the concave lunule in front of the beaks. The depth of the single valve is equal to about half the height; the point of greatest depth is situated near the midheight, a trifle in advance of the middle. Hinge unknown. Muscular scars not impressed.

To judge from the internal mold, which is in part a faint "sculpture cast," the shell may have been marked with tenuistriate lines of growth, or nearly smooth.

Locality: Chapman sandstone, Presque Isle Stream, at the end of the Tweedy road (locality 1099 A), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59770.

Comparisons.—The species closely resembles "*Ctenodonta*" *krotonis* Roemer as figured by Beushausen,[4] but the German species is lower and has the muscular scars more strongly impressed.

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[1] Clarke, J. M., The Paleozoic faunas of Para, Brazil, pt. 1, The Silurian faunas of the Rio Trombetas: Mus. nac. Rio de Janeiro Arch., vol. 10, p. 18, pl. 2, figs. 17–19, 1899 (author's English ed., 1900).

[2] Ulrich, E. O., The Lower Silurian Lamellibranchiata of Minnesota: Geology of Minnesota, vol. 2, pt. 2 (Paleontology), p. 607, pl. 42, fig. 25 (not figs. 20–24) 1894, "Nucula beds" of the Maquoketa shale, Graf, Iowa.

[3] See Paleontology of New York, vol. 5, pt. 1, p. 347, pl. 50, figs. 42, 44–46 (not fig. 43, which is a Paleoneilo of the *P. truncata* type), 1885.

[4] Beushausen, Louis, Die Lamellibranchiaten des Rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 72, pl. 5, figs. 24, 25, 1895; Wissenbach shales (lower Meso-Devonian).

"*Ctenodonta*" *primæva* (Steininger),[1] which also possesses the Myoplusia outline, is a much larger shell and has a shallower ventral margin.

In size and outline *Myoplusia chapmani* approaches most closely a little Coblenzian specimen identified by Beushausen[2] with *Cleidophorus ellipticus* (Maurer).

Genus TELLINITES McCoy (KOENENIA Beushausen).

Koenenia s. str.: Beaks decidedly prosogyrate and usually situated well forward. A single posterior sinus is well developed and is commonly marked on one or both sides by a strong fold. Occurs in the Devonian and Carboniferous of Europe and America. The subgroup Bicrenula nov. is like Koenenia, but the surface striæ on the posterior slope form two neat reentrant arches. Types: *Paleoneilo bisulcata* Hall and *P. angusta* Hall, from the Chemung formation, New York; *P. muricata* Clarke, from the lower part of the Portage ("Nunda") formation, New York.

Tellinites s. str.: Umbones subcentral or central, directed vertically or only slightly prosogyrate; posterior sinus shallow, developed more or less faintly and variably, and accompanied in some specimens by one or two rounded obsolescent radial folds. Ordovician (Bohemia), Silurian (Great Britain), Eo-Devonian (Europe, South Africa, South America, and North America), and Meso-Devonian (North and South America).

Tellinopsis Hall: Like Tellinites McCoy, but showing traces of a forward sinus also. *T. subemarginatus* (Conrad), Hamilton fauna, New York.

The above represent the principal subgroups under Tellinites. Each is capable of subdivision.

As the old term Paleoneilo Hall, formerly applied to these and similar shells, manifestly like Tellinomya, requires restriction, it has been deemed proper to restrict Paleoneilo to the forms closely resembling the genotype, *P. constricta* (Conrad). Hall included in Paleoneilo shells which ought to be separated chiefly into the groups of Verrillella, Koenenia, Tellinites, Myoplusia, and Tellinomya.

The genus Tellinites was founded in 1851 by McCoy[3] for *T. affinis* McCoy, from the Upper Ludlow of Kendal, Westmoreland. The peculiar outline was the essential characteristic of the genus, the hinge line being unknown. From their characteristic outline and evident similarity to "*Ctenodonta*" *elegans* Maurer, "*Palæoneilo*" *perplana* Hall, "*Palæoneilo*" *virginica* Hall, etc., which are known to be taxodontic, it may reasonably be assumed that Tellinites McCoy and Tellinopsis Hall, are taxodontic, and the name Tellinites McCoy may be applied to the group under discussion.

Tellinites affinis McCoy and *T. elegans* (Maurer), with the two Chapman species here described, *T. chapmani* and *T. curta*, form with their transverse rounded outline and faint sinus a well-marked group easily distinguishable from the more quadrate Tellinopsis Hall, which has a stronger sinus and fold. In *Tellinopsis subemarginata* also there is, occasionally, an anterior emargination, suggesting a well-developed anterior siphon. *T. gibbosa* Goldfuss, *T. unioniformis* Sandberger, *T. orbignyi* Clarke, and some of the Chapman shells present a closer analogy with Tellinopsis than with typical Tellinites; and the *Paleoneilo sulcata* of Hartt and Rathbun represents a type intermediate between these and typical Koenenia. The various groups in Tellinites senso lato seem to grade into one another, or at least they appear to be connected by several intermediate types.

TELLINITES CHAPMANI sp. nov.

Plate XIX, figure 5.

This name is applied to a typical Tellinites of the group of the Upper Ludlow *T. affinis* McCoy, the genotype of Tellinites.

Height, 0.57 the length in the type specimen; greatest height at the midlength; greatest length below the middle, near the inferior third or two-fifths. Umbones broad; vertical, or

[1] Beushausen, Louis, Die Lamellibranchiaten des Rheinischen Devon: K. preuss. geol. Landesantalt Abh., new ser., vol. 17, p. 72, pl. 5, fig. 13. Wissenbach shales (lower Meso-Devonian).

[2] Idem, pl. 5, figs. 28-30.

[3] McCoy, Frederick, Annals and Mag. Nat. Hist., 2d ser., vol. 7, p. 51, 1851. See also Sedgwick, Adam, and McCoy, Frederick, British Paleozoic rocks and fossils, p. 286, pl. 1 *K*, fig. 31, 1852.

extremely faintly prosogyrate; not protruding above the hinge; situated only slightly in advance of the midlength, at the anterior 0.45. Anterior end large; as high and nearly but not quite as long as the posterior end. The margin of the anterior end of the shell makes a deep, symmetrical paraboloid arch, with the forward extremity at the midheight. Ventral margin shallow, nearly straight, constricted in the middle by the undefined sinus; thence strongly ascending to the rounded postventral angle. The posterior margin is retrorse, slightly arcuate, and devoid of insinuation; it is equal in length to two-thirds the height of the shell. The hinge extremity is obtusely subangular. The hinge line is depressed-convex, nearly straight; it descends to the rear, and is only slightly longer than the posterior margin. The shell is moderately ventricose; the body of the valve is broadly inflated below the umbones. The greatest depth is equal to a little over one-third the height in each valve. The point of maximum depth is situated near the midheight at the upper third of the height. There is discernible on the surface in our specimens an exceedingly faint radial sinus or flattening extending below the umbones at a very small angle backward from the vertical. In front of the region of the post-umbonal ridge is a second obsolescent flattening, narrower and much fainter than the first and extending backward at an angle of approximately 45°. The umbonal ridge is undefined; the posterior slope is very steep, and devoid of insinuation. Ligament and dentition unknown. Muscular scars not impressed on the shell, and not discernible on the specimen which is a clean internal mold. Shell decidedly thin, almost papery.

The surface ornamentation consists of very fine concentric lines and striæ of growth, interrupted about every millimeter, more or less, by a little stronger stria of "growth" (rest), producing faint little concentric undulations. These are developed a little more prominently on the forward part. The type specimen, a single right valve in clean internal mold, is 37 millimeters long, 21 millimeters high, and 7.5 millimeters deep.

The distinguishing features of this shell are the broadly oval form, with height less than three-fifths the length; beaks nearly central (at the anterior 0.45), broad, vertical, incurved to the hinge line; anterior end as high and nearly as long as the posterior end; ventral margin shallowly convex, constricted near the middle; posterior margin well defined and devoid of insinuation; shell moderately ventricose and apparently devoid of surface sinus, except that a faint flattening extends nearly vertically behind the beaks, and a second narrower and exceedingly faint flattening occurs in front of the undefined posterior ridge.

Locality: Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59771.

Comparisons.—In the broadly oval form, strong convexity, subcentral position of the vertebral beaks, and faint character as well as the position of the posterior sinuses the species is a typical member of the group of *Tellinites affinis* McCoy,[1] from the British Upper Ludlow, the genotype of Tellinites. I was, indeed, originally inclined to unite the Chapman specimen with McCoy's species, and subsequent larger collections may possibly prove that they are the same. In the Chapman specimen, however, the height is more than half the length (0.57 the length, as compared with 0.45 for McCoy's shell), the beaks are a trifle farther forward, and the posterior sinus is slightly weaker.

The Chapman shell also bears a close similarity to the Rhenish *Tellinites elegans* (Maurer), figured as *Ctenodonta elegans* by Beushausen.[2] The German Eo-Devonian shell is flatter and proportionately higher than either *T. affinis* or *T. chapmani;* no mention is made in the text, nor is any indication given in the figure, of the subcentral constriction or sinus of the ventral margin.

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[1] McCoy, Frederick, in Sedgwick and McCoy, British Paleozoic rocks and fossils, p. 286, pl. 1*K*, fig. 31, 1852; Upper Ludlow of Benson Knot, Kendal, Westmoreland.

[2] Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 81, pl. 7, figs. 6, 7, 1895. Beushausen records the species from the Lower Coblenzian of Nellenkopfchen, in Rhenish Prussia.

TELLINITES CURTA sp. nov.

Plate XXV, figure 14.

Shell moderately large, broadly oval, nearly equilateral. Height 0.65 the length. Position of greatest height and greatest length and character of umbones, anterior end, ventral, posterior, and hinge margins, etc., as in *T. chapmani*. Moderately ventricose; broadly inflated below the umbones; point of greatest depth directly below the umbones, slightly above the midheight. Depth of the single valve very nearly equal to a third of the height. Subcentral sinus and posterior sinus essentially as in *T. chapmani*. The second or narrower sinus in *T. curta* is exceedingly faint. Its position is indicated by two obsolescent radial striæ or lines which may be discernible when orienting the specimen at varying angles to the light. A similar structure is noted in *T. chapmani*, and Beushausen [1] also records in *Tellinites elegans* (Maurer) two such "very delicate radial lines, becoming visible only with changing light." The occurrence of these delicate radial lines on the interior of the shell supports the theory associating the development of a posterior sinus in these Paleozoic taxodonts with a well-developed special internal organ, such as a posterior siphon or anal tube. Muscular scars, as in *T. chapmani*, not impressed. Shell thin, nearly papery.

Surface ornamentation as in *T. chapmani*, except that it is a trifle less strongly marked. Length 29.5 millimeters, height 19 millimeters, depth of the single right valve 5.75 millimeters.

Unfortunately only a single specimen each of *T. curta* and *T. chapmani* is known. These two specimens may possibly represent varieties or individual differences of one and the same species. *T. curta* is distinguishable from *T. chapmani* by its higher, less transversely elongated form.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59772.

TELLINITES (KOENENIA) GIBBOSA Goldfuss var. KAYSERI Beushausen.

Plate XIX, figures 3, 9, 11, 13, 15, 16; Plate XXV, figures 1, 3, 4, 5, 12.

var. CRASSA Beushausen.

Plate XXV, figure 8.

1834–1840. *Sanguinolaria gibbosa*. Goldfuss, Petrefactæ Germaniæ, vol. 2, p. 278, pl. 159, fig. 10 (figure bad; see Beushausen, 1895).
[Siegen] clay shales: Altenahr, Germany.

1850–1856. *Nucula unioniformis*. Sandberger, Versteinerungen des rheinischen Schichtensystems in Nassau, p. 277, pl. 29, fig. 1.
Lowest Coblenzian graywacke: Singhofen, Germany.

1884. *Palæoneilo neglecta*. Beushausen, Fauna des Oberharzer Spiriferensandsteins, etc., p. 77, pl. 4, fig. 22.
Spirifer sandstone (Coblenzian): Bocksberg, Harz Mountains, Germany.

1884. *Palæoneilo occulta*. Beushausen, idem, p. 78, pl. 4, fig. 25.
Spirifer sandstone (Coblenzian): Bocksberg, Harz Mountains, Germany.

1895. *Ctenodonta (Palæoneilo) crassa* (pars). Beushausen, Lamellibranchiaten des rheinischen Devon, p. 77, pl. 6, fig. 5 (not fig. 4).
Coblenz (Ems) quartzite: Rhens, Germany.

1895. *Ctenodonta (Palæoneilo) kayseri* (pars). Beushausen, idem, p. 82, pl. 19 (except fig. 18).
Lower Coblenzian: St. Johann a. Kyll, Germany.

1895. *Ctenodonta (Palæoneilo) gibbosa*. Beushausen, idem, p. 83, pl. 6, fig. 16.
Siegen graywacke: Saxler, near Gillenfeld, Siegen district, and Altenahr, Germany.

1895. *Ctenodonta (Palæoneilo) unioniformis*. Beushausen, idem, p. 84, pl. 6, figs. 10–15, except fig. 14.
Lower Coblenzian: St. Johann a. Kyll; Gemund, near Daun, in the Eifel; Nellenkopfchen; Singhofen, Germany.

1899. *Palæoneilo orbignyi*. Clarke, Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 8, figs. 14–17 (English ed., p. 74, 1900).
Devonian [Lower Coblenzian]: Rio Maecuru, Para, Brazil.

1902. *Ctenodonta (Palæoneilo) kayseri* and *unioniformis*. Drevermann, Palaeontographica, vol. 49, p. 87.
Lower Coblenzian: Oberstadtfeld, near Daun, in the Eifel, Germany.

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[1] Op. cit., p. 81.

1904. *Ctenodonta (Palæoneilo) gibbosa* (?). Drevermann, Palaeontographica, vol. 50, p. 243.
Siegen graywacke: Seifen, near Dierdorf, in the Westerwald, Germany.
cf. 1906. *Palæoneilo boyesei.* Schwarz, Albany (South Africa) Mus. Rec., vol. 1, pt. 4, p. 377, pl. 8, fig. 4.
[Lower Coblenzian] shale: Hottentots Kloof and Vitkomst, South Africa.
1907. *Paleoneilo circulus.* Clarke, New York State Mus. Bull. 107, p. 231, figs.
Lower Devonic: Presque Isle Stream, Chapman, Maine.

Ventricose, subquadrate to subovate shells, rather large for nuculoids. Equivalve, inequilateral. Proportion of height to length variable, between 7:10 and 8:10. Greatest height just back of the beaks; greatest length near the midheight, sometimes above, sometimes below. Umbones conspicuous, broad, protruding slightly above the hinge line; situated at the anterior two-sevenths to two-fifths; usually slightly prosogyrate to nearly vertical, occasionally strongly prosogyrate, especially when situated far forward. Anterior end equal to about three-fourths the total height, not quite as high as the posterior end, convexly rounded throughout, nearly horizontal for a short space in front of the beaks, subvertical for the greater part of the distance, and rounded into the ventral margin which is depressed convex to nearly straight. The portion of the shell in front of the umbones does not exceed one-fourth the total length. The ventral extremity is below the midlength, just back of the beaks. From this point the ventral margin is nearly or quite horizontal, ascending very little to the postventral extremity. Sometimes a very faint insinuation or straightening of the ventral margin occurs posterior to the middle. From the postventral extremity, the posterior margin in the lower half rises to the rear as far as the upper margin of the posterior sulcus. This portion of the margin is more or less concave near the middle, the concavity depending on the degree of development of the sulcus and being rather faint at best. The posterior extremity is a little above the sulcus at the middle of the posterior margin but below the midheight of the shell. From it the posterior margin ascends vertically, or very slightly forward, in a depressed-convex, nearly straight line to the hinge extremity. Occasionally there is a small constriction in the middle of this portion, but it is much smaller than the ventro-posterior insinuation. The hinge extremity is obtusely subangular or rounded. The length of the hinge line posterior to the beaks, which is equal to one-half to two-thirds the total length of the shell, generally nearer the former, is less than the height of the shell, varying from one-half to two-thirds the height, generally nearer the latter; rarely it nearly equals the height. The hinge line is straight or very depressed convex, usually slightly descending, frequently horizontal.

With regard to the convexity of the shell, the broad, gibbous, overarching umbones are very conspicuous. Below the umbones the body is inflated to different degrees in different shells, being nearly globular in some young individuals and always ventricose. The postumbonal ridge is rounded and extends at an angle of 30° or 40° from the vertical. The posterior sulcus is shallow and sometimes hardly discernible. It does not extend to the beaks. It is bounded above by a low, narrow ridge which, when definable at all, is broader, lower, and less conspicuous than the postumbonal ridge. Between this secondary low indistinct ridge and the hinge line there is frequently a very faint, narrow furrow or depression of the surface. The degree of development of the posterior sulci and ridges is exceedingly variable. The depth of an average single valve is equal to half or nearly half the height. The point of maximum depth is situated at the dorsal third of the height, and either on or in front of the postumbonal ridge, at the midlength or slightly in front.

Ligamental structure unknown. Apparently no cartilage pit. Dentition taxodontic. A few sparse teeth are developed in front of the umbones. Behind the umbones the number of teeth could not be distinctly counted, but there appear to be between 12 and 16, nearer the latter number. The teeth diminish in size toward the beaks. Muscular scars and pallial impression absent; not observed on any one of more than 50 specimens. Shell of moderate thickness; intimate structure not observed.

The surface ornamentation comprises tenuistriate lines of growth, occasionally crowded into low, obsolescent concentric ridges. No regular lamellose ornamentation developed. Very rarely on the body of the shell below the umbones exceedingly faint radial scratches or lines are discernible.

Mature shells have a length of 20 to 25 millimeters and a corresponding height of 14 to 18 or 20 millimeters; two large individuals were 28 millimeters long and 20 to 21 millimeters high.

The distinguishing characters of the fossils are the ventricosity; subquadrate outline; high but short anterior end; full, overarching umbones; hinge line horizontal or slightly declining; hinge extremity more or less definable; posterior margin vertical to retrorse in the upper half; ventro-posterior emargination; faint and variable posterior sulcus, bounded by two obsolescent rounded ridges; occasional development of a second very faint sulcus; absence of muscular impressions in finely preserved specimens.

Locality: Chapman sandstone, abundant 2 miles west of Presque Isle Stream and common at Presque Isle Stream, where the greater softness and finer grain of the sediments have permitted the specimens to become distorted in several directions. Some globular young individuals from locality 1099 J (Pl. XXV, fig. 8), representing one of the many variations of the species at this locality, are indistinguishable from "*Ctenodonta*" *crassa* Beushausen, from the German Coblenz quartzite. No specimen observed had the lamellose ornamentation of the typical forms of Goldfuss's and Sandberger's species.

U. S. National Museum, catalogue Nos. 59773, 59774, 59775.

Comparisons.—The variety *kayseri* Beushausen is distinguished from the typical form of *T. gibbosa* by the absence of lamellose markings, the surface lines of growth being tenuistriate. Beushausen retains Sandberger's species T. *unioniformis* as distinct from Goldfuss's *T. gibbosa*. *T. unioniformis* is supposed to be slightly lower and more transverse; to have the hinge line slightly more arcuate and reclining, and to have a deeper and narrower sulcus and less regular sculpture; both forms, however, are lamellose. A glance at Beushausen's figure will show that the supposed distinctions of the two forms intermingle and interchange. Furthermore, the great variability in the Chapman shells, as well as in the Rhenish shells, in the proportion of height to length, the direction of the hinge line, and the strength of the posterior sulcus affords convincing evidence that in spite of the lack of German fossils for study, the forms described as *T. unioniformis* and *T. gibbosa* represent a single species with lamellose concentric ornamentation. The Chapman varietal form is tenuistriate and seems indistinguishable from the Brazilian "*Palæoneilo*" *orbignyi* Clarke, of the Coblenzian fauna of Rio Maecuru. One of the small globular specimens from Maine is indistinguishable from "*Ctenodonta*" *crassa* Beushausen, and as the same form is also represented by Clarke[1] from Brazil, there can be little doubt that Beushausen's fossil is one of the forms of this variable and apparently long-ranging and widely distributed species of the lower half of the Eo-Devonian. The other synonyms given above are suggested by the occurrence of similar or approximately similar forms in the Maine collections, which close study shows to be evidently specimens of the variety originally defined by Beushausen.

The Chapman and Brazilian fossils, especially the former, closely approach *Tellinopsis subemarginata* Hall,[2] from the New York Hamilton, but they lack the anterior faint sulcus and ridge usually developed in Tellinopsis. In Hall's fossil also the beaks are more persistently central or directed vertically or backward, and it is a thinner shell. *Paleoneilo virginica* Hall [3] is a near ally, but is transversely more elongate and has the sculpture strengthened, becoming finely lamellose toward the postumbonal ridge and sulcus. *Paleoneilo perplana* Hall [4] is also similar to the Chapman fossils, but has less overarching umbones, and, like *P. virginica*, is transversely more elongate and has stronger ornamentation posteriorly. The Chapman fossils also resemble the figures of *Paleoneilo sulcata* Hartt and Rathbun,[5] but that species is much flatter, with beaks narrower, not inflated or overarching, situated farther forward, and more decidedly prosogyrate; the sulcus is more persistently and strongly developed; a few minor points of distinction might be added.

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[1] Clarke, J. M., Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 8, fig. 14, 1899.

[2] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 464, pl. 76, figs. 21-31, 1885.

[3] Idem, p. 340, pl. 93, fig. 14. From beds of Hamilton age, Patterson Creek, Va.

[4] Idem, p. 339, pl. L, figs. 15-22, pl. 93, fig. 12. The species is from the New York Hamilton.

[5] Hartt, C. F., and Rathbun, R., New York Lyceum Nat. Hist. Annals, vol. 11, p. 124, 1875. See also Clarke, J. M., op. cit., p. 75, pl. 8, fig. 13. The species is from the Hamilton fauna (Middle Devonian) of Erere, Para, Brazil. The comparisons made above are based on the three type specimens of Hartt and Rathbun preserved in the Cornell University collections.

Genus DITICHIA F. Sandberger, 1891.

The genus Ditichia was founded by F. Sandberger [1] on some Lower Coblenzian taxodontic shells which have two strongly developed muscular septa dividing the cavity of the valve into a narrow central compartment with a lateral chamber on each side. The types are from the Conde Valley, near Winnegen, in the Coblenz district. Sandberger erroneously identified his shells with a species from the Haupt quartzite of the Harz Mountains which had been described as *Leda mira* Beushausen,[2] which is a different shell. In the typical Coblenzian forms thick septal ridges extend on the umbonal side of the two muscular scars; these ridges reach nearly to the ventral margin, producing a characteristic tripartite appearance in casts and giving them, as suggested by Sandberger, the appearance of a large Beyrichia.

These typical forms, with their highly developed septa,[3] present an appearance so remarkable among lamellibranchs that they would seem to make up a valid genus. Beushausen,[4] however, has attempted to demonstrate that Sandberger's typical forms of Ditichia are merely the young of *Cucullella* (*Cleidophorus*) *elliptica* (Maurer), and that the posterior septum disappears with age and the anterior septum becomes sharp.

In the Chapman shells the septa do not attain the bizarre and extreme development shown in typical Ditichia, but the material shows that the variability in the septa is due not to advancing age in the individual but to difference in degree of development in different individuals. The septa are faint or absent in some young shells and highly developed in some of the largest specimens, and vice versa. It is interesting to note that similar septal structures, a fairly strong anterior septum and weaker posterior septum, occur in the Leda-like *Nuculana* (*Ditichia*) *securis* Clarke,[5] in the oval, nonsinuated *Cleidophorus elliptica* (Maurer), and in the emarginate *Paleoneilo mainensis* and similar forms. There is also a faint approach to a posterior septum in addition to the umbonal septum in some forms of *Adranaria securiformis* (Goldfuss).[6] The occurrence of these septate structures in such dissimilar forms tends to bear out Beushausen's suggestion that the character does not seem in itself to be of generic value. I doubt, however, whether Beushausen's explanation of the development of the septa as a juvenile character is correct. On the contrary, inferences drawn from analogous structures in other lamellibranchs and in brachiopods lead to the conclusion that the development of these septa is originally a senile character. If the name Ditichia is used as indicating a separate genus, it will have to be restricted to the typical forms, having both the anterior and posterior septa well developed and extending nearly to the ventral margin.

Genus PALEONEILO Hall, 1869.

PALEONEILO (DITICHIA) MAINENSIS Clarke.

Plate XIX, figures 10, 12, 19; Plate XXV, figures 6, 9, 11, 13.

1907. *Palæoneilo mainensis*. Clarke, New York State Mus. Bull. 107, p. 230, figs.
Lower Devonic: Presque Isle Stream, and in the burnt district 2 miles westward; Chapman Township, Maine.
cf. 1907. *Palæoneilo* (*Nuculites*) *folles*. Clarke, idem, p. 232, 2 figs.
Lower Devonic limestones: Dalhousie, New Brunswick.

Large, moderately convex shells of regularly ovate outline, tapering behind, the regularity of the outline slightly interrupted by a faint postventral constriction of the margin. Proportion of height to length varying from 74:100 in high shells to 65 or 67:100 in the commoner forms and to 60 or 61:100 in the transversely more elongated specimens. Greatest length at or slightly below the midheight; greatest height indefinitely at or slightly in advance of the midlength. Umbones are moderately broad, rarely central, usually situated between the middle and

[1] Sandberger, F., Bemerkungen über Ditichia, eine neue Nuculaceen-Gattung aus dem Unterdevon: Neues Jahrb., 1891, vol. 2, pp. 104–105.
[2] Beushausen, Louis, Beiträge zur Kenntniss der Oberharzer Spiriferensandsteins: Abh. geol. Specialkarte Preussen, vol. 6, pt. 1, p. 90, pl. 3, fig. 15, 1884.
[3] See Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 104, pl. 5, figs. 12 and 14, 1895.
[4] Idem, p. 105; K. preuss. geol. Landesanstalt Jahrb., 1891, p. 95.
[5] Clarke, J. M., Some new Devonic fossils: New York State Mus. Bull. 107, p. 233, figs., 1907.
[6] See Beushausen, Louis, Abh. geol. Specialkarte Preussen, vol. 6, pt. 1, pl. 6, fig. 1, 1884.

anterior third. They are slightly overarching; usually directed vertically, or nearly so, but often decidedly prosogyrate, especially when the beaks are farther forward. The anterior end includes one-third or more of the total length and five-sixths or more of the height of the shell. The anterior margin is convexly rounded in a symmetrical paraboloid arch. No lunule in front of the beaks. The forward extremity is just below the midheight of the shell. The anterior margin merges into the ventral margin in a broad curve. The ventral margin is usually bellied down; the ventral extremity is at the midlength, either directly under or, more frequently, very slightly behind the beaks. The ventral margin is symmetrically arched, except that the posterior third is constricted or faintly insinuated. The posterior margin is ill defined, owing to the convergence of the dorsal and ventral margins, and is symmetrically rounded, with the posterior extremity usually at the inferior one-third or two-fifths the height of the shell, rarely near the midheight. There is no definable hinge extremity; the dorsal edge declines rapidly from behind the beaks and merges into the narrow posterior end. The hinge line behind the beaks is very depressed convex, nearly straight. The valves are moderately ventricose. The umbones are prominent and incurved over the beaks. The body is full below the beaks and slopes so as to produce a deep anterior end and a less convex posterior end. The posterior half of the surface includes a broad, undefined, very shallow sinus or flattening, sometimes so little developed as to be almost or quite unrecognizable. Behind this the surface is again rather convex over the short distance to the postdorsal margins. The point of greatest depth of the shell is situated below the umbones, slightly in front when the umbones are prosogyrate, variably between the dorsal one-third and one-fourth the height. In full, uncompressed shells the depth of the single valve is two-fifths the height or frequently a little less. Ligamental structure unknown.

Clarke's lower figure shows, as is usual, no cartilage pit. The Maine specimens show no trace of an external ligament. However, they have one peculiar feature which is worthy of notice. Clean internal molds sometimes show a linear incision below the teeth extending back of the beaks nearly or quite to the posterior muscular scar. This may represent the sharp inner edge of the hinge plate or it may perhaps indicate an elongated narrow cartilage or internal ligament below the posterior hinge, such as exists in the recent taxodontic genus Glomus and its allies.[1]

Dentition taxodontic; five, six, or seven nuculoid teeth in front of the beaks and 20 or more teeth behind the beaks; of the latter those immediately behind or under the beak are minute and numerous. The teeth increase in size posteriorly and are V shaped, with the apices directed, as is usual, toward the umbones. The muscular scars, especially the anterior one, are made conspicuous by a blunt septal thickening or deposition of shell on the umbonal side of each scar. The anterior septal ridge is the stronger and more persistently developed, occurs immediately in front of the beaks, and extends directly downward or, more often, a little forward from the vertical. It is arched and tapers downward, extending less than halfway down, usually decidedly less than halfway. Except for this ridge or septum the muscular scars are only faintly impressed or defined. The posterior ridge is blunter and fainter than the anterior ridge, occurs less than halfway from the beaks to the posterior end of the shell, and is directed downward and backward. Frequently it is not definable. Pallial line faintly impressed anteriorly; not at all impressed in clean molds posteriorly. Hence it is impossible to state whether or not the shell was sinupalliate. Shell thin, except for the thickening on the umbonal side of the muscular scar.

In surface ornamentation the shells vary from a few that are nearly smooth to those that exhibit tenuous striæ of growth. The largest specimen had a length of 32 millimeters and a height of 21 millimeters. Ordinary mature specimens have a length of 24 to 29 millimeters and a proportionate height. The smallest specimen observed was 7 millimeters high and 11 millimeters long.

[1] See Verrill, A. E., and Bush, K. J., Revision of the genera of Ledidæ and Nuculidæ of the Atlantic coast of the United States: Am. Jour. Sci., 4th ser., vol. 3, pp. 53, 60, figs. 1, 2, 1897.

The distinguishing features of the species are the rounded ovoid outline tapering behind; height generally two-thirds the length; umbones prominent, variably between subcentral and subvertical to the anterior third and prosogyrate; anterior end large and well developed; vertical margin arched and symmetrical except for a rather broad, very faint insinuation or constriction postventrically; posteriorly converging ventral and dorsal margins; moderate ventricosity; very faintly developed posterior sinus, which is occasionally hardly discernible; strong septal ridges on the umbonal side of the scars, stronger and more persistent on the anterior scar, sometimes obsolescent on the posterior scar; septa thick, blunt, and extending less than half the height; and tenuistriate surface.

Locality: Chapman sandstone, Presque Isle Stream and 2 miles west of Presque Isle Stream (localities 1099 A and 1099 J) and Edmunds Hill (locality 1099 C′), Chapman Township, Aroostook County, Maine.

Two forms of the species occur, both at Presque Isle Stream (1099 A) and in the region west of Presque Isle Stream (1099 J). One form has the umbones subcentral and vertical, the sinus extremely faint, and the muscular septa less well developed. In the other form the umbones are more decidedly prosogyrate and situated farther forward, and the septa are more strongly developed. These characters, however, interchange, so that it has been considered advisable to unite the two forms in one species. *Paleoneilo* (*Nuculites*) *folles* Clarke from New Brunswick is a probable synonym, conforming with those Chapman specimens which have the umbones forward and prosogyrate.

U. S. National Museum, catalogue Nos. 59776, 59777, 59778.

Comparisons.—Among the ovate, smooth, emarginate shells with well-developed septa which approach *Paleoneilo* (*Ditichia*) *mainensis* may be mentioned *Paleoneilo crassa* (Beushausen's *Ctenodonta crassa*),[1] which is, however, less tapering posteriorly and higher anteriorly and in which the teeth in front of the hinge are more numerous. *Paleoneilo prisca* (Goldfuss) as figured by Beushausen [2] is also similar but is a narrower species with the beaks situated farther forward. *Paleoneilo intermedia* (Beushausen's *Cucullella intermedia*) [3] and *Paleoneilo speciosa* Beushausen,[4] especially the latter, are also closely similar but vertically narrower species.

PALEONEILO MAINENSIS Clarke var. UMBONATA var. nov.

Plate XXV, figures 16, 20.

The collections from Presque Isle Stream (locality 1099 A) contain, with *Paleoneilo* (*Ditichia*) *mainensis*, two specimens which exhibit the normal variability in outline of *P. mainensis* but which differ from all the normal forms of the species in having the umbones much more highly developed, situated in advance of the anterior third, and directed decidedly prosogyrate. Some of the variability of the two specimens, however, may be due to distortion by pressure. In the ventricosity of the shells, arching umbones, large anterior end, subsymmetrically arched ventral margin, tapering posterior, faint post-ventral sinus, and ornamentation var. *umbonata* agrees with the usual forms of the species. The anterior septal ridge is moderately developed, short, and blunt, as usual; the posterior septal ridge in the two specimens at hand is not discernible. The high umbones, situated farther forward and strongly prosogyrate, will readily distinguish the present variety.

Locality: Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59779.

Comparisons.—Some of the forms of *Paleoneilo mainensis* approach the well-known American *Paleoneilo constricta* Conrad [5] but differ in having the anterior muscular septum persistently developed and in being more inflated; the Maine shells also lack the change in ornamentation posteriorly which characterizes the typical forms of *P. constricta*.

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1 Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 77 pars, pl. 6, fig. 4 (not fig. 5, which is the young of the *Tellinites* (*Koenenia*) *kayseri* type), 1895; Coblenz or Ems quartzite of Rhens, Prussia.

2 Beushausen, Louis, Beiträge zur Kenntniss der Oberharzer Spiriferensandsteins: Abh. geol. Specialkarte Preussen, vol. 6, pt. 1, p. 79, pl. 3, fig. 16, 1884; as *Ctenodonta prisca*.

3 Beushausen, Louis, op. cit. (1895), pl. 5, fig. 16.

4 Idem, pl. 6, fig. 8.

5 See Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 333, pl. 48, figs. 1-16; pl. 51, fig. 17, 1885.

Genus LEDA Schumacher, 1817.

Although the existence of taxodontic shells of characteristic lediform outline as low down in the Paleozoic section as the Ordovician has long been known, there has been some doubt as to whether these shells really exhibit the pallial sinus and cartilage pit characteristic of Leda Schumacher, or, as some have chosen to call it, the genus Nuculana.[1] The Ordovician-Devonian genus Adranaria includes taxodontic lediform shells lacking both cartilage pit and pallial sinus but is easily distinguished by having a low blunt radial septum or ridge on the interior of the shell. Such lediform taxodonts can, because of their umbonal ridge or septum, easily be placed where they belong, near Nuculites and Ctenodonta; but in other Paleozoic shells resembling Leda even in the presence of a cartilage pit there is no trace of a pallial sinus. Goodchild[2] has called attention to some Carboniferous species of so-called "Leda" which distinctly lack the pallial sinus of the real Leda (Nuculana), and his observation as to the absence of pallial sinus has been corroborated by Hind;[3] in these shells a cartilage pit occurs. Hall[4] showed a cartilage pit in the Mississippian *Leda pandoriformis*, in which also the pallial line was not observed. Goodchild and Hind have demonstrated the cartilage pit in the English Carboniferous "Ledas," which lack the pallial sinus. However, the diversity of genera based on the soft animal parts, as in Arca where many different generic types have the same external form of shell, should lead to hesitation before asserting actual identity of these primitive fossil Ledas with the recent Leda. It is apparent, from the little now known of the forms living in Paleozoic time as interpreted through the fossils, that even then there was at least as much diversification among these forms as exists among their descendants of the present day.

The occurrence of a callosity (?) on the interior of these Paleozoic "Ledas," is of interest. In the more recent and typical Leda the body of the shell below the umbones is full and inflated; but Hind has called attention to the fact that many Carboniferous species of Leda display a persistent thickening of the shell on the interior, or a flattening or faint depression on internal molds below the umbones. This character, indeed, is present in most though apparently not all Paleozoic "Ledas" and may have some function similar to that of the umbonal ridge or septum of the lediform Adranaria. This subumbonal depression in internal molds is well defined in the Chapman *Leda* (?) *harrisi*.

The Chapman specimens, unfortunately, do not indicate whether or not the pallial sinus and cartilage pit were present. Hence, the reference of the fossils to Leda and the Ledidæ may be open to some question, in spite of the pronounced and typical lediform expression.

LEDA HARRISI sp. nov.

Plate XXV, figures 15, 19.

Lediform shells of small to medium size, length $1\frac{1}{2}$ times the height. Umbones vertical, or slightly directed backward (opisthogyrate), situated at the anterior two-fifths of the length depressed to the hinge line. Anterior margin symmetrically arched, paraboloid, a trifle deeper than a semicircle. Forward extremity at the midheight. Ventral margin rounded, ascending only slightly toward the rear, nonemarginate; ventral extremity directly below the umbo. Posterior end fairly broad for Leda, elliptically rounded, horizontal. Posterior hinge extremity not definable. Hinge margin back of the beaks nearly horizontal in the middle, ascending strongly toward and immediately behind the beaks; nowhere quite horizontal or descending from the posterior extremity forward. Convexity depressed. A broad depression or flattening on internal molds descends from the umbones at an angle of less than 15° backward from the vertical. This is most conspicuous near the midheight. The anterior end is convexly rounded, of rather subdued convexity. Posterior to the infraumbonal flattening, the surface again becomes convex in a rounded posterior ridge, which is discernible for one-half the distance

[1] Nuculana Link, 1807, has priority over Leda Schumacher, 1817. According to Dall, however, the Nuculana of Link is a synonym of Nucula Lamarck.

[2] Goodchild, J. G., Notes on Carboniferous lamellibranchs (Ctenodonta and Nucula): Roy. Phys. Soc. Edinburgh Proc., vol. 11, p. 244, 1892.

[3] Hind, Wheelton, A monograph of the British Carboniferous Lamellibranchiata; pt. 2, Mytilidæ, Arcidæ, Nuculæ: London Palæontogr. Soc. Pub., vol. 51, p. 176, 1897.

[4] Paleontology of New York, vol. 5, pt. 1, p. 332, pl. 47, fig. 50, 1885.

from the beaks. This ridge bears the point of greatest depth of the shell, at the midlength, a little below the dorsal margin and on a line to the beaks at an angle of approximately 40° from the vertical. There is no persistent umbonal ridge nor carina. The depth of the single valve is equal to one-fourth the height or less.

Ligamental structure and dentition unknown. Muscular scars of approximately equal size, the posterior scar possibly slightly the larger. Anterior scar distant from the beaks, situated at the forward extremity of the shell; fairly well impressed. Posterior scar situated about midway between the beaks and posterior extremity. No accessory scars observed on our two specimens. Pallial line not impressed. Shell apparently thin.

Surface apparently smooth or with faint tenuistriate lines of growth. Internal molds quite smooth. The type is 7.6 millimeters long and 5 millimeters high; the depth approximately one-fourth the height for the single valve. A larger specimen is much flatter; it is 14.9 millimeters long and 9 millimeters high.

The distinguishing features of the species are the broad posterior end; the length of the shell, 1½ times the height; beaks at the anterior two-fifths; ventral extremity directly below the umbones; the infraumbonal flattening or depression of the internal mold; and the moderate convexity.

Locality: Chapman sandstone, 2 miles west of Presque Isle Stream (locality 1099 J), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59781.

Comparisons.—The species is somewhat similar to the Hercynian Leda described and figured by Beushausen [1] as *Nucula krachtæ* Roemer but differs in having the ventral extremity directly below the umbones and the umbones farther back; moreover, *L. krachtæ* is a gibbous shell and appears to lack the infraumbonal depression of *Leda harrisi.*

Leda minuta sp. nov.

Plate XXVI, figure 1.

Shell minute, ovate triangular; length one-half greater than the height. Anterior portion a broadly rounded parabola, deeper than a semicircle; posterior portion abruptly narrowed, rounded at the extremity. Postdorsal margin concave, nearly horizontal in the hinder portion, but nowhere quite horizontal nor ascending from the beak to the posterior margin. Beaks broadly rounded, arching over the cardinal line; vertical or opisthogyrate. Dimensions, 3 by 2 millimeters.

The internal mold is smooth, being devoid of ornamentation and muscular impressions.

Locality: Chapman sandstone, Presque Isle Stream (locality 1099 A), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59782.

Comparisons.—*Leda minuta* is readily distinguished from *Leda harrisi,* the other Leda of the Chapman sandstone, by its more minute size and more gibbous outline; it is sharper posteriorly and more bellied down ventrally. Finally, *Leda minuta* lacks the more conspicuous median depression of *Leda harrisi.*

Leda minuta resembles *Leda brevirostris* Hall,[2] from the Hamilton formation of New York, but it attains only half the size, and its front margin is more deeply rounded.

Family NUCULIDÆ Adams.

Several Nucula-like shells of the Chapman fauna possess characters which place them in an intermediate position between Dall's family ?Ctenodonta and Adams's family embracing the later and recent Nuculidæ. To these forms I apply the name Nuculoidea, classing them as a subgeneric group of the genus Nucula Lamarck to give them a legitimate taxonomic rank. Evolutionally these Paleozoic Nuculas may more properly be considered as the ancestral stock out of which Nucula and perhaps all the true Nuculidæ have arisen.

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[1] Beushausen, Louis, Beiträge zur Kenntniss des Oberharzer Spirifensandsteins und seiner Fauna: Abh. geol. Specialkarte Preussen, vol. 6, pt. 1, pl. 4, figs. 7, 12, 1884.

[2] Hall, James, Paleontology of New York, vol. 5, pt. 1, Lamellibranchiata, pl. 47, fig. 40, 1885.

Genus NUCULA Lamarck.

Subgenus NUCULOIDEA subgen. nov.

The distinguishing marks of Nuculoidea are a distinct cartilage pit, as in *Ctenodonta albertina* Ulrich, of the Upper Ordovician, and a nonpectinated ventral margin, which differentiates them from the true Nuculas of the Cenozoic. The species *Nucula opima* Hall = *N. randalli* Hall and authors, of the Hamilton, is taken as the type of the group.

Cucullea opima Hall was described and illustrated in 1843.[1] In 1870[2] Hall described *Nucula randalli* (without figures) and declared *Cucullea opima* Hall, 1843, to be identical with *Nucula lirata* Conrad, 1842. In 1885[3] Hall stated that after reexamining the original of *Cucullea opima* he unhesitatingly regarded *Nucula opima* Hall, 1843, as identical with *Nucula randalli* Hall, 1870. *N. opima* has priority and according to the rules of nomenclature must be retained.

With regard to the supposed identity of *N. lirata* Conrad and *N. opima* Hall, it is a fact that the great majority of specimens as ordinarily preserved are not distinguishable specifically, the finer ornamentation being only rarely discernible and the convexity and outline being variable both originally and as a result of crushing.

Two internal molds (No. 201 A) in the Jewett collection at Cornell University, labeled "*Nucula opima* Hall, from the Hamilton at Delphi, N. Y.," show distinctly a well-developed cartilage pit under the umbones. A similar specimen with cartilage pit, from beds of Hamilton age at Cumberland, Md., is illustrated by Hall,[4] and the very closely similar *Nucula lirata* Conrad, from the Hamilton, is also known to have a cartilage pit.[5] The Mississippian *Nucula houghtoni* Stevens,[6] from the Mississippian of Ohio and beds of corresponding age in Michigan, is known to have a cartilage pit. More recently nuculoid shells possessing a cartilage pit have been found in the Eo-Devonian of Germany, in several Taunusian and Coblenzian species.[7] They occur also still lower in the geologic column, in the Ordovician, for E. O. Ulrich[8] has shown that although in the Trenton species of his "group of '*Ctenodonta*' *levata* (Hall)" (= the "group of '*Ctenodonta*' *socialis* Ulrich," or subgroup under Myoplusia, described on p. 162) there is no cartilage pit, a more or less undefined pit is developed in some Upper Ordovician forms, and finally "*Ctenodonta*" *albertina* Ulrich[9] has a good cartilage pit and is congeneric with *Nucula opima* Hall.

The Paleozoic nuculoid shells mentioned above agree with Nucula in general outline, configuration, pearly shell, and taxodontic hinge, as well as in having a cartilage pit. Apparently these shells conform, so far as these characters indicate, with typical Nucula. However, one of the characters commonly associated with Nucula is the denticulate ventral margin on the interior of the shell. This denticulate or pectinate margin is developed in all the Recent and Tertiary species of Nucula examined by me and Mr. Breger, comprising several dozen species, as well as in several Cretaceous forms. On the other hand, the Paleozoic shells otherwise identifiable with Nucula lack the denticulations on the interior along the ventral margin. We have not discovered a single specimen from the Ordovician, Silurian, Devonian, or Mississippian which possesses the denticulate ventral margin, except the little *Nucula shumardiana* Hall, from the Mississippian Spergen limestone of Indiana. Doubtful appearances of a crenulate margin in this tiny species have been observed on some specimens from Spergen Hill. This species appears, however, even externally, to be more nearly related to the recent *Nucula pernula* than to the other Paleozoic Nuculas. The persistent absence of the denticulate ventral margin in the early and frequently large Nuculas and its persistent development in the Recent Nuculas furnish a ready and easy distinction. The nondenticulate and earlier form is

[1] Hall, James, Geology of New York, Rept. Fourth Dist., p. 197, fig. 78, No. 3, 1843.

[2] Preliminary Notice of the Lamellibranchiata, No. 2, p. 3, 1870.

[3] Paleontology of New York, vol. 5, pt. 1, p. 315, 1885.

[4] Idem, pl. 45, fig. 27.

[5] Idem, fig. 25.

[6] Idem, fig. 31 and p. 324.

[7] Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, pl. 4, figs. 9 (*N. fornicata*), 17 (*N. grandæva*), 19 (*N. aquisgranensis*), 20 (*N. krachtæ*), etc., 1895.

[8] Ulrich, E. O., The Lower Silurian Lamellibranchiata of Minnesota: Geology of Minnesota, vol. 3, pt. 2, Paleontology, p. 581, 1894.

[9] Idem, p. 598, pl. 42, figs. 76–82.

here designated Nuculoidea, from its resemblance to Nucula. Some of the Triassic and Jurassic Nuculæ may possibly belong in the same group.

In the type species of Nuculoidea the accessory muscular scars are well developed. In addition to the pedal retractory muscles, situated one above the anterior occlusor scar and one over the posterior scar, there are usually discernible in the antero-umbonal region three minute muscular impressions, the strongest one hindmost; in well-preserved specimens a fourth minute and strong muscular scar is situated at the tip of the umbo. Hall figured, apparently, still a fifth minute scar between the anterior pedal retractor and foremost umbonal scars. These five represent the full quota of "umbonal scars," but usually only three are visible. From the position of these scars in *Nuculoidea randalli*, *N. lirata*, and other species of Nuculoidea, I had originally regarded the larger end of the shell bearing these scars as the posterior end, in which case the beaks would have been (as is usual in Nucula) directed backward. Examination of the Cretaceous *Nucula percrassa* Conrad, however, led to the belief that in this shell the beaks were directed backward and that the large end was the anterior end, as in normal Nucula; therefore, the umbonal scars, being situated on this large rounded end, were necessarily anterior. This view as to the antero-umbonal position of the umbonal scars is supported and corroborated by the Devonian *Paleoneilo constricta* (Conrad), where the emarginate end is practically known to be the posterior end and where the umbonal scars are situated in the narrower, anterior end. It may be regarded as established, therefore, that the umbonal scars are always antero-umbonal; and this feature affords another means of distinguishing the anterior from the posterior end in these Paleozoic shells. Such umbonal scars are present in several species of Nuculoidea and in many more species which appear to belong to Nuculoidea; they are absent in modern Nuculas. This would seem, at first sight, to be another distinction between Nucula and Nuculoidea, were it not that similar scars are discernible in *Nucula percrassa* Conrad, from the Cretaceous Ripley formation,[1] which has the denticulate margin of the real Nucula. Similar umbonal scars are also present in some forms of Paleoneilo, in Koenenia, and in the group of *Nuculites oblongus*, and are exceedingly well developed and specialized in the Barrandean species erected by Neumayr into the genus Myoplusia. The occurrence of similar scars in these diverse taxodontic groups suggests the belief that they are not of generic value.

The species which will probably fall under Nuculoidea may be divided into three groups, as follows:

Group of *Nuculoïdea opima* (Hall). Umbones twisted to a vertical position or actually faintly prosogyrate; the anterior end usually longer and semilunulate under the beaks.

Group of *Nuculoidea aquisgranensis* (Beushausen). Umbones opisthogyrate; anterior end convexly rounded and usually larger; posterior outline semilunuliferous. This group includes shells having the common cordate, ovate, or veneriform Nucula expression.

Group of *Nuculoidea* (?) *niotica* (Hall). Umbones opisthogyrate; posterior margin truncate, nearly vertical; anterior margin also nearly straight, producing a characteristic vertically triangular outline.

Representatives of all three groups appear in the Chapman sandstone. *Nuculoidea bellatula* sp. nov. belongs to the group of *N. opima*. *N. trigonale* is related to the triangular Nuculoideas of the third group. The group of *N. aquisgranensis* includes *N. cordata* sp. nov. and Nuculoidea cf. *N. aquisgranensis*.

Nuculoidea bellatula sp. nov.

Plate XIX, figure 4.

Small triangular shells, astartiform; height nearly equal to or slightly greater than the length. Umbones situated typically back of the midheight, and variably directed forward or nearly vertical. The posterior (?) end (as determined from analogy with *Nucula* (*Nuculoidea*) *fornicata* Goldfuss, *N.* (*N.*) *opima* Hall, etc.) is high but rather short; the posterior margin descends from the umbones and forms the longest margin of the shell; the hindmost extremity is usually below

[1] Jewett collection, Cornell University, No. 7509 (original number 202). From Columbus, Miss.

the midheight. The ventral margin is deeper but short; together with the anteroventral and posteroventral portions it includes approximately a semicircle. The ventral extremity is near the middle. The anterior (?) margin is faintly concave in front of the beaks. Convexity moderate. Surface smoothly rounded; umbones depressed to the hinge line. Greatest convexity below the umbones and above the midheight. Depth of the single valve equal to one-fourth the height or less. Ligament, dentition, and muscular scars unknown. The sculpture casts show fine regular concentric lines of growth, which are fairly conspicuous over the middle of the body and die out anteriorly and posteriorly. In the type there are 9 or 10 lines in the space of 3 millimeters at about 5 millimeters below the beak. There also appear in the typical forms two or three distant varicose striæ of growth. The type has a height of 10 millimeters and a width of 9.5 millimeters. Another specimen is 10.5 millimeters high and 10 millimeters broad.

The distinguishing features of this fossil are the height equal to the length, or greater; short and high posterior end, convexly rounded; umbones prosogyrate to subvertical; anterior margin concave; ventral margin semicircular; moderate convexity; fine bellistriate lines of growth with a couple of varicose striæ of rest.

Locality: Chapman sandstone, west side of Edmunds Hill (locality 1099 M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59783.

Comparisons.—*Nuculoidea bellatula* is closely similar to *Nucula* [*Nuculoidea*] *lodanensis* Beushausen,[1] from the Upper Coblenzian of Rhenish Prussia, but the latter is a trifle wider and has a shallower ventral margin and its ornamentation is not bellistriate. In ornamentation *N. bellatula* is similar to *Nucula* [*Nuculoidea*] *fornicata* Goldfuss, *N.* [*Nuculoidea*] *sandbergeri* Beushausen, *N.* [*Nuculoidea*] *pelmensis* Beushausen as figured by Beushausen,[1] and *N.* [*Nuculoidea*] *bellistriata* Conrad,[2] but these species have a different outline. *N. fornicata* Goldfuss, however, approaches it closely but is less elongated vertically. *Tellinomya* [*? Nuculoidea*] *socialis* Foerste[3] (not *Ctenodonta socialis* Ulrich), from what has been called the Clinton formation in Ohio, is approximately similar to *Nuculoidea bellatula* in outline and convexity, but is not quite so high vertically.

NUCULOIDEA CORDATA sp. nov.

Plate XIX, figure 6.

Shell small, obliquely cordate; height nearly equal to the length; greatest length, 8.3 millimeters, is across about the inferior fourth; height from beak to middle of ventral extremity equal to about seven-eighths the length, or 7.3 millimeters. Beaks only slightly if at all behind the middle, directed posteriorly, arching slightly beyond the hinge line. The anterior margin is gently convex throughout, nonlunulate, and extends forward and downward at an angle between 30° and 45° to the anteroventral extremity, where it rounds into the ventral margin. The ventral margin is broad and shallow, and its lowest point is at the midlength. The posterior outline of the shell is convex below the umbones and also convex distally, but concave in the middle, thus producing a heart-shaped outline with the anteroventral end of the shell considered as apex. This heart-shaped outline is a little unsymmetrical, the postventral lobe being slightly more protuberant than the postdorsal. The shell is of moderate convexity. The umbones are not particularly conspicuous. The surface is evenly rounded, except for a faint appearance of a narrow truncated strip below the beaks posteriorly, and a steepened slope along the anterior margin. The point of greatest depth is at the midlength, a trifle above the midheight and slightly in advance of the beaks. The depth of the single valve does not attain a fourth the height. Hinge features and muscular scars unknown.

The sculpture casts show regular, even, "bellastriate" lines of growth, much finer than in *L. bellatula* and upon close examination just visible to the naked eye. About 10 or 11 of

[1] Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 48, pl. 4, figs. 6, 7, 1895.

[2] Paleontology of New York, vol. 5, pt. 1, pl. 46, figs. 1–9, 1885: "Corniferous" limestone of the Ohio and Indiana region.

[3] Foerste, A. F., Fossils of the Clinton group in Ohio and Indiana: Geology of Ohio, vol. 7, pt. 2, p. 563, pl. 37, fig. 12, 1895.

these fine raised lines may be counted in a width of 2 millimeters, 5 millimeters from the beak. Two or three distant obscure varices, or impressed striæ of rest, are also discernible.

The distinguishing features of this fossil are the gently rounded anterior (?) margin; the concave posterior (?) margin; broad, shallow ventral margin; high form with height nearly equal to the length; moderate convexity; and very fine bellistriate surface markings.

Locality: Chapman sandstone, loose on Edmunds Hill (locality 1099 C′), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59784.

Comparisons.—This species is similar in size and high trigonal outline to *Nuculoidea trigonale*, also found on Edmunds Hill, but is easily distinguished by having a convex anterior margin and concave posterior margin instead of both margins straight. *Nuculoidea cordata* resembles *Ledopsis perobliqua* Beushausen [1] in the high trigonal outline and general outline of the margins, but in the German species the posterior or concave outline is vertical and the beaks are farther posterior. *Nucula* (*Nuculoidea*) *varicosa* Hall,[2] another member of the group of *Nuculoidea aquisgranensis*, has the high outline of *N. cordata*, but differs in the greater size and stronger convexity; moreover, like *Ledopsis perobliqua* Beushausen, it has the beaks farther back. The remaining and typical forms of the group of *Nuculoidea aquisgranensis* are lower, more transverse shells.

NUCULOIDEA cf. N. AQUISGRANENSIS (Beushausen).

Plate XIX, figure 7.

cf. 1895. Nucula n. sp. aff. *N. aquisgranensis*. Beushausen, Die Lamellibranchiaten des rheinischen Devon, p. 56, pl. 4, fig. 16.

Lower (?) Coblenzian: Laubach Valley, Prussia.

cf. 1895. *Nucula aquisgranensis*. Beushausen, idem, p. 56, pl. 4, fig. 25.

Stringocephalus limestone (Meso-Devonian): Breiniger Mountain, near Aachen, Germany.

A species very close to *Nuculoidea aquisgranensis* (Beushausen) is represented in the Chapman fauna by a single specimen, of which, unfortunately, the umbonal and dorsal region is broken away. The specimen represents a small left (?) valve, 10 millimeters long and probably about 7.5 millimeters high, of veneriform outline, like Beushausen's *N. aquisgranensis* and Hall's *N. diffidens*, especially the former. The muscular scars are preserved; that at the larger (anterior) end is slightly the larger. The pallial line is simple. The lines of growth are strongly marked but not quite bellistriate. The specimen is moderately convex.

Locality: Chapman sandstone, west side of Edmunds Hill (locality 1099 M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59785.

NUCULOIDEA TRIGONALE sp. nov.

Plate XIX, figure 8.

Outline subvertical, triangular, with the height a little less than the length. The greatest length, 8.3 millimeters, is across the postventral and anteroventral extremities near the base of the shell; the height, from beak to middle of ventral margin, is 7 millimeters. The beaks are depressed to the hinge line, inconspicuous, narrow, and directed posteriorly (?). The anterior margin is straight from the beaks to the antero-ventral extremity, and is directed at an angle of 45° with the vertical; it is equal in length to the height of the shell. The posterior margin is also straight to the postventral extremity; it is nearly as long as the anterior margin and makes with the latter an angle of 80°. The ventral margin is symmetrically arched, with the lowest point at the midlength. Surface evenly rounded, except that along the upper posterior margin the surface is truncate. The shell is of moderate convexity, the depth of the single valve equal to less than one-fourth the height. The point of greatest depth is slightly

[1] Beushausen, Louis, Beiträge zur Kenntniss des Oberharzer Spiriferensandsteins: Abh. geol. Specialkarte Preussen, vol. 6, pt. 1, p. 93, pl. 6, fig. 18, 1884.

[2] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 319, pl. 46, figs. 12-23; pl. 93, fig. 4, 1885; Hamilton group of New York.

above and behind the middle. The umbones are depressed to the hinge line. Hinge features unknown. Muscular scars not impressed. The sculpture casts show very fine "subbellistriate" lines of growth, hardly visible to the naked eye and much fainter than in *N. bellatula*. As in that species, these fine lines are interrupted by a couple of distinct, coarse striæ or varices of rest. The type is 8.3 millimeters long and 7 millimeters high. Another imperfect specimen is of about the same size.

Locality: Chapman sandstone, west side of Edmunds Hill (locality 1099 M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59786.

Comparisons.—This species agrees in outline, ornamentation, and depressed convexity with *Nuculoidea* (?) *putilla* (Clarke),[1] from the Silurian of the Rio Trombetas, Brazil; but the Brazilian and Maine shells have the greatest depth on respectively opposite sides of the beak. The "small central, subtriangular tooth and socket" in the hinge on the Brazilian internal molds, as described and figured by Clarke, may possibly represent the cartilage pit of Nucula and Nuculoidea. An undescribed species of Nuculoidea of similar triangular outline, from the Hamilton formation at East Berne, Albany County, N. Y., is more globular or inflated and has slight differences in the details of outline. *Nuculoidea trigonale* also recalls in general appearance *Paleoneilo brevicula* Clarke,[2] from the higher Portage formation (Neo-Devonian) of western New York; but Clarke's species has the postventral emargination characteristic of Paleoneilo. *Ledopsis trigona* Beushausen [3] has the characteristic Nuculoidea outline. It is distinguished from *N. trigonale* by being more gibbous and having the beaks more nearly central.

Superfamily PTERIACEA Dall.

Family PTERINEIDÆ Dall.

Genus PTERINEA Goldfuss and allied genera.

The difficulties in nomenclature encountered in attempting to classify the fossils of the Chapman fauna falling under the general definition of Pterinea were so complex that it was found necessary to revise the original conception of the genus and to redistribute the original species included by Goldfuss under the name, erecting new genera for the distribution of well-known species which differ from the true Pterinea.[4] In this revision the first species mentioned by Goldfuss, *Pterinea lævis*, was retained as the type of the genus Pterinea Goldfuss s. str., and the following diagnosis of characters was formulated:

1. Hinge line long.
2. Valves equal in circumference but unequal in convexity; the left valve always convex, the right valve in earlier stages of growth convex, but less so than the left, becoming flat or concave (resupinate) at maturity.
3. Ears well developed, more or less distinctly differentiated from the body of the shell, reaching to or in front of the anterior edge of the body of the shell.
4. Wings more or less distinctly differentiated from the body, flattened, reaching posteriorly as far as the extreme posterior margin of the shell.
5. Body of the shell with its longer axis produced ventrally at a considerable angle from the hinge line.
6. Posterior muscular scar distinct, large, and more or less sharply impressed in the shell wall.
7. Anterior muscular scars small and generally strongly impressed, situated on the ear, not body, of the shell.
8. Ligamental area well defined and longitudinally striate.
9. Posterior lateral teeth (or tooth) distinct, elongate, and situated at or near the junction of wing with the body of the shell.
10. Anterior cardinal teeth distinct, short, separated from the lateral teeth, and inclined at large angle from hinge line.
11. Surface smooth, with concentric growth lines and radial lines or ribs.

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1 Clarke, J. M., The Silurian fauna of the Rio Trombetas: Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 2, figs. 10, 11, 1899 (author's English ed., p. 16, 1900); described as *Anodontopsis* or *Sluzka putilla*.

2 Clarke, J. M., The Naples fauna in western New York: New York State Mus. Mem. 6, pt. 2, p. 425, pl. 15, fig. 16, 1904.

3 Beushausen, Louis, Beiträge zur Kenntniss der Oberharzer Spiriferensandsteins und seiner Fauna: Abh. geol. Specialkarte Preussen, vol. 6, pt. 1, p. 93, pl. 4, fig. 11, 1884.

4 Williams, H. S., On the revision of the mollusk genus Pterinea Goldfuss: U. S. Nat. Mus. Proc., vol. 34, pp. 83, 90, 1908.

The type species of the genus, *Pterinea lævis* Goldfuss, was found in the Coblenzian at Ems, Germany. The Ordovician species, *Pterinea demissa* Conrad and *Avicula ampliata* Phillips, seem to belong to the genus Pterinea as emended. These shells resemble Leiopteria Hall,[1] but that genus has the right valve convex throughout life, though less so than the left, and has the ligament thin and nonstriated, or with only a single groove (canaliculate). Pterinea as restricted also resembles more or less closely Leptodesma Hall and Pteronites McCoy, but these genera are edentulous, or have a single posterior lateral tooth close under the ligament and not oblique to the hinge. Pteronitella Billings is also smooth, like Pterinea s. str.; but, like Leiopteria, it is biconvex and with different dentition.

The genus Micropteria Frech [2] was proposed for a subdivision of Goldfuss's genus, which differs from *Pterinea lævis* and Pterinea s. str. in having the left valve more deeply inflated and in having a less definable anterior ear. *Pterinea ventricosa* Goldfuss is the genotype of Micropteria Frech. In ornamentation, dentition, convexity, etc., Micropteria conforms with Pterinea.

The radially ornamented shells which have hitherto been confounded with Goldfuss's genus Pterinea have been distributed for the most part among Tolmaia Williams, Follmannella Williams, Actinopterella Williams, and Cornellites Williams.[3]

The genus Tolmaia Williams was proposed and defined to include finely radiate forms like *Pterinea lineata* Goldfuss; it corresponds to Frech's "gruppe der *Pterinea lineata*." In erecting the genus, Frech's original definition was closely followed.

In the "gruppe der *Pterinea ventricosa*" Frech included a form to which he gave the name *P. ostreiformis*. A more distinctly ornamented related shell is represented by the species *Pterinea mainensis* Clarke,[4] from the Moose River sandstone of northern Maine, and this species was taken as the type of a genus for which the name Follmannella was proposed, in appreciation of the valuable contribution made by Dr. Otto Follmann in elucidating the characters of the Pterineas. Follmannella was based on the backward sweep or recurving of the body of the shell in old individuals, a character well developed in some of the more recent Ostreidæ.

After such radially lined forms as *P. lineata* Goldfuss were provided for by the erection of the genus Tolmaia, it was found that the faunas of Maine contain an important set of similar species, both valves of which are uniformly convex, the right valve lacking the resupination characteristic of Tolmaia and the typical Pterinea groups. The genotype described under the name *Pterinea radialis* Clarke is from the Chapman sandstone.

In this dissection of the heterogeneous Pterinea of Goldfuss and authors still another distinct group was recognized, to which Frech called attention in discussing his "gruppe der *Pterinea costata*." In erecting the genus Cornellites for this group, *Pterinea fasciculata* Goldfuss was chosen as the type, with the hardly distinguishable *Pterinea flabella* Conrad as an American cotype. The most conspicuous feature of Cornellites is the coarse, usually unequal ribbing on the left valve.

The genus Pterinea and the family Pterineidæ Dall, to which it belongs, are believed to be restricted in range to the Paleozoic. All the species of Pterinea are dimyarian (heteromyarian); the anterior adductor scar is smaller than the posterior, but both are distinct in adult shells. The closely allied genus Avicula Bruguière (=Pteria Scopoli) is monomyarian in adult shells, though the young shells exhibit an anterior adductor scar, which disappears with age. In young forms both Avicula Bruguière and Pterinea Goldfuss s. str. are biconvex, though the left valve appears to be generally the more strongly convex. With age the right valve of Pterinea becomes resupinate. This resupinate character of the right valve is observed in Pterinea, Micropteria, Tolmaia, Follmannella, and Cornellites, but the genus Actinopterella is biconvex throughout life.

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. xiii, 1885.
[2] Frech, Fritz, Die devonischen Aviculiden Deutschlands: Abh. geol. Specialkarte Preussen, vol. 9, pt. 3, p. 80, 1891.
[3] Williams, H. S., op. cit., pp. 86–89.
[4] Clarke, J. M., Some new Devonic fossils: New York State Mus. Bull. 107, p. 201, 1907.

Genus FOLLMANNELLA Williams, 1908.

In Follmannella are included the following hitherto described species:

Follmannella mainensis (Clarke), genotype.

Actinopteria (*Pterinea*) *fronsacia*. Clarke, Some new Devonic fossils: New York State Mus. Bull. 107, pp. 198, 201, 1907. Gaspe Basin, Quebec; Delos Lake dam and Moosehead Lake, 7 miles north of Kineo, Maine.

Pterinea ostreiformis. Frech, op. cit., p. 98, pl. 11, figs. 9–9c. *Spirifer cultrijugatus* zone, in the Eifel, on the mountain opposite Lissingen, not far from Gerolstein, Germany.

Avicula sp. Kayser, Die Fauna des Hauptquarzits und der Zorger Schiefer des Unterharzes: K. preuss. geol. Landesanstalt Abh., new ser., vol. 1, p. 18, pl. 8, figs. 1, 1a, 1889. Lower Eo-Devonian of the Harz Mountains (the Cloister grounds near Michaelstein). Included in Follmannella because Frech identified the shell with *Pterinea ostreiformis*, though it seems to be rather a shell of the type of *Limopteria* (*Paropsis*) *chevanus*.

Actinopteria humboldti. Clarke, The Paleozoic faunas of Para, Brazil, pt. 2, Devonian Mollusca: Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 5, figs. 3, 7, 11, 12, 1899 (Author's English ed., p. 47, 1900). Lower Coblenzian fauna of Rio Maecuru.

Avicula obliquata. Hall, Paleontology of New York, vol. 3, p. 285, pl. 51, figs. 9, 10, 1859. Pentamerus limestone of the Lower Helderberg group: Schoharie County, N. Y.

Pterinea correcta. Barrande, Système silurien du centre de la Bohême, vol. 6, particularly pl. 356, figs. 14–22, 1881.

Pterinea obsequens. Barrande, idem, particularly pl. 357, fig. 26. [The other figures, of smaller shells, show hardly any recurvation and indicate that the recurvature in this species is an adult or senile character. The preceding species, *P. correcta* Barrande, is in the young state apparently similar to *P. obsequens*, as may be determined from the lines of growth in mature shells. *Pterinea cuneata* Barrande (op. cit., pl. 356) is a shell of the same type and is apparently not at all recurved. The shells passing under these three names occur together and are apparently modifications of the same specific type, showing that in these Silurian early members of Follmannella the recurvature is perfectly attained only at maturity. The species are from étage E^2.]

Avicula danbyi. McCoy, Systematic description of the British Paleozoic rocks and fossils in the Geological Museum of the University of Cambridge, in Sedgwick, Adam, and McCoy, Frederick, British Paleozoic rocks and fossils, p. 258, pl. 1, figs. 11–15, 1852. [The species is abundant in the greenish Upper Ludlow quartzites of Benson Knot, Kendal, Westmôreland. It is like the Bohemian Silurian species, recurved only slightly and only in older shells. The three Silurian species here referred to Follmannella are not very characteristic forms, being variable with regard to the recurvature, which becomes more fixed in the Devonian forms. The Silurian shells also have the ribs rather stronger than in the typical forms of the group. *Follmannella danbyi* occurs in the late Silurian of the Cobscook Bay region at Whiting, Falls Point, Dennysville, Long Cove, Horan Head, etc., Washington County, Maine.]

Leiopteria rafinesquii (not Hall). Walcott, Paleontology of the Eureka district [Nevada]: U. S. Geol. Survey Mon. 8, p. 166, pl. 5, fig. 10, 1884. Lower Devonian limestone: Brush Peak and Atrypa Peak, Eureka district, Nev.

These shells are all of moderate or depressed convexity, with more decidedly explanate umbone than Cornellites. The right valve is resupinate and, on the whole, concave or flat. The anterior auricular portion is fairly well developed but hardly separable from the body by any definable byssal sinus in typical forms. The shells are large, and the two typical species, *Follmannella mainensis* and *Follmannella ostreiformis*, Frech, are among the largest Paleozoic lamellibranchs known. Each one of the species is usually decidedly larger than any of the other pterinoids in the fauna in which it occurs.

The shell structure in the typical species, *Follmannella mainensis*, is also characteristic; the main mass of the shell is strongly lamellar or concentrically foliaceous, with the radial striæ confined to an outermost thin layer. Frech's figure of *P.* (*F.*) *ostreiformis* indicates a similar shell structure.

FOLLMANNELLA MAINENSIS (Clarke).

Plate XVI, figures 1–6; Plate XVII, figures 1–11.

?1907. *Aviculopecten alcis*. Clarke, New York State Mus. Bull. 107, p. 195, fig.
Lower Devonic: Moosehead Lake, 7 miles north of Kineo, Maine.

1907. *Aviculopecten flammiger* (pars?). Clarke, idem, p. 196, left-hand figure only.
Lower Devonic. Askwith Siding, Misery Stream, and Moose River, Maine.

1907. *Pterinea mainensis* (pars?). Clarke, idem, p. 201, figs. (?except lower right-hand figure).
Lower Devonic. Telos Lake dam and Moosehead Lake, 7 miles north of Kineo, Maine.

1907. *Pterinea radialis* (pars). Clarke, idem, p. 207; lower figures only.
Lower Devonic. Matagamon Lake and elsewhere in Somerset County, Maine.

This species is abundant in and characteristic of the Moose River sandstone of Somerset County, Maine, and probably occurs also at Gaspe, Quebec. Shells of this type do not occur in the Chapman sandstone fauna. The mature shells are easily recognized by their large size, depressed convexo-concavity, recurvature, numerous radial lines, and foliaceous shell structure.

Outline obliquely rhomboid, with the lower half prolonged backward in mature shells. Height nearly but not quite equal to the length; the proportion of height to length varies between 8:9 and 21:22. Greatest height at about the posterior extremity of the hinge. Hinge line long and straight, continuous on both sides of the beak, generally not more than four-sevenths the length of the shell, rarely exceeding five-sevenths the length except that in younger individuals which have not attained the recurvature the hinge line may be equal to the length of the shell. The posterior wing, though distinctly developed, is comparatively small and sometimes not sharply demarcated from the body; it includes an angle of about 25°. The posterior margin of the wing is deeply concave; the lower half curves upward and forward; the upper half recurves to the rear and meets the hinge at an angle of 45° to 65°. The anterior auricular portion is large but because of the almost total lack of any definable byssal sinus is not conspicuously demarcated from the body of the shell. The byssal sinus is extremely faint, being represented by an obscure constriction of the upper anterior margin slightly below the hinge line. The body of the shell is large and includes at the umbones an angle of over 70°, occasionally as high as 90°. The beaks do not protrude appreciably above the hinge line and are directed upward and slightly forward; they are commonly situated between the anterior one-third and three-eighths the length of the hinge, generally nearer the latter, occasionally at about the midlength of the hinge line. The oblique height or axis of the body is about equal to the length of the shell, sometimes slightly less, but is decidedly greater than the oblique or transverse width of the body.

In mature shells the forward extremity of the shell is on the auricular expansion, only slightly in advance of the anterior margin farther down. The anterior margin is gently curved in the upper half, at an angle of 80° to 85° with the hinge line, and swings in a broad catenaric quarter circle into the ventral margin. The ventral margin is strongly convex, with the lowest point directly below or slightly in advance of the posterior hinge extremity; thence arching strongly upward, then forward. The posterior margin of the body is paraboloid, much more deeply convex than the ventral margin; the upper posterior margin of the body extends far forward at a very acute angle (less than 45°) to the hinge line. In mature shells the posterior portion of the body is well behind the posterior hinge extremity. In the young shells the contours are quite different and exceedingly variable in outline; there is some variability of course in the old shells, but the backward recurvature is a common character at full maturity. The depressed-convex form is characteristic. The umbonal region on the body is moderately convex, but the convexity of the main surface of the body is very slight. The slope forward over the auricular portion is generally slightly concave, but there is no sharply definable byssal sinus on the surface. The ear is depressed convex. The wing is concave and nearly but not quite "flat," in the plane of the margin. The right valve is depressed convex on the umbo, which is lower than that of the left valve, but concave over the greater portion of the surface; as a whole, the right valve is slightly concave fitting up into the cavity of the left valve. The body cavity of the shell, between right and left valves, is apparently very slight, being less than one-sixth the height of the valves.

Ligamental area broad and striated.

Cardinal teeth, about four in each valve; the foremost is slightly the stronger. The second and third cardinals in the right valve are generally united above in a narrow inverted V, or tend so to unite. The cardinal teeth are narrow ridges directed radially, parallel to the oblique axis of the shell. There is a single strong posterior lateral tooth in the left valve situated at the junction of the wing with the body. In the right valve there is a still stronger radial ridge or posterior lateral tooth underlying that of the left valve, and a fainter ridge above it. The anterior muscular scar is situated on the ear at the junction with the body. It is very deep and well marked and is underneath and in front of the foremost cardinal tooth. Two very small umbonal scars are also present at the apex of each valve; the posterior scar is a little the higher. The posterior adductor muscular scar is very faint and indistinct in all the specimens examined. It appears, however, to have been large. It is situated at the extremity of the posterior laterals, mostly on the body of the shell. The shell structure is characteristic in these fossils, which are readily recognized by the foliaceous laminæ of which the bulk of the shell substance is composed. These laminæ are black, indicating a high organic content; they are concentric and without indications of the radial ornamentation, which is confined to an outermost, thin, membranaceous layer. Hence, unless this outer layer is present the shell appears to be only concentrically ornamented. Compare *Avicula* (*Follmannella*) *obliquata* Hall (op. cit.), the internal mold of which, likewise, appears to be only concentrically marked, whereas the exterior is radially ornamented. No microscopic sections have been made.

The surface ornamentation consists essentially of more or less unequal radial lines on the body of the left valve, crossed by concentric striæ of growth; these striæ are closer together and more prominent on the wing, where they furnish the dominant ornamentation. On the forward part of the body, near the anterior margin and on the ear, the radial lines are absent, this portion of the shell being marked only by concentric lines. The radial lines vary considerably in size and arrangement. Plate XVII, figure 3, shows a specimen with close subequal radial lines; Plate XVI, figure 1, shows a similar closely lineate form, but here the radial lines are unequal, a finer line being intercalated between two normal lines. Usually an intermediate radial line is developed between each adjacent pair of primary lines and occasionally a still finer single line appears on one or both sides of this intermediate one. No one type of radial ornamentation is dominant; the same shell may have in one portion several lines subequal, whereas in another portion an intermediate line may be intercalated between each two primary lines, in still another portion there may be an even finer lineation on one or the other side of the intermediate lines, and occasionally such a third fine lineation may be observed on both sides of the intermediate lines. In all the specimens observed the radial lineation begins to fade over the middle of the body, toward the front, and near the upper anterior margin no radial lines are discernible. This portion of the surface is covered with faint concentric striæ, which are most conspicuous and best developed on the ear.

The wing is marked by concentric coarse striæ or fine wrinkles; a few very faint, thin radial lines may be observed on the wing in the best preserved specimens, but ordinarily the wing appears to be only concentrically marked.[1] In some specimens there is an impressed line and abrupt change of ornamentation which causes the wing to be sharply demarcated from the body. In other shells this impressed line is absent and the wing is less abruptly demarcated from the body. The concentric lines on the wing also cross the body, where they are well developed but commonly subordinate to the radii; occasionally, in areas on the body of the shell, the concentric lines may be as strong as the radial. Ornamentation of the right valve unknown.

The species is large for a pterinoid shell, the specimen figured in Plate XVI, figure 5, being 65 millimeters high and 80 millimeters long. This is an unusually broad variety. Fragments of still larger specimens have been observed.

The posterior recurvature is a constant character in mature specimens of the species and occurs occasionally in some smaller specimens. In general the recurvature in young shells is not so well defined, frequently there is not the slightest indication of it.

The variability in width is shown by the narrow shells illustrated in Plate XVI, figures 1 and 3, and the wider shells illustrated in Plate XVII, figures 1 and 2. Plate XVI, figure 5, shows an unusually wide or elongated shell, which is also decidedly more strongly convex than any other specimen, and the anterior margin differs somewhat by being protuberant in the middle. Such specimens may perhaps, in large collections, prove to be a distinct variety or species.

For the specific name I have adopted *mainensis* Clarke, in spite of the fact that in Clarke's text descriptions of both *Aviculopecten alcis* and *A. flammiger* Clarke precede that of *Pterinea mainensis*, for the reason that under the name *Pterinea mainensis* is given the first full description and illustration of the typical and especially the adult or mature, normal form of the species.

[1] Since the above description was written I have seen an unusually clean external mold that shows the surface markings in perfection and indicates the occurrence of fine radial lines on the wing.

The form called *Aviculopecten alcis* Clarke is not quite mature and the figure represents the shell with no visible anterior wing. Under *Aviculopecten flammiger* Clarke two species are described, and the description applies particularly to a "strongly radiated shell" unlike typical specimens of *Follmannella mainensis.* Finally, owing to the wide distribution of the species in the Moose River sandstone of Maine, the name *mainensis* is particularly appropriate, though of course, under the laws of priority, this fact in itself would have no weight.

Locality: Moose River sandstone, between Parlin Pond and Detroit, Somerset County, Maine. The species is abundant in the richly fossiliferous gritty calcareous sandstone filled with *Leptocœlia flabellites* (Conrad), *Chonetes novascoticus* Hall var. *canadensis* Billings, *Leptostrophia perplana* (Conrad), *L. blainvillei* (Billings), *Chonostrophia complanata* Hall, and *Spirifer murchisoni* (Castelnau).

U. S. National Museum, catalogue No. 59787.

Comparisons.—Follmannella mainensis closely resembles the German Eo-Devonian *Follmannella ostreiformis* (Frech) and from the figures might easily be mistaken for it. Frech's species, however, is a very gibbous shell, whereas the Maine fossil is characteristically depressed convex. The anterior margin is more protuberant in *F. ostreiformis* than in normal *F. mainensis,* but in this respect the Maine shells figured in Plate XVI, figure 5, and by Clarke [1] approach Frech's species. The German shells also exhibit more profuse cardinal dentition.

From *Actinopteria (Follmannella) humboldti* Clarke the Maine fossil differs in having a much larger auricular expansion and the beaks not so anterior; the shell is larger and the ornamentation finer.

From Hall's *Avicula (Follmannella) obliquata Follmannella mainensis* may be distinguished by its finer and more abundant radii, a character that will also serve to distinguish the Maine shell from the other Silurian species, as well as from *Follmannella fronsacia* (Clarke), which occurs in the Gaspe fauna at Gaspe, Quebec, and in the Moose River sandstone of Somerset County, Maine.

Two of Clarke's figures, one of *Pterinea radialis,*[2] from Matagamon Lake, Maine, and one of *Aviculopecten flammiger,*[3] show forms that very closely resemble young shells of *Follmannella fronsacia.*

Genus ACTINOPTERELLA Williams.

Several species of a group of radiately lined pterinoid shells occur in profusion in the Chapman sandstone fauna. The generic characteristics of this group are the numerous radiate lines on the surface and the convexity of both valves, the latter feature distinguishing it from Tolmaia and allied pterinoids, in which the right valve is resupinate or concave in adult shells. The presence of both cardinal and lateral teeth distinguishes the group from Actinopteria Hall. The lateral teeth, however, are close to the hinge line, and in this respect also the shells differ from the pterinoids, in which the posterior lateral teeth are on the border between wing and body. To this group the generic name Actinopterella was applied.[4] It was founded upon the specific form named *Pterinea radialis,* by Clarke,[5] and figured in his first and second figures but not in the third and fourth, which represent *Follmannella mainensis* and probably *Follmannella fronsacia* (Clarke), respectively.

The diagnosis of the genus includes the following characters:

1. Size small; length not over 35 millimeters.
2. Shape of shell, oblique pterinoid, with posterior wing and anterior ear both developed.
3. Both valves strongly convex; left valve ventricose with narrow oblique body; right valve convex from beak to ventral margin, generally less convex than left valve, but not becoming resupinate with maturity; rarely nearly equivalve.
4. Umbones slightly protruding beyond hinge line.
5. Ligamental area well developed, striated.
6. Cardinal teeth present; three or four in number.

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[1] Clarke, J. M., Some new Devonic fossils: New York State Mus. Bull. 107, p. 201, left-hand figure, 1907.
[2] Idem, p. 207, lower left-hand figure.
[3] Idem, p. 196, right-hand figure.
[4] Williams, H. S., On the revision of the mollusk genus Pterinea Goldfuss: U. S. Nat. Mus. Proc., vol. 34, p. 87, 1908.
[5] Clarke, J. M., op. cit., p. 207.

7. Lateral teeth (or tooth) well developed and close to ligamental area, not on the margin of body and wing.
8. Anterior muscular scar small and deep, situated on the ear.
9. Posterior muscular scar obscure, large.
10. Surface ornamentation, fine or strong radial ribs on body and wing and occasionally on ear of left valve; radial ribs on body of right valve generally obscure but occasionally strong.

The well-known Devonian genus Limoptera Hall, of which *L. macroptera* (Conrad) is the genotype, presents some similarity to Actinopterella. Hall's genus includes large, nearly erect pterinoids with numerous fine nonfasciculate ribs frequently obsolescent; the two valves are normally unequal, and the right valve is frequently convex, though often resupinate. Actinopterella is distinguished from Limoptera by having the right valve always convex and the left valve more gibbous and oblique. In Actinopterella the anterior ear is always conspicuously developed; it is the foremost part of the shell, and is separated from the body of the shell by a vertical sinus. In Limoptera the anterior ear is never well developed; when present at all it is not separated from the body by a vertical sinus, and the forward extremity of the shell is the anterior margin of the body rather than the ear. Finally, Limoptera is described by Hall as having, in *L. macroptera*, only two cardinal teeth, and the single posterior tooth is defined as "oblique." The dentition of Limoptera is therefore quite different from that of Actinopterella, where the single posterior tooth is close to the hinge line and where there are three to five cardinal teeth. There should be no difficulty in distinguishing at sight the small, oblique, strongly eared, biconvex Actinopterella from the large, nearly erect, earless or obscurely eared and semiresupinate Limoptera.

Actinopterella also resembles superficially the genus Actinopteria,[1] which was described by Hall in 1883 and 1885 to include shells that differ from Pterinea in being biconvex, in having fine, numerous radial riblets, and, particularly, in being edentulous and without a well-developed striated ligamental area. Of the dozen or more New York Devonian shells described by Hall as Actinopteria, the only species known definitely to exhibit this combination of generic characters is *Actinopteria decussata* Hall. Although Actinopterella agrees with Actinopteria s. str., in biconvexity and approximately in ornamentation, size, and general appearance the genus Actinopteria Hall s. str. is edentulous and has a linear nonstriated ligament. Most specimens of Paleozoic Actinopteria and of pterinoid shells in general appear to be edentulous, owing to poor preservation. Specimens showing the teeth are very rare, and those with cardinal teeth are exceedingly uncommon. However, a large number of specimens of *Actinopteria decussata* have been examined by geologists; the species is everywhere common under diversified conditions of preservation in the arenaceous Hamilton formation of eastern New York, the shales of central New York, and the calcareous beds of western New York, and in none of these have teeth ever been recorded or, so far as known, observed. Large series in the Cornell University collections have also been examined during the preparation of this paper. The absence of teeth and conspicuous ligament in *A. decussata* must therefore be ascribed, for the time being, at least, to original absence rather than to poor preservation.

The genus Actinopterella includes several species among the lamellibranchs of the Chapman fauna, and in addition the following species previously described:

Avicula reticulata Goldfuss (not Hisinger, Sowerby, nor Weller). Frech, Die devonischen Aviculiden Deutschlands: Abh. geol. Specialkarte Preussen, vol. 9, pt. 3, 1891. German and western European Meso-Devonian.

Pterinea lindstroemi. Philippi, Ueber die echte "*Avicula reticulata* Hisinger:" Deutsch. geol. Gesell. Zeitschr., vol. 52, p. 561, fig. 2, 1900. [The real *Avicula reticulata* of Hisinger is shown by Philippi to be an Aviculopecten. Philippi's species, from the Silurian of Gotland, seems to be an Actinopterella, though the right valve has not yet been described. On the other hand, the shell figured by Sowerby[2] as *Avicula reticulata* Hisinger represents a different genus which has the curvature, ornamentation, oblique posterior lateral teeth, and strong ligament of Tolmaia, Cornellites, and Tiogana. This shell, which has been renamed *Pterinea sowerbyi* McCoy,[3] should probably be included in Cornellites along with *Pterinea hians* McCoy and some similar shells occurring in the Eastport quadrangle, Maine, as should also *Actinopteria reticulata* Weller,[4] although these Silurian species do not quite attain the pronounced coarse ribbing of the typical Devonian Cornellites species.]

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 107, 1885.
[2] Murchison, R. I., The Silurian system, pt. 2, p. 614, pl. 6, fig. 3, 1839.
[3] Sedgwick, Adam, and McCoy, Frederick, British Paleozoic rocks and fossils p. 263, 1855.
[4] Weller, Stuart, Paleontology of New Jersey, Paleozoic faunas, p. 245, pl. 22, fig. 3, 1903.

Pterinea tenuistriata. McCoy, op. cit., p. 263, pl. 1, I, fig. 4. [The types are from the Upper Ludlow of Benson Knot, Kendal, Westmoreland, but the species is widely distributed in the Ludlow of Brecknockshire, Caermarthenshire, Shropshire, and Westmoreland.]

Pterinea rhombopsia. Barrande, Système silurien du centre de la Bohême, vol. 6, pl. 217, box IV, figs. 1-3, 1881. Eo-Devonian of Konieprus (étage F^2).

Avicula (Pterinea) confortans. Barrande, idem, pl. 218, figs. 11, 12, 15, 16, 18. Eo-Devonian of Konieprus (étage F^2).

Avicula textilis. Hall, Paleontology of New York, vol. 3, p. 288, pl. 52, figs. 9, 10 (?); pl. 53, figs. 2, 3, 5, 7, 10, 1859. [This Helderbergian shell has the ligament broad and striated. According to Weller [1] the right valve is convex No teeth have yet been observed, but the species is apparently an Actinopterella.]

Actinopteria boydi (Conrad). Acad. Nat. Sci. Philadelphia Jour., vol. 8, p. 237, 1842. Hamilton, Madison County, N. Y. Upper Silurian shale.

Actinopteria tenuistriata. Hall, Paleontology of New York, vol. 5, pt. 1, p. 120, pl. 84, figs. 5, 6, 1884. Ithaca shale member of the Portage formation. [Described by Hall as having the "right valve smaller, nearly equally convex," compared with the left valve. Such apparently convex right valves are not uncommon near Ithaca, but the specimens are incomplete and small; the right valves at maturity, when complete, are resupinate in front. If Hall's *A. tenuistriata* is a mature shell with the right valve really convex throughout it belongs to the genus Actinopterella.]

A few Meso-Devonian or Neo-Devonian species from Frech's groups of *Avicula reticulata*, *Avicula wurmi*, and *Avicula mariæ* may belong to Actinopterella, in addition to *Avicula reticulata* Goldfuss (not Hisinger).

The genus Actinopterella is first recognized in the Ordovician and ranges through the Silurian and Lower and Middle Devonian.

No species of Actinopterella is at present known above the middle Neo-Devonian (the Ithaca shale member of the Portage formation), and there is doubt as to the certain occurrence of the genus as high as the Neo-Devonian. The greatest known development of Actinopterella is in the marine beds of Upper Ludlow age in Great Britain, in the Baltic province, and in the Chapman sandstone, of late Helderbergian age, in Aroostook County, Maine. In the early and typical Actinopterella the radial markings on the body of the right valve are nearly as strong as on the left valve. In such Meso-Devonian forms as *A. boydi* (Conrad) radial markings in the right valve are confined to the wing, the body being nearly or quite smooth. The *boydi* type also occurs in the Silurian.

ACTINOPTERELLA RADIALIS (Clarke).

Plate XV, figures 1–17; Plate XXIII, figures 6, 8, 9, 11–13.

1907. *Pterinea radialis* (pars). Clarke, New York State Mus. Bull. 107, p. 207, upper figures only; lower right-hand figures are *Follmannella mainensis* (Clarke).
Lower Devonic: Presque Isle Stream, Chapman Township, Aroostook County, Maine (not "Matagamon Lake and elsewhere").

1907. *Pteronitella peninsulæ.* Clarke, idem, p. 212, figs. (internal molds of the right valves of the species).
Lower Devonic: Presque Isle Stream, Chapman Township, Aroostook County, Maine.

Outline obliquely rhomboid, obliquity varying from 25° to 40° from the perpendicular, commonly 30° or a little more. Height less than the length, the ratio varying from 12:13 in only slightly oblique specimens to 2:3 in mucronately winged or very oblique specimens. Greatest height commonly just back of the middle; in a few very oblique specimens as far back as the posterior two-thirds. Hinge line long, continuously straight on both sides of the beak, and including the greatest length of the shell. Frequently the hinge line is prolonged posteriorly in a mucronate extension. The posterior end is acutely pointed; the anterior end is rounded. Clarke's figure of *Pterinea radialis* shows the anterior end too sharp. The posterior wing is large, distinctly developed, concave, and set off from the gibbous body and umbones by a sulcus. In the right valve the wing is somewhat less distinctly demarcable from the umbones and body. The posterior margin of the wing is concave; the lower part of the posterior margin of the wing is directed upward and somewhat forward; the upper part is usually directed backward at an angle of 40° to 70° with the hinge, or very rarely is nearly vertical. The anterior ear is large, conspicuous, and well developed; rounded; height slightly greater than the length. The ear is

[1] Weller, Stuart, Paleontology of New Jersey, Paleozoic faunas, p. 332, pl. 43, fig. 13, 1903.

separated from the body by a broad sinus which extends vertically downward or slightly backward. The insinuation of the anterior margin reaches half or occasionally as much as three-fifths the length of the anterior end of the shell. The front of the ear is obtusely rounded; the extreme upper portion curves backward, rounding into the hinge line. The length of the ear ranges between one-third and one-half that of the body proper. The body of the shell includes at the umbones an angle of less than 60°. The beaks protrude above the hinge line; that of the left valve is usually higher than that of the right. They are situated between the anterior two-fifths and one-third the length of the hinge line, and in a few mucronately extended specimens are only one-fourth the length from the front. The oblique height, or oblique axis, of the body is one and one-third to one and one-half times the oblique width of the body, commonly nearer the latter proportion. The forward extremity of the shell is on the ear, below the hinge line. The anterior margin includes with the hinge line an angle of about 60° or a little less. The ventral margin is deeply convex, nearly semicircular; the lowest point is three-fifths the length or more from the front. The posterior margin of the body is convex, with the hindmost extremity at the lower third or fourth; the hinge extremity generally reaches in front of this, particularly in more oblique specimens, and is frequently directed above it. In mucronate specimens the hinge extremity extends a trifle beyond the posterior extremity of the body. Both valves are strongly convex throughout. The left valve is ventricose; the right valve usually is less convex than the left valve. The umbones are highly inflated and incurved. The point of maximum depth of the valves is on the oblique axis of the body, varying from the midheight to the upper quarter, whence the slope is strongly convex over the body of the shell toward the anterior sinus and just back of the beak. The depth of the left valve is equal to three-tenths the length of the oblique axis. The right valve is a little less convex but is variable, being in some specimens nearly or quite as deep as the left valve. The anterior ear is strongly convex. The posterior wing is flattened, concave, nearly in the plane of the margin, and is sharply demarcated from the body, especially umbonally. In the right valve the wing is a little less flattened than in the left and a trifle less distinctly demarcated from the body. The byssal sinus is shallow, broad, and undefined. It is vertical or occasionally slightly inclined backward, especially in the more oblique specimens. The ligament is in a narrow, deep escutcheon, which is continuous in front of and behind the beaks. In front of the umbones the striated ligament arches upward over the cardinal teeth. The area in the left valve is larger and wider than in the right valve and is nearly in the plane of the margin of the valves. In some specimens it is marked by three or four wrinkled longitudinal striæ. In one or two right valves examined the area is similarly striated but is more elevated—that is, not so nearly in the plane of the margin. The margins of the ligamental strip are parallel. The anterior muscular scar is small but rather deep. It is situated in front of the umbones, at the base of the foremost cardinal tooth, or between the ear proper and the byssal sinus. The posterior scar is several times larger than the anterior scar, but is shallower. It is situated partly on the body, but mostly on the wing, and is rounded subcircular to quadrate in outline. The pallial line is feebly impressed and simple, but partakes of the broad, shallow insinuation or constriction anteriorly in the region of the byssal sinus. Dentition variable in specimens taken from the same rock layer. In the simplest types there are three or four simple cardinal teeth in the right valve and four or five in the left. These teeth are narrow radial ridges, slightly inclined posteriorly. They may become thickened or ridged, or even divided, in various ways on different shells. The cardinal teeth are all situated in front of the umbones. There is a single posterior lateral tooth in each valve, situated as closely as possible to the hinge line and parallel with it for the greater length of the tooth. That of the left valve is slightly the longer and stronger and is situated below that of the right valve.

Body of the shell of the left valve marked by low, rounded, flexuous radial riblets, which begin back of the byssal sinus and are most distinct on the posterior half and on the lower half of the body. The riblets are equal or subequal in width and strength in most specimens; in others a finer elevated radial line is intercalated between two adjacent normal riblets. There are from 16 to 32 riblets on the body in different individuals, those in front being very faint and obscure. The interspaces are narrower than the riblets above, but become as wide as the riblets, or slightly wider, below. The ribs increase by intercalation, a fine one forming between each normal pair and quickly developing to the strength of the rest. The body of the shell is crossed by obsolescent concentric lines of growth, including a few somewhat distant stronger varices. The wing is too poorly preserved in the specimens to warrant a definite statement that radial ornamentation is altogether absent on this portion of the shell, but if it is present it is very much subdued. In the material at hand the wing appears to be smooth or marked only by fine concentric lines of growth which may aggregate into low, undulose, obsolescent varices. The ear and byssal sinus are marked only by concentric lines of growth, which are highly lamellose and conspicuous on the ear and forward part of the sinus. No distinct radial riblets or lines are discernible on sinus or ear. Of about a dozen right valves only one shows radial ornamentation anywhere, that one (the best in the collection) having one or two extremely faint, short, interrupted, narrow ridges, or exceedingly subdued riblets, on the posterior half of the body near the umbones. They are exceedingly obscure and may be adventitious.[1] If the specimens examined by us represent the real conditions, the right valve may be regarded as smooth and devoid of radial ornamentation. A couple of the better specimens show only fine concentric lines and a few distant, somewhat stronger, imbricose varices over the body. These concentric lines converge and become much stronger and more imbricose toward the ear and forward part of the sinus, as in the left valve. The wing appears quite smooth.

The largest specimen in our collection is a shell of less than usual obliquity, 27.5 millimeters high and 30 millimeters long along the hinge. The usual size is between three-fourths and seven-eighths of that given. The dimensions of the smallest specimen are about two-thirds those of the largest.

The distinguishing characters of this fossil are its size and outline; the large, well-developed, and conspicuous ear, behind which a broad, shallow sinus extends downward or slightly posteriorly, causing half to three-fifths of the anterior margin to be slightly insinuated or constricted; anterior margin inclined about 55° to the hinge; oblique axis inclined 48° to 65°, generally about 60°, to the hinge line; the strong ventricosity and protruding umbones, with right valve convex, but usually less ventricose than the left; the ornamentation on the ear and sinus consisting only of strong concentric lamellæ; the posterior wing nearly (apparently quite) smooth; radial ornamentation consisting of 16 to 32 broad, elevated lines or riblets confined to the body, and especially the posterior half; riblets flexuous, with interspaces narrower or at most only slightly wider than the riblets; ribs generally equal or subequal, occasionally increasing by implantation and showing rarely strong and weak riblets alternating; right valves without radial ribbing.

Locality: Chapman sandstone, Presque Isle Stream (locality 1099 L), Chapman Township, Aroostook County, Maine, where the species is very abundant, there being over 50 specimens in the material at hand. This form is very distinct from *Actinopterella aroostooki*, described below, which is from Edmunds Hill.

U. S. National Museum, catalogue No. 59788.

Comparisons.—In the smooth wing and ear the species is like the Helderberg *Avicula communis* Hall,[2] which is recorded throughout the Helderburg, but it is most common in the shaly New Scotland ("Delthyris") limestone. Specimens from Albany County, N. Y., show a striated ligament. In Hall's species, however, the right valve is resupinate, so that it can not be even congeneric with *Actinopterella radialis* Clarke; the ribs are also more distant from each other, the ear is smaller, and there are other distinctive features. The British Upper Ludlow species *Actinopterella mesoclathrata* (McCoy) conforms with Actinopterella generically and with *A. radialis* specifically in outline, convexity, and variability and in having the radial ornamentation confined to the body, but its ribs are much finer and more closely set.

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[1] Compare the right-hand figure of *Pterinea* (*Pteronitella*) *incurvata* Clarke, op. cit., p. 210.

[2] Hall, James, Paleontology of New York, vol. 3, p. 286, pl. 52, figs. 1-7; pl. 53, figs. 1, 4, 6, 1859.

ACTINOPTERELLA AROOSTOOKI (Clarke).

Plate XV, figures 18–23; Plate XVII, figures 14–16.

1907. *Pterinopecten aroostooki*. Clarke, New York State Mus. Bull. 107, p. 199.
Pterinea edmundi. Clarke, idem, p. 203, figs.
Lower Devonic: Edmunds Hill, Chapman Plantation, Aroostook County, Maine.

This species closely resembles *A. radialis* in outline and general aspect, but may be distinguished by several particulars. The ribs and their interspaces are somewhat different in the two species. In *A. aroostooki* the posterior wing is distinctly radially ribbed, instead of being nearly or quite smooth; the ligament is nearly or quite in the plane of the margin and widens posteriorly instead of having the edges parallel; the shell is also strongly ribbed externally over the ligament; the radial ribbing extends farther forward, including the anterior byssal sinus; and the ear is also more or less distinctly ribbed radially. The right valve is distinctly ribbed on the body and over the ligament on the posterior wing. In *A. aroostooki* the ear is somewhat smaller, the beaks are situated farther forward, and the shell is usually less oblique and slightly less ventricose than in *A. radialis* Clarke.

Outline obliquely rhomboid; obliquity varying generally between 24° and 35° from the perpendicular, commonly about 30°, very rarely 45°. Ratio of height to length varying from 12:13 to 5:8; average about 3:4. Greatest height back of the middle, at about two-thirds the distance from front to back. Hinge line long, continuously straight on both sides the beak, and including the greatest length of the shell; frequently pennate posteriorly, but not, so far as known, mucronate. Anterior end of the hinge line generally rounded, rarely slightly angular; posterior end acutely pointed, rarely rounded. The posterior wing in both valves is large and concave, nearly in the plane of the margins, and distinctly demarcable from the umbones and body. The posterior margin of the wing is deeply concave; the lower part of this margin is directed upward and generally a little forward; the upper part of the margin, which includes most of the posterior margin of the wing proper, is directed backward at an angle of 40° to 60° with the hinge line; rarely as much as 80°. The posterior hinge extremity is commonly pointed; in one or two specimens, rounded. The anterior ear is rounded, moderately well developed, usually much higher than long, though in a single right valve it seems pointed and about as long as high. The byssal sinus which separates the ear from the body of the shell is faintly represented by a slight insinuation or constriction of the anterior margin; this obsolescent byssal sinus is approximately vertical. The length of the ear is from less than one-fourth to about one-third that of the body proper. The body of the shell at the umbones includes an acute angle, generally 60° or less, very rarely as much as 80°. The beaks protrude a little above the hinge line, and that of the left valve is occasionally a trifle higher than that of the right; they are situated between one-third and one-fourth the distance from the front. The oblique height or oblique axis of the body is equal to one-fourth to one-fifth the oblique width of the body. The forward extremity of the shell is on the ear below the hinge line. The anterior margin of the shell inclines at an angle of about 60° from the hinge line. The ventral margin is deeply rounded, nearly semicircular; the lowest point is about three-fifths the length from the front. The posterior portion of the body proper is strongly convex, especially in the more oblique specimens, in some of which it forms a deeply inflated catenaric or parabolic arch; the hindmost extremity is at the interior fifth or sixth, rarely as high as the inferior fourth. The posterior hinge is above the hindmost extremity of the body proper. Both valves are convex, the left valve being almost ventricose. The right valve in all the specimens examined is decidedly less convex than the left. The umbones are inflated in both valves—that of the left much more so than the right—and are incurved to the hinge line. The point of maximum depth of the shell is situated on the oblique axis of the body in the umbonal region, at the upper third or fourth of the height and the anterior third or two-fifths of the length; the slope is strongly convex over all the body proper and is a little steeper toward the anterior byssal sinus and just behind the beaks. The depth of the left valve varies from a minimum of about one-fifth the length of the oblique axis to a maximum of eight twentysevenths the oblique length of the shell; commonly between one-fifth and one-fourth. The depth of the right valve is about one-sixth the length of the oblique axis. The anterior ear is strongly convex. The posterior wing is flat to concave and is well demarcated from the body in both valves. The byssal sinus is extremely shallow and indistinct and runs nearly vertical to the hinge line.

The ligamental strip is elongate wedge-shaped, widening posteriorly, and is nearly in the plane of the margin of the valves. It is narrow under the umbones and several times wider at the posterior hinge extremity. In sculpture casts the surface over the ligamental strip is marked by five to eight flexuous, narrow radial riblets, which are usually stronger than any of the others on the posterior wing, though much finer than the radii on the body of the shell. This ornamentation about the ligamental area may possibly represent striations of the ligament, but more probably it is surface ornamentation. There is one posterior lateral tooth in each valve, very close to and parallel with the hinge line, or inner edge of the ligament. This tooth extends about half or occasionally three-fifths the length from beak to posterior tip. The tooth of the left valve is underneath the short tooth of the right valve and is longer and stronger, but in some specimens a second tooth appears in the right valve, as well developed as that of the left valve and below it. The cardinal teeth are represented in the right valve by three or four narrow ridges, directed radially slightly posteriorly, and situated in front of the beaks, and by four or five such ridges in the left valve. The anterior muscular scar is situated on the floor of the interior, on the ear, close under the foremost cardinal tooth, and is deep and small. The posterior scar is not impressed. The pallial line is extremely faint, and is slightly constricted in the region of the byssal sinus.

The body proper is covered with 16 to 21 simple radial ribs of rather characteristic appearance.[1] The ribs extend from beak to front and rise abruptly from the interspaces, which are flat or slightly convex; the interspaces themselves, where convex, have the appearance of interstitial riblets. The ribs are low and rounded, almost planicostate; they are wider than the interspaces—much wider toward the umbones, but more nearly equal to them toward the front. Both ribs and interspaces increase in width below. Rarely the ribs increase in number by an interspace gradually swelling so as to assume the character of a rib. There are in our collections no conspicuous concentric striæ on the body, but Clarke[2] reports and figures such striæ. Such concentrically striate forms may represent a distinct variety. In the left valve the obscure radial ornamentation is continued forward over the byssal sinus and becomes still less pronounced on the ear, though present in all the better-preserved specimens. Six or seven narrow, crowded, obsolescent riblets are discernible on the byssal sinus, and three to five extremely faint radial riblets may be observed on the ear in well-preserved external molds; but the dominant ornamentation on the ear and byssal sinus consists of closely crowded, imbricose lines of growth. The posterior wing is distinctly radially ribbed. The riblets on the wing are finer, less regular, and less conspicuous than those on the body of the shell. They are 10 to 12 in number below the hinge line; but above the hinge line, and between it and the upper edge of the ligamental strip, a sculpture cast shows five to eight additional flexuous narrow riblets similar to those on the wing but stronger, though not so strong as those on the body. These five to eight ribs seem to represent surface ornamentation rather than ligament wrinkles. The wing is also crossed by concentric lines of growth, much stronger than those on the body, where they are hardly discernible in the typical forms. In the right valve the radial ornamentation is weaker, but distinctly developed on the body and less distinct on the wing. The characteristic ribbing on the upper part of the wing over the ligamental strip is equally well developed on both valves. No radial ornamentation has been observed on the ear or byssal sinus of the right valve.

[1] Typically illustrated in Clarke's left-hand figure of *Pterinopecten aroostooki* (op. cit.).

[2] Op. cit., p. 199, right-hand illustration.

A series of specimens have the following dimensions:

Dimensions of specimens of Actinopterella aroostooki.

Height (mm.).	Length (mm.).
19	25
20	28
24	26
19	24
16.5	26.5

The principal distinguishing features of this species have already been indicated. To these may be added the peculiar character of the interspaces between the ribs on the body of the shell. These interspaces are usually very abruptly demarcated from the low, nearly planicostate ribs and are commonly flat; but a few of them are slightly convex, producing the appearance of an intercalated riblet between the broader, principal ribs. Occasionally these convex interspaces develop into mature or nearly mature ribs.

Locality: The species is represented in our collections by several dozen specimens from the Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine (locality 1099 M), where it is abundant. Several varieties, based on the variability in obliquity of the shell and on slight modifications in ornamentation, may possibly be erected.

U. S. National Museum, catalogue No. 59789.

Comparisons.—*A. aroostooki* Clarke may be recognized among the Chapman species by its peculiar body ornamentation—the radial ribbing continued over the byssal sinus and ear in the left valve; the radially ribbed wing; the ribs on the wing increasing in strength about the ligamental strip. The radial ribbing is developed in the right valve over the ligamental strip quite as well as in the left valve, and is present also on the body, though less distinct. The species is distinguished from *Actinopterella textilis* (Hall) by its broader ribs and much narrower interspaces, and to some extent also by the character of the intermediate riblets, which in *A. aroostooki* are developed only in spots on the shell, not regularly, and all over the body.

ACTINOPTERELLA AROOSTOOKI (Clarke) var. ERECTA var. nov.

Plate XVII, figure 17.

cf. 1907. *Pterinopecten aroostooki* (pars). Clarke, New York State Mus. Bull. 107, p. 200, left figure only.
?1907. *Pterinea edmundi* var. *subrecta*. Clarke, idem, p. 204 (not figured and only incompletely described).

This shell agrees with *Actinopterella aroostooki* in the peculiar character of the ornamentation—broad, low, rounded ribs, abruptly demarcated from the narrower interspaces. Some of the interspaces on the posterior half of the body gradually assume the character of intermediate riblets or ribs. As in *Actinopterella aroostooki* the wing is radially ribbed; this ribbing continues forward faintly over the byssal sinus. The shell is only slightly ventricose, and the umbones are hardly protuberant. The variety is easily distinguished from the principal form by its very slight obliquity, only about 15° or less from the perpendicular, giving the shell a nearly vertical, quadrate expression with the height equal to the length.

This variety may be identical with the variety *subrecta* indicated under the *Pterinea edmundi* of Clarke. The latter name represents the more oblique phase of specimens of *Actinopterella aroostooki*. The shells figured as *Pterinopecten aroostooki* by Clarke are a trifle less oblique than most of the specimens at Edmunds Hill.

Locality: Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine; a single specimen.

U. S. National Museum, catalogue No. 59790.

ACTINOPTERELLA AROOSTOOKI (Clarke) var. PLANICOSTA var. nov.

Plate XVII, figure 13.

This name is applied to a small left valve, because its ribs are actually flat topped and separated from each other by abrupt narrow grooves, rarely wider than half the width of the ribs and generally mere slits. In its strongly ribbed byssal sinus and posterior wing and in its moderate convexity the shell conforms with *Actinopterella aroostooki*, from which it appears to be only varietally distinct.

Locality: Chapman sandstone, Edmunds Hill (locality 1099 C[1]), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59791.

ACTINOPTERELLA CONCENTRICA sp. nov.

Plate XVII, figure 12.

?1907. Pterinea cf. *P. fasciculata* (not Goldfuss). Clarke, New York State Mus. Bull. 107, p. 204, figs.
Lower Devonic: Presque Isle Stream, Chapman Plantation, Aroostook County, Maine.

An imperfect small left valve in the United States Geological Survey collections from the Chapman sandstone of Edmunds Hill represents an interesting species, easily recognizable from its peculiar ornamentation. which is characterized by well-defined concentric raised lines on the body of the shell, particularly in the wide interspaces between the ribs. These concentric lines are also developed across the ribs, though somewhat less strongly, producing a crenulating or imbricating effect. The radial lines are low, rounded, and far apart, especially in the lower portion, where they are separated by interspaces two or three times their width. In most of these interspaces another intermediate line is developed, and in several specimens there is, as in *A. textilis* (Hall), a still finer, hardly discernible line between the principal and intermediate lines. There are 16 to 20 principal radial lines on the body; they are somewhat more crowded on the posterior portion near the wing. Ten or twelve of these lines form the principal ornamentation of the main mass of the body. The posterior wing has faint radial ribs that become a little stronger over the region of the ligamental strip.

Among the other characters of this fossil are its moderate ventricosity; a very long, shallow, ventral margin; large umbonal angle, between 60° and 80°; slight obliquity, only 25° from the perpendicular; and alate wing with pennate extremity, which extends, in the specimen examined, beyond the hindmost point of the body. The type shell is of diminutive size and is incomplete anteriorly. From the beak to the hinge extremity, exclusive of the anterior end, the length is 12.2 millimeters; the height of the shell is 10.3 millimeters.

Locality: Chapman sandstone, Edmunds Hill (locality 1099 M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59792.

Comparisons.—The above description, drawn up in the winter of 1906, reads almost as if it were based upon the specimen figured by Clarke as Pterinea cf. *P. fasciculata* (not Goldfuss's species, which is the genotype of Cornellites). Clarke's specimens, which apparently represent the same species, were obtained from Presque Isle Stream, and differ slightly from the typical *A. concentrica*, being more oblique and having a narrower umbonal angle.

This species somewhat resembles *Actinopterella aroostooki* in the low, radial ribs, with abruptly marked interspaces in the ribbed wing and strong ribbing over the ligamental area, and, as shown in Clarke's figure, in the radial ribbing on the body of the right valve. It differs from *A. aroostooki* in the much more distant ribs, more profuse development of interstitial riblets, and especially in the much greater development of concentric lines on the body. These lines in typical *A. aroostooki* are rarely discernible. The outline also appears to be somewhat different, for *A. concentrica* has a longer and shallower ventral margin. In the widely separated radial ribs, and particularly in the development of finer interstitial riblets, the ornamentation is very much like that of *Actinopterella textilis* (Hall);[1] the two forms also agree in outline,

[1] Hall, James, Paleontology of New York, vol. 3, p. 288, 1859; compare especially Hall's pl. 52, fig. 9.

broad shallow ventral margin, etc., but *A. concentrica* is a much smaller shell, and its concentric lines on the body are quite characteristic. Nevertheless *A. concentrica* may prove to be only a variety of *A. textilis* (Hall).

ACTINOPTERELLA TENUIRADIATA sp. nov.

Plate XVII, figure 18.

1907. *Pterinea mainensis* (pars). Clarke, New York State Mus. Bull. 107, p. 201, lower right-hand figure only.
Lower Devonic: Telos Lake dam and Moosehead Lake, 7 miles north of Kineo, Somerset County, Maine.

This is the only species of Actinopterella which has been found in the Moose River sandstone fauna of Somerset County, Maine. In this fauna, as contrasted with the late Silurian marine faunas of southern Maine and the late Helderbergian Chapman fauna, the genus Actinopterella is rare, and the present species is represented by only a single left valve. The species resembles *A. radialis*, of the Chapman fauna, in its prominent ventricosity, obliquity, and vertical or posteriorly directed byssal sinus, but it is distinguished by the very fine and more numerous radial riblets or lines on the body.

The type and only specimen is very oblique; the oblique axis is inclined at an angle of about 45° with the hinge. Height less than the length; incomplete posteriorly; total length probably about 33 millimeters or 1⅓ times the height. Greatest height far back at the posterior third. Hinge line long, continuously straight on both sides of the beak, and equal to the greatest length of the shell. Anterior end rounded; posterior end acutely pointed. The posterior wing in the left valve (right valve unknown) is large, concave, approximately in the plane of the margin of the shell, and distinctly demarcated from the body. The posterior margin of the wing is deeply concave, the lower portion directed upward and forward, the upper portion directed backward at an angle of about 65° or more with the hinge line. The anterior ear is well developed, rounded, slightly higher than long. The byssal sinus which separates the ear from the body of the shell is well developed, extends downward vertically or a trifle posteriorly, and produces a long constriction of the anterior margin. The body of the shell includes at the umbones an angle of 45° or less. The beaks protrude somewhat above the hinge line and are situated at the anterior one-fourth the length of the hinge line. The oblique height or oblique axis of the body is a trifle less than twice the oblique width of the body proper. The forward extremity of the shell is on the ear, just below the hinge line. The anterior margin includes an angle of 45° to 50° with the hinge line and is essentially parallel with the oblique axis. The ventral and posterior margins of the body are deeply convex. Ventral extremity far back, at the posterior third; posterior extremity of the body below the midheight. Hinge extremity is directly over the posterior extremity of the body or slightly farther back. The left valve is strongly ventricose. The umbo, the body of the shell, and the anterior ear are highly convex, inflated. The posterior wing is abruptly depressed from the body, is concave, and lies nearly in the plane of the margin of the shell. The point of maximum depth is on the oblique axis, slightly above the midheight. The depth of the left valve, 7 millimeters, is equal to more than one-fourth the height. The byssal sinus is well developed on the surface, where it is of moderate depth, but it hardly insinuates the front margin. The ligament is in a narrow semicylindrical escutcheon, which does not appear to be wrinkled or striated in the specimen examined except just back of the umbones, where a couple of striations are discernible. The ligamental strip is nearly in the plane of the margin. Cardinal teeth not observed. Posterior lateral tooth just below the ligament; single in the left valve, deep, rigid, extending to the posterior three-fourths the length of the hinge line. Anterior muscular scar small and deep, situated on the floor of the anterior of the valve, in front of the umbones, underneath the place of the foremost cardinal tooth. The posterior scar and pallial line are not impressed.

Surface ornamentation not very distinctly preserved on the specimen, which is a sculpture cast. The ornamentation, so far as it is preserved, consists of very fine, narrow, subequal radial riblets or lines on the body. At a distance of 12 millimeters from the umbo, just in front of the middle of the body, there are between four and five radial lines in the width of 1 millimeter. Ear and wing ornamentation indistinct.

Height, 25 millimeters; length, when complete, about 33 millimeters; depth of left valve, 7 millimeters.

Locality: Dense blue calcareous Moose River sandstone, Somerset County, Maine (locality 1100 A).

U. S. National Museum, catalogue No. 59793.

Comparisons.—As already indicated, the species is most closely related, among the Maine forms, to *A. radialis*, from which it is distinguished by its very fine, narrower, and more numerous radial lines. *Actinopterella tenuiradiata* has many features in common with the Bohemian *Actinopterella confortans* (Barrande) from an equivalent horizon, the Konieprussian. The two species agree in the long, narrow, very oblique body, very fine radial lineation, ventricosity of the shell, etc.; but the American fossil has more protruding umbones, a larger ear, and a longer and shallower byssal sinus.

Actinopterella sp. β.

Plate XXV, figures 17, 18.

This is a very small shell, about 1.5 centimeters high, nearly erect, with an extraordinarily large ear and nearly subcentral beak; right valve convex and usually concentrically striate; rarely marked with a few very faint radial lines. The left valve is strongly ribbed over the body. The wing of the left valve has a few radial ribs. The radial ornamentation continues faintly over the sinus but is not detected on the ear. The shell is ventricose. The byssal sinus is well developed and, in the right valve, is accompanied by a deep notch. This small species, which may be called Actinopterella sp. β, closely resembles *A. aroostooki* in the peculiar character of the ribbing on the body of the left valve and in the subdued extension of the ribbing on the wing and over the sinus. It differs from *A. aroostooki* in its much larger ear, more nearly subcentral beaks, and more nearly erect form; the ligament is highly inclined to the plane of the margin, and the ornamentation over the region of the ligament is faint.

Locality: Chapman sandstone, Presque Isle Stream, at end of Tweedy road (locality 1099 A), Aroostook County, Maine.

U. S. National Museum, catalogue No. 59794.

Actinopterella sp. γ.

Plate XXIII, figures 3, 7.

This shell, which is represented by crushed and imperfect specimens, may possibly be the mature stage of Actinopterella sp. β, which it resembles in ornamentation, ligamental structure, and ventricosity; it differs, however, in being larger and more oblique and in having the beaks more anterior. The height is from 2 to 3 centimeters. Several of these shells show ornamentation similar to that of *A. textilis* (Hall),[1] but in Actinopterella sp. γ intermediate riblets occur sparsely and irregularly, not uniformly as in *A. textilis*. The species may be distinguished from *A. radialis* by its more distant ribs and more distinctly ribbed wing.

Locality: Chapman sandstone, Presque Isle Stream, at end of Tweedy road (locality 1099 A), Aroostook County, Maine (associated with sp. β).

U. S. National Museum, catalogue No. 59795.

Actinopterella sp. δ.

Plate XXIII, figure 2.

This form is represented by an obscurely marked, strongly oblique ventricose left valve distinguished by its fine, profuse ribbing, which is continued over the wings. The umbones are broad and protrude above the hinge. The specimen bears some superficial resemblance to *Actinopterella tenuistriata* (McCoy) but is more oblique and has a stronger byssal sinus.

[1] Hall, James, Paleontology of New York, vol. 3, pl. 52, fig. 10, 1859.

Locality: Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59796.

Genus PTERONITELLA Billings.

Billings [1] defines the genus Pteronitella as follows:

> Among the fossils collected at Arisaig there are many casts of the interior of several species congeneric with *Avicula retroflexa* (Hisinger). These show that in front of the beaks there are several small anterior cardinal teeth and that close beneath the hinge line there are several more or less elongated posterior teeth. This arrangement is quite different from that of both Avicula and Pterinea, to which these shells are usually referred. There is a strong anterior muscular impression, and the whole structure of the hinge resembles closely that of Cyrtodonta.
>
> Prof. McCoy has noticed these teeth in his description of *P. retroflexa* (Paleozoic fossils, p. 262) but did not seem to think their structure of generic importance. I propose to separate *P. retroflexa* and others of similar structure from Pterinea and to place them in a new genus, Pteronitella.

This genus is of interest because of its wide distribution and, so far as known, rather small geologic range. As stated by Billings, the genus was erected in 1874 for the species *Avicula retroflexa* (Wahlenberg), to which Billings added three similar species from the Ludlow faunas of Arisaig, Nova Scotia. Barrande defined three Bohemian species of the Wenlock Aymestrian, étage E^2, as probably belonging to Pteronitella, but the genus appears to have been neglected by later authors until Clarke [2] recognized it in the faunas of Dalhousie, New Brunswick, and Aroostook County, Maine. Indeed, although both Billings and Barrande used the generic name Pteronitella it was not recognized in conchologic manuals. In 1899 Philippi,[3] in calling attention to some discoveries connected with the hinge structure of the genotype, calls the fossil *Pterinea retroflexa*. Three years later Reed[4] described under the name *Pterinea condor* a typical Pteronitella, neglecting to notice the existence of the name Pteronitella.

As neither Billings, Barrande, nor Clarke has given a complete description of the genus, the following diagnosis is proposed:

Pterinoid shells, with right valve less convex than the left but apparently not becoming resupinate in front; body of the shell erect; surface concentrically striate; small auricle and very large wing distinctly developed; the marginal sinus below the auricle usually very faint and small, occasionally indistinguishable; the anterior margin frequently continuing convex up to the hinge line, but in such specimens there is a distinct auricular expansion in advance of the umbones. The posterior wing is alate and well developed; the posterior margin sigmoidal, but never very deeply so. The lack of obliquity is characteristic of the typical members of the group. The shells are quadrate, or more frequently transversely elongated, forming an inverted oblong trapezoid. The left valve varies from depressed to moderate convexity, and is rarely a little gibbous; the right valve is convex, typically less so than the left; it varies from depressed convexity to nearly flat, but so far as known does not become concave in front. The ligamental area is broad, striated; continuous in front of and behind the beaks. Both cardinal and posterior lateral teeth are developed; the latter are situated nearly parallel with and but little if at all removed from the hinge line. The cardinal teeth are narrow radial ridges, four or five [5] in number in the left valve, one less in the right. The foremost one is the stronger and inclines downward and slightly forward, the others incline slightly backward. The cardinal teeth are situated in front of the beaks on the hinder portion of the auricle. The posterior lateral teeth

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[1] Billings, Elkanah, Paleozoic fossils, vol. 2, pt. 1, pp. 141-144, pl. 9, figs. 5, 6, 7, 1874. *Avicula (Pterinea) retroflexa* (Wahlenberg) is the genotype. Billings described three species from Arisaig—two transversely elongated, oblong forms, *P. venusta* and *P. oblonga*, and one nonelongated, quadrate form, *P. curta*.

[2] New York State Mus. Bull. 107, pp. 210-213, 1907.

[3] Philippi, Emil, Ueber das Schloss von *Pterinea retroflexa* Wahlenberg's sp.: Deutsch geol. Gesell. Zeitschr., vol. 51, pp. 181-183, April, 1899.

[4] Reed, F. R. C., Woodwardian Museum notes; Salter's undescribed species: Geol. Mag., 2d ser., decade 4, vol. 9, p. 147, pl. 7, figs. 6, 7, 1902.

[5] Billings (op. cit., p. 142, pl. 9, fig. 5b) describes and figures four cardinal teeth, but his figure shows four teeth in the left valve and three in the right. Philippi has observed four tooth sockets in the left valve of the typical specimen of *P. retroflexa* (Wahlenberg), from the sandy crinoidal limestone of Mount Hoburg, Gotland. The foremost tooth or socket is the stronger and is vertical or inclines slightly forward; the others are directed backward, as also illustrated and described by Billings. Philippi states that there were five cardinal teeth in the left valve of his Gotland specimens and four in the right.

are narrow, septa-like ridges, close under the hinge line,[1] and not oblique nor far removed from it. There is usually one in the right valve, inserted between two in the left valve;[2] the lower tooth in the left valve is stronger than the upper, which is also smaller and shorter and, indeed, in some specimens is absent. Rarely there are two laterals in the right valve and three in the left. In one species, *P. cometula* Barrande, there are several postlateral teeth, all situated close under the hinge line, and the uppermost is the strongest. The posterior lateral teeth extend usually not more than half the distance from the umbones to the posterior hinge extremity. Muscular scars two; the anterior scar small, deeply impressed (bifid, according to McCoy), and situated on the auricle, in advance of the rostral cavity; the posterior scar is large and very feebly impressed, and is situated mainly or entirely on the wing. Shells thick; structure unknown. Ornamentation, concentric striæ, frequently lamellose, especially on the wing; no radial ornamentation except very rarely faint radial lines or scratches.

Geologic range, early, middle, and late Silurian (from the May Hill to the Upper Ludlow-Downtonian faunas) of Europe and America; unknown in the Ordovician; of doubtful occurrence in the lowest Devonian of Germany.

The following species are referable to the genus Pteronitella as above defined:

1. *Pterinea retroflexa*. Wahlenberg, Petrificata telluris svecanæ examinata: Soc. reg. sci. Upsala Acta, vol. 8, p. 57, 1821. Sandy crinoidal limestone (Silurian): Hoburg, island of Gotland. See also Hisinger, Wilhelm, Lethæa svecica seu Petrificata sveciæ iconibus et characteribus illustrata, p. 57, pl. 17, fig. 12, Hohinæ, 1837; Philippi, Emil, op. cit. Hisinger referred the species to the Liassic and Oolitic. The shell currently identifiable with Wahlenberg's species occurs in extreme profusion in the Silurian sandy crinoidal limestone of Hoburg.

?2. *Avicula whitfieldi*. Foerste, Fossils of the Clinton group in Ohio and Indiana: Ohio Geol. Survey, vol. 7, p. 558, pl. 37, fig. 5, 1894. Clinton: Todds Fork and Wilmington, Ohio.

3. Pterinea sp. Kindle and Breger, Paleontology [of the Niagara of northern Indiana]: Indiana Dept. Geology and Nat. Res. Twenty-eighth Ann. Rept. (for 1903), p. 448, pl. 10, fig. 8, 1904. Niagara or Guelph: Delphi and Wabash, Ind.

4. *Avicula subplana*. Hall, Paleontology of New York, vol. 2, p. 283, pl. 59, figs. 3a, 3b, (not fig. 3c), 1852. Rochester shale: Lockport, N. Y.

5. *Avicula naviformis* (pars) (not Conrad). McCoy, British Paleozoic rocks and fossils, p. 263, 1855. Wenlock limestone: Dudley, Staffordshire. [Conrad's species is the New York Helderberg (Coeymans limestone) fossil. He incidentally mentions the same species as occurring at Dudley, England.]

6. *Posidonomya? rhomboidea*. Hall, op. cit., p. 284, pl. 59, fig. 5, Niagara group: Lockport, N. Y.

7. *Pterinea condor* (Salter). Reed, Woodwardian Museum notes; Salter's undescribed species: Geol. Mag., 2d ser., decade 4, vol. 9, p. 147, pl. 7, figs. 6, 7, 1902. Lower Ludlow: Dudley, Staffordshire.

8. *Pterinea subplana* (not Hall?). Clarke and Ruedemann, Guelph fauna in the State of New York: New York State Mus. Mem. 5, p. 49, pl. 5, fig. 4, 1903. Guelph dolomite: Rochester and Shally, N. Y.

9. *Avicula comes*. Barrande, Système silurien du centre de la Bohême, pt. 1, vol. 6, pl. 223, box I, fig. 5, 1881.

10. *Avicula cometula*. Barrande, idem, pl. 356, figs. 1–7.

11. *Avicula dispersa*. Barrande, idem, pl. 223, box I, figs. 3, 4.

12. *Avicula explanata*. Barrande, idem, pl. 224, box III.

13. *Avicula inclinata*. Barrande, idem, pl. 222, box I, figs. 6, 7.

14. *Avicula jacens*. Barrande, idem, pl. 223, box I, figs. 1, 2.

15. *Avicula reinformis*. Barrande, idem, pl. 225, box VIII.

16. *Avicula tristis*. Barrande, idem, pl. 224, box IV.

Nos. 9–16 from étage E^2 (equivalent of Aymestry of England and Guelph of America), Bohemia.

17. *Pterinea retroflexa* (Wahlenberg) var. *gamma* (not=*Avicula erecta* Conrad). McCoy, op. cit., p. 262, pl. 1, I, fig. 8. Upper Ludlow: Laverock Lane. Tilestones: Horeb Chapel, Llandovery, South Wales. *Avicula erecta* Conrad, which was identified by McCoy as a form of *Pterinea retroflexa*, equals *Glyptodesma erectum*. McCoy also regarded *Avicula demissa* Conrad and *A. ampliata* Phillips as forms of *P. retroflexa*, but these shells are oblique, have a resupinate right valve and oblique posterior lateral teeth, and belong to the genus Pterinea Goldfuss s. str.

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[1] McCoy (British Paleozoic rocks and fossils, p. 262, 1855) states that the posterior lateral tooth in *P. retroflexa* diverges "slightly" from the hinge line, and Billings (op. cit., pl. 9, fig. 7) figures a very slight divergence in *P. oblonga*, but the teeth are not oblique to nor distantly removed from the hinge line, as they are in *Pterinea lævis* Goldfuss, *Cornellites flabella* Conrad, and *Follmannella mainensis*, in which the teeth are situated at or near the inner boundary of the wing, where the wing meets the body of the shell. In Pteronitella, as in Actinopterella, the posterior lateral teeth have not yet migrated inward away from the hinge.

[2] Philippi records two in the left valve of the typical Gotland species *P. retroflexa* (Wahlenberg). McCoy describes "two slender posterior teeth about two-thirds the length of the hinge line," and his only figure which shows dentition (op. cit., pl. 1, fig. 8) indicates one posterior lateral in the right valve. Billings (op. cit., p. 142) describes two lateral teeth in the right valve and one in the left in *P. venusta*, but his figures (pl. 9, figs. 5, 5a, 5b) show just the reverse, one in the right valve and two in the left, with the upper tooth in the left valve more weakly developed than the lower tooth.

18. *Pterinea retroflexa* (Wahlenberg) var. *beta* (cf. *Avicula naviformis* Conrad). McCoy, idem, p. 262, pl. 1, I, figs. 9, 10. Upper Ludlow: Kirby Moor, Kendal, Westmoreland; also Hall End in the Malverns, and near Usk, according to Sowerby (Murchison, R. I., Silurian system, pp. 609–610, pl. 5, fig. 9, 1839).
19. *Pteronitella venusta*. Billings, Paleozoic fossils, vol. 2, pt. 1, p. 142, pl. 9, fig. 5, 1874.
20. *Pteronitella oblonga*. Billings, idem, p. 143, pl. 9, fig. 7.
21. *Pteronitella curta*. Billings, idem, p. 143, pl. 9, fig. 6.
   Nos. 19–21 from Moydart and Stonehouse formations: Arisaig, Nova Scotia.
22. *Avicula rectangularis*. Sowerby, op. cit., p. 603, pl. 3, fig. 2. Tilestones: Horeb Chapel, South Wales.
23. *Pteronitella passer*. Clarke, Some new Devonic fossils: New York State Mus. Bull. 107, p. 212, figs., 1907. Lower Devonic: Dalhousie, New Brunswick. *Pteronitella hirundo* Clarke, from the same locality, is a Palæopinna. The Chapman *Pteronitella peninsulæ* Clarke equals *Actinopterella radialis* (Clarke).
24. *Pteronitella quadrata* sp. nov. Chapman sandstone: Aroostook County, Maine.
25. *Pterinea lævis* Goldfuss var. *præcursor*. Frech, Die devonischen Aviculiden Deutschlands: Abh. geol. Specialkarte Preussen, vol. 9, pt. 3, p. 93, pl. 2, figs. 14–15b; pl. 9, fig. 10, 1891. Siegen graywacke and Taunus quartzite: Rhenish province, Germany. The shells figured on pl. 2, figs. 14–15, from the Siegen graywacke of Unkel, are too oblique for a Pteronitella and resemble internal molds of an Actinopterella.
26. Pterinea aff. *P. lævis* (not Goldfuss). Drevermann, Die Fauna der Untercoblenzschichten von Oberstadtfeld bei Daun in der Eifel: Palaeontographica, vol. 49, p. 82, pl. 9, fig. 17, 1902. Lower Coblenzian: Oberstadtfeld, near Daun, in the Eifel, Germany.
27. *Liopteria browni*. Clarke, The Paleozoic faunas of Para, Brazil; Devonian Mollusca: Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 5, fig. 13, 1899 (author's English ed., p. 48, 1900). Lower Coblenzian: Rio Maecuru, Para, Brazil. The species differs from Liopteria in being erect and in having the posterior scar on the wing, as in Pteronitella.

Many species of Pteronitella have been referred by recent authors to Pterinea on account of the presence of the broad ligamental area, deep anterior muscular impression, cardinal and posterior teeth, and concentric ornamentation. In the last feature they conform with Pterinea s. str. (*P. lævis* Goldfuss). Pteronitella Billings differs from Pterinea Goldfuss in several respects. The teeth in Billings's genus, unlike those of *Pterinea lævis*, *Pterinea demissa* Conrad, and *Pterinea ampliata* Phillips, are close under the hinge line, as in Actinopterella. In the smooth shells constituting the true Pterinea the posterior lateral teeth are very oblique to the hinge line and are situated on the inner portion of the wing near the junction of the wing with the body. As another distinction may be mentioned the erect expression of Pteronitella. Pterinea is oblique, and this distinction in external outline will permit the ready reference of shells to Pteronitella when the internal features are unknown. A third distinction lies in the fact that whereas the right valve of Pterinea is always depressed and resupinate (slightly convex on the umbones, concave below), the right valve of Pteronitella is frequently rather convex, generally decidedly less convex than the left valve, though apparently not resupinate.

It is unfortunate that no right valves of typical Pteronitella are at hand for examination. The right valve in several species has been described as "depressed," a term also applied by authors to the right valve of Pterinea. However, it is important that a distinction be made between "depressed" valves which are depressed-convex throughout and those which are resupinate, having a "double curvature," convex on the umbones and concave below, as in the Pterinea groups. I am of the opinion that the right valve of Pteronitella is convex and not resupinate, for right valves wherever they have been figured are shown either depressed-convex or strongly convex, never resupinate. If this opinion is well founded the persistently resupinate character of the right valve of Pterinea will be recognized, in strong contrast to the nonresupinate right valve of Pteronitella and Actinopterella.

The oblong forms of Pteronitella, like *P. naviforme* (Conrad), *P. venusta* and *P. oblonga* Billings, *P. condor* (Salter) Reed, and *P. retroflexa* (Wahlenberg), bear a certain resemblance in their transverse extension to McCoy's genus Pteronites. Unfortunately McCoy's types are not well known. In the New York Upper Devonian shells referred to Pteronites by Hall [1] (*P. profundus*, *P. rostratus*, and *P. inoptatus*, to which should probably be added *Leptodesma aliforme* Hall, *L. extenuatum* Hall, and the right valve figured on his plate 90, figure 20 (not fig. 19), as *Leptodesma hector*) the posterior scar is much larger than in Pteronitella and is situated mainly or entirely on the body, instead of on the wing, as in Pteronitella. Hall's *Leptodesma aliforme* shows a posterior lateral tooth in the right valve close to the hinge line, in this respect con-

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, vol. 1, pp. 237–239, pl. 22, figs. 24–27; pl. 87, fig. 5, 1884.

forming with Pteronitella. The right valve is "flat" below, depressed-convex in the middle, and more decidedly convex on the umbones. All these shells occur in the higher Chemung of Tioga and Bradford counties, Pa., and Allegany and Cattaraugus counties, N. Y. It is apparent that they are merely extreme forms of the shells called Leptodesma by Hall, but whether these forms ought to be referred to the Pteronites of McCoy is by no means certain. Hall's shells also differ from Pteronitella in the extreme obliquity of the anterior margin, which gives them a superficial aspect like that of Aviculopinna. Pteronites McCoy lacks the broad, striated, ligamental area of Pteronitella, and has only a single cardinal tooth under the beak of the right valve, in which respects it is decidedly distinct. The well-developed anterior muscular scar situated on the auricle in Pteronitella has never been observed in Pteronites; indeed, McCoy describes Pteronites as wanting the anterior adductor impression. In Hall's species *Leptodesma aliforme* the pallial line extends toward the rostral cavity, as in several other species of Leptodesma and in the Aviculidæ, and not to the auricle, as in the Pterineas. If the anterior scar is lacking in Pteronites and Leptodesma, or is very feebly developed and is umbonal, as seems probable, this character will remove McCoy's genus Pteronites, as well as the Leptodesma, to the monomyarian Avicula and its allies. The relations of Pteronitella, on the other hand, are decidedly with the heteromyarian Pterinea.

Pteronitella might be confused with Leiopteria Hall, with which it agrees in the concentric ornamentation, in having the right valve convex but less so than the left, and in having posterior laterals (usually not discernible) close under the hinge line; but Leiopteria is easily distinguished from Pteronitella by its characteristic obliquity. Leptodesma Hall is generally still more oblique.

Palæopinna Hall bears some general resemblance in outline to the typical Pteronitellas (*P. condor* (Salter) Reed, *P. retroflexa* (Wahlenberg), *P. naviforme* (Conrad) and *P. venusta* and *P. oblonga* Billings), but differs from them in the persistence of radial lineation; in the typically thin linear ligamental area and, especially, in its truncate anterior margin, which is entirely devoid of auricle and which has the beaks terminal.

Some discussion has arisen regarding the relative values of the names Pteronitella Billings, 1874, and Mytilites Wahlenberg, 1821. The name Mytilites Wahlenberg can have no value in zoologic nomenclature, as it was used in a very general way by Wahlenberg to include practically all fossil lamellibranchs embedded in solid rocks. Wahlenberg divided Recent bivalve shells into Mytili, Ostrei, and Anomiæ, and recorded *Mytilus edulis* and *Mytilus pholadis*, two now living shells, from the glacial beds of Uddevalla. It is apparent that Wahlenberg included under the name Mytilus all the dimyarian and heteromyarian lamellibranchs—in fact, all the lamellibranchs except the Ostreidæ. The "Mytili" embedded in the solid rocks Wahlenberg called "Mytilites," so that the name has a significance similar to that of Anomites as applied by early authors to the fossil brachiopods, and this significance is certainly unlike and more general than that of a generic name. *Mytilites retroflexus* is the second species described by Wahlenberg, who records it from southern Gotland in calcareous and arenaceous beds. The first species of Mytilites described is *Mytilites edulis affinis* Wahlenberg, from the graptolite shales of Westrogothia, so that even if the name Mytilites were restored, which it ought not to be, it could not be applied to *Pteronitella retroflexa,* but would have to be used for the "*Mytilites edulis affinis*" of Wahlenberg.

PTERONITELLA QUADRATA sp. nov.

Plate XXIII, figure 5.

Outline erect, quadrate. Height, 23 millimeters, nearly equal to the length ("width"), which is 24¼ millimeters. Greatest height near the midlength; greatest length at the inferior two-sevenths. Hinge line long, slightly less than the length of the shell. The umbones are situated at the anterior fifth or sixth of the length of the hinge, are rather full, incurved, and prosogyrate, and protrude slightly above the hinge line. The anterior margin is sigmoidal and erect. In front of the umbones the anterior margin is convex, producing in the outline the appearance of a small ear; below this the margin is strongly insinuated by a byssal sinus that extends down one-third or two-fifths the height, below which the anterior margin along the body of the shell is again convex, in general vertical, and with the foremost extremity vertically below or rather distinctly in advance of the "auricle." The ventral margin is broad, depressed-convex, and with the lowest point in front of the middle; the margin slightly ascending toward the rear and curving into the posterior margin, which turns upward at an angle of about 95° with the hinge line. The hindmost extremity of the shell is near the base of the posterior margin, at two-sevenths the height of the shell above the ventral extremity. The posterior margin is depressed-convex in the lower part, broadly and faintly concave near the middle, and straight and directed slightly forward in the upper part. The left valve is strongly convex, especially in the umbones, and is also very full in the body. The subalate posterior is indistinctly demarcable from the body. The byssal sinus, though strongly marked in the anterior outline, is very faint on the surface, which has here a steep slope. The so-called "auricle" is not flattened, but is slightly inclined—more so than the subalate posterior. Although the shell as a whole is erect, the gibbous umbones are inclined at an angle of about 20° from the perpendicular. The point of greatest depth is between the anterior third and fourth of the length and at the upper third of the height, just behind the byssal sinus. The depth of the left valve is 5 millimeters, or a little more than one-fifth the length.

The impression of a single, slender, horizontal posterior-lateral tooth is preserved; it must have been very close to the hinge line. Above this tooth the specimen is broken away. The cardinal margin at the umbone is also broken away, so that it is impossible to describe the cardinal teeth. Muscular scars not preserved.

Surface concentrically striate, with a few low concentric wrinkles and lamellose varices. The varices are most distinct along the ventral margin and along the anterior margin below the byssal sinus; the posterior is faintly striate, as is also the region of the byssal sinus. The concentric striations are occasionally rather regular, almost bellastriate over the body, but are rather faint; they are still fainter on the posterior.

Locality: Chapman sandstone, on Presque Isle Stream near the Tweedy road (locality 1099 L); Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59797.

Comparisons.—The distinguishing features of the species are the erect quadrate outline, with the height very nearly equal to the length; anterior margin vertical or protruding, not diagonally retroceding; anterior or byssal sinus well developed in the outline; posterior margin faintly or hardly at all sigmoidal, the upper part reaching upward and slightly forward to the hinge. Its quadrate outline distinguishes it from the transversely elongated species of Pteronitella, such as *P. retroflexa* (Wahlenberg), *P. naviforme* (Conrad), *P. condor* (Salter) Reed, *P. venusta* and *oblonga* Billings, *P. cometula* (Barrande), etc. *P. quadrata* belongs to a group of quadrate species of Pteronitella in which the height is about equal to the length; includes *Pteronitella curta* Billings, *P. rectangularis* (Sowerby), *P. erecta* (McCoy), etc. From the last two species *P. quadrata* differs in having the anterior margin vertical instead of diagonally retroceding. From the Arisaig *P. curta* Billings, which it closely resembles, *P. quadrata* differs in having the ventral margin less bellied down, in being more quadrate instead of semielliptical, in having the posterior margin sigmoidal—though only slightly so—and directed upward and forward; and in being smaller. *P. quadrata* bears a close resemblance in outline and convexity to the *Posidonomya? (Pteronitella) rhomboidea* Hall, of the Niagara, but differs from it in having a well-developed byssal sinus in the upper anterior margin, which, in *P. rhomboidea*, is convex throughout. In the quadrate outline, vertical anterior margin, byssal sinus, and slightly auricular expansion the shell resembles *Leiopteria (Pteronitella?) browni* Clarke, but that species is much larger and, unlike *P. quadrata*, has the upper part of the wing extended posteriorly.

Genus MEGAMBONIA Hall, 1859.

The genus Megambonia was founded by Hall[1] in 1859 to include eleven species from the Helderberg group, two from the New York Oriskany, and one from the "Corniferous" limestone. These fourteen species comprise a heterogeneous assemblage including species referable to Vanuxemia Billings, Leiopteria Hall, and other genera.

[1] Hall, James, New York State Cab. Nat. Hist. Twelfth Ann. Rept., p. 12, 1859: Paleontology of New York, vol. 3, pp. 272 et seq., 1859 [1860?].

Of the eleven species of Megambonia described by Hall from the Helderberg, only two appear to belong to the genus, namely, *M. ovoides* and *M. rhomboidea* Hall. *M. mytiloidea* and *M. obscura* are species of Plethomytilus or some allied mytiloid; *M. aviculoidea* and the Oriskanian *M. lamellata* belong to the genus Leiopteria; *M. lata* is a species of the Cypricardites-Cyrtodonta group; *M. cordiformis* and *M. ovata* appear to be species of Vanuxemia, though they have been regarded as Mytilarca or Plethomytilus by Miller and by Hall. *Megambonia suborbicularis* and *M. spinneri* may also possibly belong to Vanuxemia. *Megambonia oblonga* Hall is the genotype of the new genus Preavicula described on page 205.

The genotype of Megambonia is *M. cardiiformis* (Hall),[1] from the "Corniferous" limestone.

Hall separated Megambonia from Ambonychia because it has a well-developed anterior lobe or auricle, which is absent in Ambonychia; the auricle is separated from the body by a distinct byssal sinus. The anterior muscular impression is distinctly developed, fairly large, and situated on the auricle. In the ambonychioids the anterior muscular impression is either lacking or indistinct and minute, the pallial line terminating in the rostral cavity. Megambonia is therefore related to the heteromyarian Pterineæ, whereas Ambonychia represents the early monomyarian Avicula type. The shells of Megambonia have a characteristic expression easily recognized by their subcircular outline; inflated umbones, ventricose, equal valves; rounded auricle; wing obscurely developed or lacking; surface typically covered with fine radial lines crossed by concentric lines. In the original diagnosis of the genus given in 1859 Hall laid stress on the occurrence of numerous teeth or crenulations on the anterior portion of the hinge line. In 1885 this portion of the description was retracted.

The original diagnosis of the genus is as follows:[2]

> Shell equivalve or subequivalve, inequilateral, subovoid, usually very gibbous in the middle and toward the umbones; anterior side often lobed or auriculate, a strong muscular impression occupying a considerable portion of this portion of the shell; posterior cardinal margin expanded, more or less compressed and frequently alate; hinge crenulated on the anterior end; teeth numerous. Surface marked by concentric laminæ of growth and often by fine radiating striæ. The entire structure of the hinge is unknown; and the grouping of the species has been mainly determined by external form and marking and the large anterior muscular scar, which is a conspicuous feature in most of the species.

Hall[3] designated *Pterinea? cardiiformis* Hall, 1843, as the type of the genus.

In 1885 the generic description was emended by Hall[4] to read as follows:

> Shell equivalve or subequivalve, very inequilateral, obovoid, body very oblique; anterior end (in two typical forms) lobed; posterior large, constituting the principal part of the shell; beaks anterior; cardinal line short; subalate posteriorly; umbonal slope ventricose, not defined. Surface marked by fine striæ of growth, which in some species are crossed by fine radiating striæ. Hinge line short; a distinct lateral fold and groove near the postcardinal angle. Ligament internal. Anterior muscular impression large and strong; posterior impression large. The type of the genus is well marked, and its form and external characters are very distinctive. It does not, however, show the anterior teeth or crenulations mentioned in the original description. In the third volume of the Paleontology of New York several species are described under this designation which further study has shown not to be congeneric. At the present time the only forms which I regard as strictly belonging to the genus are from the Corniferous limestone and Oriskany sandstone. Those from the Lower Helderberg group require more material for a final determination.

Hall then designated *Megambonia cardiiformis*, from the "Corniferous" limestone, and *M. bellistriata*, from the Oriskany, as characteristic of the genus. These two species are regarded by Clarke[5] as identical. Hall also indicated that such forms as *M. lamellosa* are doubtfully referred to the genus. This species is apparently a Leiopteria.

In all the American radiostriate shells which conform with *M. cardiiformis* and *M. bellistriata* Hall the posterior wing is rounded and there is no wing nor alation at the hinge extremity, but in some of the European species a wing is faintly developed. The occurrence of an internal ligament, as noted by Hall, is doubtful, as one of his figures[6] seems to indicate an external ligament. One figure of *M. striatocostata* Giebel given by Barrois,[7] however, indicates an internal ligament.

[1] Hall, James, Geology of New York, Rept. Fourth Dist., p. 173, 1843. This shell should not be confused with *Megambonia cordiformis* Hall, 1859, from the Helderberg.

[2] Hall, James, Paleontology of New York, vol. 3, p. 273, 1859 (1860?).

[3] Idem, p. 272.

[4] Paleontology of New York, vol. 5, pt. 1, p. lv, 1885.

[5] Clarke, J. M., The Oriskany fauna of Becraft Mountain, Columbia County, N. Y.: New York State Mus. Mem., vol. 3, p. 35, 1900.

[6] Paleontology of New York, vol. 5, pt. 1, pl. 52, fig. 2, 1885.

[7] Barrois, Charles, Faune du calcaire d'Erbray: Soc. géol. Nord Mém., vol. 3, pl. 10, fig. 8a, 1889.

The genus Myalinopteria Frech is apparently a synonym of Megambonia Hall.

Megambonia Hall is closely related to the Ordovician genus Prolobella Ulrich,[1] agreeing in outline, biconvexity, and presence of radial ornamentation. The Ordovician shells, however, are much smaller; the auricle and the anterior muscular impression are proportionately more minute than in Megambonia, and the radial lines are somewhat different.

The genus Megambonia Hall as above interpreted includes the following species:

Megambonia rhomboidea. Hall, Paleontology of New York, vol. 3, p. 275, pl. 49, fig. 9, 1859. Helderberg group: New Scotland, N. Y.

Megambonia ovoidea. Hall, idem, p. 276, pl. 49, *A*, fig. 4. Helderberg group: New Scotland, N. Y.

Megambonia parva. Weller, Paleozoic faunas: Paleontology of New Jersey, vol. 3, p. 333, pl. 43, fig. 12, 1903. *Dalmanites dentatus* zone or Trilobite beds: New Jersey.

Megambonia bellastriata. Hall, op. cit., p. 467, pl. 109, fig. 4. Oriskany: New York.

Megambonia crenistriata. Clarke, New York State Mus. Mem., vol. 3, pl. 4, p. 35, figs. 15–17, 1900. Oriskany fauna: New York; Gaspe, Quebec.

Megambonia denysia. Clarke, New York State Mus. Bull. 107, p. 216, figs., 1907. Lower Devonic: Perce Rock, Quebec.

Pterinea striatocosta. Giebel, Die silurische Fauna des Unterharzes, p. 27, pl. 5, figs. 15, 18, 1858. Hercynian: Harz Mountains. The Pterinea sp. of Kayser (Die Fauna der ältesten Devon Ablagerungen des Harzes: Abh. geol. Specialkarte Preussen, vol. 2, pt. 4, p. 135, pl. 19, fig. 4, 1889), from the Schneckenberg limestone of the Harz, represents this species. The fossil is also recorded and well illustrated by Barrois (Faune du calcaire d'Erbray: Soc. géol. Nord Mém., vol. 3, p. 171, pl. 10, fig. 8, April, 1889) from the Erbray limestone of Loire Inferieure, western France.

Myalinopteria alpina. Frech, Die devonischen Aviculiden Deutschlands: Abh. geol. Specialkarte Preussen, vol. 9, pt. 3, p. 139, pl. 18, fig. 1, 1891. Hercynian reef limestone: Wolayer Thörl, Carnish Alps.

Megambonia cardiiformis. Hall, Paleontology of New York, vol. 5, pt. 1, p. 515, pl. 52, figs. 1–8, 1885. *M. bellastriata, M. crinita, M. denysia,* and *M. subcardiiformis* appear to be synonyms. Corniferous limestone: New York.

Megambonia subcardiiformis Hall = *M. cardiiformis* Hall.

(*Myalinoptera*) *crinita* (A. Roemer). Frech, op. cit., p. 138, pl. 11, figs. 1–7, Lower Neo-Devonian: Grund and Claus Valley, Germany.

MEGAMBONIA cf. M. CARDIIFORMIS Hall.

Plate XXIV, figure 4.

1843. *Pterinea? cardiiformis.* Hall, Geology of New York, Rept. Fourth Dist., p. 173, fig. 1 (on p. 172). Corniferous limestone: Clarence Hollow, Erie County, N. Y.

1859. *Megambonia cardiiformis.* Hall, New York State Cab. Nat. Hist. Twelfth Ann. Rept., p. 13.

cf. 1859. *Megambonia bellistriata.* Hall, Paleontology of New York, vol. 3, p. 467, pl. 109, fig. 4. Oriskany sandstone: Albany and Schoharie counties, N. Y.

1885. *Megambonia cardiiformis.* Hall, Paleontology of New York, vol. 5, pt. 1, p. 515, pl. 52, figs. 1–8. Upper member of the Corniferous limestone: Clarence Hollow, Erie County, N. Y.

cf. 1900. *Megambonia crenistriata.* Clarke, New York State Mus. Mem., vol. 3, p. 35, pl. 4, figs. 15–17. Oriskany fauna: Becraft Mountain, Columbia County, N. Y.

cf. 1908. *Megambonia crenistriata.* Clarke, idem, vol. 9, p. 157, pl. 21, figs. 6, 7. Gaspe limestone: Grande Greve, Gaspe, Quebec.

No species of Megambonia has been discovered in the Chapman fauna, but in the Moose River sandstone fauna of Somerset County, Maine, two small specimens of Megambonia have been found which, to judge from their outline and convexity, represent two distinct species. The larger specimen is identified with Hall's species, though it is much smaller than the typical New York forms. The smaller specimen, described below as the variety *parviuscula* var. nov., is distinct in outline and convexity and may be a distinct species instead of a variety. The specimen identified with Hall's species shows the following characters: Outline subovoid, erect.[2] Height, 27.7 millimeters; length, 26.5 millimeters without the auricle, but the shell is proportionately more transverse in the younger stages, as indicated by the lines of growth. Greatest height at the midlength; greatest length just below the midheight at the inferior three-sevenths. Umbones subventral, directed vertically upward, protruding very slightly beyond the hinge line. The hinge line back of the umbones is not preserved but was apparently rounded, convex, short; its length less than half the height of the shell, declining pos-

[1] Ulrich, E. O., Geology of Minnesota, vol. 3, Paleontology, pt. 2, p. 532, pl. 25, fig. 27, 1894.

[2] The shell is arbitrarily oriented as erect. Figures of these shells are usually oriented in an oblique position, which, technically, may be more nearly correct, considering the fact that the two muscular scars ought to be on a horizontal line. Practically it is found that comparison of the different forms of Megambonia is facilitated by orienting the figures with the shell seemingly erect instead of oblique.

teriorly at an angle of nearly 30° with the horizontal. The posterior hinge extremity is convexly rounded, not alate nor pointed. The posterior margin is strongly and symmetrically convex throughout; the hindmost extremity is at the inferior three-sevenths the height or near the midheight. The ventral margin is deeply bellied down, forming with the lower posterior and lower anterior margins a symmetrical, semicircular arc or paraboloid. The anterior margin is convex, with the foremost extremity of the body of the shell at the midheight. The upper part of the anterior margin, including the auricle, is not preserved on the specimen, which shows, however, traces of the byssal sinus extending radially forward from the beak. The shell is gibbous throughout, a little less so along the upper posterior margin than elsewhere. Just below the umbones it is very gibbous. The point of greatest depth is vertically below the beak at the superior third; the depth of the single left valve (7.7 millimeters) is more than one-fourth the height (27.7 millimeters). The byssal sinus appears to have been narrow but is distinctly preserved on the surface; it extends radially forward at an angle of 35° with the vertical. Hinge structure and musculature unknown. Shell very thin; crystalline; colored black, probably indicating a high organic content.

Surface covered with undulating concentric wrinkles of growth and a few low, lamellose varices, strongest in the middle. These are crossed by very fine radial lines over the entire body (the auricle is not preserved). The lines are more strongly developed over the central portion than toward the rear.

Locality: Moose River sandstone between Parlin Pond and Detroit (locality, 1100 A), Somerset County, Maine.

U. S. National Museum, catalogue No. 59798.

Comparisons.—The shell is much smaller than either Hall's *Megambonia bellistriata,* from the Oriskany, or his *M. cardiiformis,* from the "Corniferous." As suggested by Clarke in 1900, both of these names represent a single species, there being no reliable distinction between the Oriskany *M. bellistriata* Hall and the "Corniferous" *M. cardiiformis* Hall. Hall suggested that the latter was much more gibbous, which does not seem to be always true, and that the byssal sinus is shallower in *M. cardiiformis* than in *M. bellistriata,* which is only generally true; one of Hall's figures[1] shows a "Corniferous" *M. cardiiformis* with a deep and well-marked byssal sinus.

Any distinctions which may possibly exist between *Megambonia cardiiformis* Hall, from the Onondaga, and the so-called *Megambonia bellistriata* have yet to be proved, so that these two names may be regarded as identical. *M. cardiiformis* is the older name. All the other American species of Megambonia, including the Maine shell under discussion, are much smaller than Hall's *M. cardiiformis,* which is relatively of gigantic size. *Megambonia crenistriata* Clarke, from the Oriskany of Becraft Mountain, N. Y., differs from *Megambonia bellistriata* (= *cardiiformis*) Hall in being smaller and proportionately broader, and in having a longer, straighter, and more distinct hinge line. The other characters mentioned by Clarke—convex auricle, deep byssal sinus, coarser striæ on the auricle, and crenulations of the striæ—are also present on the normal *Megambonia bellistriata* (= *cardiiformis*) Hall. The distinctive characters of the small Becraft Mountain shell appear insufficient to separate it as a distinct species from *M. bellistriata* (= *cardiiformis*), the greater proportionate breadth in smaller specimens being, indeed, the normal occurrence in the immature of these shells. The ventral margin is much less bellied down in the so-called *M. crenistriata* than is usual in *M. cardiiformis,* and the hinge line is more distinct; but these may be regarded as extreme characters of a single species, the Maine specimen here described being intermediate in these respects between the two forms, though agreeing with the Becraft Mountain Oriskany shell in small size, as well as in habitat—at least so far as habitat is indicated by the same rock (a very hard, fine-grained blue quartzose limestone) and by similar fauna.

In its small size, outline, and convexity the Maine shell resembles the Helderberg *M. ovoidea* Hall, which has, however, a much less developed byssal sinus.

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[1] Paleontology of New York, vol. 5, pt. 1, pl. 52, fig. 1, 1885.

MEGAMBONIA cf. M. CARDIIFORMIS var. PARVIUSCULA var. nov.

Plate XIX, figure 23.

This small shell occurs with the normal *M. cardiiformis* above described in the Moose River sandstone fauna of Detroit, Somerset County, Maine. The two specimens, though associated, are regarded as at least varietally distinct. The small shell here described is more transverse and more nearly subcircular than the typical form; the length (14 millimeters) is slightly greater than the height (12 millimeters). The greatest length of the small variety is at the upper third, whereas it is below the middle in the larger shell. The umbones are central, directed upward, incurved, hardly if at all protruding above the hinge line. They subtend an angle of 90° or more. The posterior limit of the umbonal angle is less sharply defined than the anterior limit. The hinge line back of the umbones is short, convex, horizontal; equal in length to a trifle more than the height of the shell (in typical *M. cardiiformis* it is a trifle less than half the height and declines at an angle of 30° or more). The posterior hinge extremity is convexly rounded, decidedly not alate. The ventral margin is broadly rounded and is less deeply bellied down than in the larger forms. The forward extremity of the shell is lower down, being at the inferior third in the variety *parviuscula*. A deep byssal notch or sinus extends from the midheight to a point above the midheight of the anterior margin. The byssal sinus marks off from the body a proportionately very large, rounded auricle, which extends directly above or slightly in advance of the forward extremity of the body; the margin rounds off into the hinge line, which continues ascending backward to the umbones. Just below the umbones the shell is tumid. The greatest depth is near the midheight at the anterior third, not directly below the beak at the upper third, as in the larger normal form. The postumbonal slope is less inflated than the body of the shell. The byssal sinus is definable on the surface and extends to the umbo.

The characteristic fine lines and striæ are preserved on the body, but are not definable on the ear and posterior slope in the specimen at hand. Concentric striæ and undulations cross the body, but they are better developed on the auricle, and especially on the postumbonal slope.

This little shell may be easily distinguished from the typical form by its minute size, greater width, longer and horizontal hinge line, shallower ventral margin, and the other minor distinctions mentioned above.

Locality: Moose River sandstone, between Parlin Pond and Detroit (locality, 1100 A), Somerset County, Maine.

U. S. National Museum, catalogue No. 59799.

Family CONOCARDIIDÆ Neumayr.

Genus CONOCARDIUM Bronn, 1835.

?CONOCARDIUM DUBIA sp. nov.

Plate XXIII, figure 1.

A fantastically ornamented little bivalve is represented in the Chapman fauna by a fragment of a right valve. The generic position of the shell is uncertain, but the specific characters are conspicuous. The fragment is deeply inflated and shows three strong rounded ribs radiating downward from the beaks, with three or four narrower and fainter ribs just back of them. In front of the radially plicate portion of the shell is a nonplicated portion of about the same width. The hindmost of the radial ribs seems to mark a sort of postumbonal ridge or respiratory angle, behind which the shell descends in a deeply inflated, concentrically striate slope. The extreme postdorsal and anterior portions of the shell are not known.

The peculiar markings are the most characteristic feature of the shell.

Locality: Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59800.

Comparisons.—The development of pronounced radial ribbing over a centrally demarcated area and the presence of only concentric lines of growth both before and behind the ribbed area suggest at first a relationship with the shells commonly referred to the genera Pholadomya Sowerby and Pholadella Hall; but the deep inflation, the contour of the surface, and the outline indicate a more probable relationship elsewhere.

The Chapman fragment seems most nearly allied to a group of Silurian species of Conocardium from Gotland [1] and Bohemia,[2] which are characterized by having only a few radial ribs, situated near the respiratory angle; the surface only concentrically striate, both anteriorly and posteriorly; and a steeply convex slope just back of the ribs. The Chapman species is, indeed, very similar to *Conocardium brachypleura* (Lindström), the Gotland form, but has more numerous ribs and a less tumid umbone. The Chapman species differs from the Bohemian Silurian species of Conocardium in the character of the ribs and in other features.

Family PTERIIDÆ Meek.

Genus LIMOPTERA Hall.

The shells of the genus Limoptera are distinguished from the pterinoids which they superficially resemble by the large, only slightly oblique, nearly erect forms; the anterior ear usually small or absent; the posterior wing large; both valves frequently convex; radial ribs, if present, simple, not fasciculate, in many specimens obsolescent. The ending of the pallial line in the umbonal apex rather than in a more distinct anterior scar, situated on the ear, removes Limoptera from the pterinoids and indicates the affiliation of the genus with the primitive aviculoids. The term Limoptera s. str. may be restricted to the more or less radially ribbed shells having the ear or auricular portion to some extent discernible, as typified by *L. macroptera* Conrad, the genotype. Other shells which have been called Limoptera may be distinguished from that genus in two sections to which the names Myalinodonta and Paropsis Oehlert are applicable. In the shells of both these sections there is not the slightest trace of an ear, the beaks are not at the forward termination of the hinge line, the forward extremity of the body is far in advance of the beaks, and the upper anterior margin to the beaks is concave. One of the sections is represented by *Limoptera semiradiata* Frech,[3] *L. bifida* (Sandberger),[4] *L. longialata* Drevermann,[5] and *Myalinodonta normaniana* (D'Orbigny).[6] To this section may be applied the name Myalinodonta Oehlert, 1881. The last-named species is the type. It is depressed convex, equivalve, and radially striate or finely ribbed, and is in some respects a combination of Myalina and Tolmaia. An interesting feature is the occurrence of a triangular patch under the beak in the horizontally striated ligament. A similar feature is figured by Drèvermann[7] in his Limoptera (?) (nov. subgen. ?) n. sp. The occurrence of such a triangular pit in the striated ligamental area has been utilized by Girty [8] to separate his new genus Limipecten from Aviculopecten. A similar triangular (cartilage) pit under the umbone in the broadly striated ligamental area occurs in several species of Lyriopecten Hall [9] (Orbipecten Frech).

To Myalinodonta may possibly be added *Aviculopecten incertus* Oehlert.[10]

This species is figured with terminal beak and concave upper anterior margin and is included in Limoptera by Barrois.[11] No ear is shown by either of Oehlert's figures, and its absence

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[1] *Pleurorhynchus brachypleura* Lindström (Angelin, N. P., Fragmenta silurica, p. 19, pl. 13, figs. 42–46, 1880), from the late Ordovician or early Silurian limestones of Dalecarlia, Sweden.

[2] *Conocardium correctum* Barrande (Système silurien du centre de la Bohême, vol. 6, 1881, pl. 203, box IV, figs. 5–12, not figs. 1–4), from the hills between Lodenitz and Bubowitz; *Conocardium dorsatum* Barrande (idem, box V), from Kozel; *Conocardium binotatum* Barrande (idem, pl. 202, box III), from Dlauha Hora. All three species are from the middle Silurian limestones of étage E^2.

[3] Frech, Fritz, Die devonischen Aviculiden Deutschlands: Abh. geol. Specialkarte Preussen, vol. 9, pt. 3, p. 65, pl. 5, figs. 1–3, 5–8, 1891.

[4] Idem, p. 64, pl. 6, fig. 2.

[5] Drevermann, F., Die Fauna der Untercoblenzschichten von Oberstadtfeld bei Daun in der Eifel: Palaeontographica, vol. 49, p. 79, pl. 9, fig. 12, 1902.

[6] Oehlert, D. P., Documents pour servir à l'étude des faunes dévoniennes dans l'ouest de la France: Soc. géol. France Mém., 3d ser., vol. 2, pp. 29–31, pl. 5, 1881.

[7] Drevermann, F., Palaeontographica, vol. 49, pl. 9, fig. 13, 1902.

[8] Girty, G. H., New molluscan genera from the Carboniferous: U. S. Nat. Mus. Proc., vol. 27, pp. 722 et seq., pls. 45, 46, 47, June, 1904.

[9] Hall, James, Paleontology of New York, vol. 5, pt. 1, pl. 10, figs. 2, 6, 1885.

[10] Oehlert, D. P., op. cit., p. 26, pl. 4, figs. 2, 2a.

[11] Barrois, Charles, Faune du calcaire d'Erbray: Soc. géol. Nord Mém., vol. 3, p. 175, 1889.

would indicate that the species belongs to the more convex group of species of Myalinodonta; but in the text Oehlert mentions a small "ear" on each side of the beak.

If Myalinodonta should prove to possess a triangular cartilage pit, it may be removed from Limoptera and affiliated with the pectenoids.

The second entirely earless group confounded with Limoptera but properly to be dissociated therefrom is characterized by the absence of radial ribbing, the body being only concentrically striate. This group, the genus Paropsis of Oehlert,[1] includes *Avicula (Paropsis) orbicularis* Oehlert, *Limoptera rhenana* Frech, *Limoptera gigantea* (Follman) Frech, and *Limoptera obsoleta* Hall.[2]

Limoptera s. str. will, then, be restricted to strongly convex, radially ribbed limopteroid shells in which there is at least some trace of an ear or auriculate expansion in front of the umbones and in which the umbones are subterminal, not quite terminal. Some of these shells approach some of the forms of Myalinodonta, but in Limoptera s. str. the ribs are more distant and the upper anterior margin more nearly vertical.

Paropsis and Myalinodonta occur in the Lower Devonian (Siegen graywacke through the Upper Coblenzian) of Germany and France, and a single species of Myalinodonta is recorded from the lower Meso-Devonian of France (Calceola or Porsguen shales of Krouzon, near Brest).[3]

In America Myalinodonta is apparently unknown and the only species referable to Paropsis (*Limoptera obsoleta* Hall) is from the Middle Devonian (Hamilton formation).

Avicula pauciradiata Hall,[4] from the shaly New Scotland ("Delthyris") limestone of the Helderberg group, Schoharie, N. Y., is a plicated limopteroid. Apparently the only specimen known is the single internal cast of the left valve, described and figured by Hall. The anterior end is incomplete but appears to have been faintly auriculate. The species is apparently a Limoptera s. str. and, if so, is the oldest one known from the American faunas.

Avicula (Pterinea?) correcta Barrande,[5] from the Silurian étage E^2 of Bohemia (equivalent of Aymestry and Guelph), has the general superficial expression of a Limoptera and, if it belongs to the genus, is probably the oldest species known, being earlier than the Helderberg *L. pauciradiata*.

In the Bohemian Lower Devonian or Hercynian faunas of étage F^2 occur several typical species of Limoptera represented by such forms as *Avicula (Pterinea?) ala* Barrande,[6] *A. (P.?) bohemica* Barrande, *L. volitans* Barrande, and several others. Species of Limoptera of this type are widespread in the Lower Devonian, occurring in the Harz region in Germany (*Pterinea hercyniæ (Giebel)*,[7] from the calcareous beds of Schneckenberg, in the Harz Mountains), and in the Erbray limestone fauna of western France (*Limoptera bohemica* (Barrande)).[8]

In the Rhenish Devonian Limoptera s. str. is unknown, its place being taken by Myalinodonta and Paropsis. In the American faunas Limoptera s. str. is well developed and widespread in the upper Eo-Devonian and in the Middle Devonian faunas. In the higher beds of the Onondaga ("Corniferous") limestone at Stafford, Genesee County, N. Y., occurs *Limoptera pauperata* Hall.[9] *Pterinea grandis* Hall,[10] which occurs in the Jeffersonville ("Corniferous") limestone of Scott County, Ind., appears to be a Limoptera. In the Lower Devonian limestone of the Eureka district, Nev.,[11] occurs a large, erect, strongly marked limopteroid which probably belongs to Limoptera s. str. *Limoptera sarmentica* Walcott, from the Lower Devonian of the Eureka district, does not seem to belong to the genus.

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[1] Oehlert, D. P., Note sur quelques pélécypodes dévoniens: Soc. géol. France Bull., 3d ser., vol. 16, p. 647, pl. 15, fig. 1, 1888.

[2] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 249, pl. 26, fig. 10, pl. 29, figs. 5, 6 (not pl. 92, fig. 10), 1884. The shells illustrated on pl. 27, fig. 4, and pl. 29, fig. 2 (?), and labeled *Limoptera macroptera* may also possibly belong to the species *Limoptera (Paropsis) obsoleta*.

[3] Frech, Fritz, op. cit., pp. 64, 66.

[4] Hall, James, Paleontology of New York, vol. 3, p. 287, pl. 52, fig. 8, 1859.

[5] Barrande, Joachim, Système silurien du centre de la Bohême, vol. 6, pl. 205, box III; pl. 217, box V; pl. 218, figs. 21-23; pl. 281, figs. 1-6, 1881.

[6] Idem, pl. 223, box IV.

[7] Kayser, Emanuel, Die Fauna der ältesten Devon-Ablagerungen des Harzes: Abh. geol. Specialkarte Preussen, vol. 2, pt. 4, p. 133, pl. 19, fig. 1, 1878.

[8] Barrois, Charles, Faune du calcaire d'Erbray: Soc. géol. Nord Mém., vol. 3, p. 173, pl. 10, fig. 9, April, 1889.

[9] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 243, pl. 26, fig. 5, 1884.

[10] Idem, p. 91, pl. 83, fig. 14.

[11] Walcott, C. D., Paleontology of the Eureka district [Nevada]: U. S. Geol. Survey Mon. 8, p. 168, 1884.

In the Middle Devonian (Hamilton) of America Limoptera s. str. reaches its maximum development. Several species occur in the Hamilton faunas of New York [1] and Indiana.[2]

The genus is not reported from any faunas more recent than the Hamilton. Its range is therefore from the middle part of the Silurian to the Middle Devonian and it is most widespread in the upper Eo-Devonian and the Meso-Devonian.

LIMOPTERA PAUCIRADIATA Hall var. CHAPMANI var. nov.

Plate XXIII, figures 4, 10.

Hall's original species is described from a single internal cast of the left valve in the New Scotland ("Delthyris") limestone of New York. An imperfect internal mold in the Chapman faunas agrees superficially with Hall's specimen as figured, but the corresponding external mold from Maine shows some interesting features of ornamentation not indicated on the interior. Whether such external features will be found on the New York *L. pauciradiata*, should that species ever be discovered, is of course problematic. The Chapman fossil may therefore be identical with *L. pauciradiata* (Hall) or it may be quite distinct. I have chosen for the present to describe the specimens as the variety *chapmani*, in the belief that this "variety" will ultimately prove to be either a synonym or a distinct species.

Outline vertically elongated, nearly erect, slightly oblique; obliquity 15° or 20° from the perpendicular. Height (about 39 millimeters) equal to or a little greater than one and one-half times the length (about 26 millimeters). Posterior wing very large, the height of the wing equal to its length; wing distinctly demarcated from the body. The posterior margin of the wing is concave; for the greater portion of the height the margin extends upward and only very slightly forward in a nearly straight line, and then for a shorter distance curves backward a little more strongly to the hinge. The anterior portion of the shell including the ear is unknown. The body of the shell is narrow and high. The umbonal angle is acute, hardly, if at all, exceeding about 45°. The beaks are depressed to the hinge line and do not extend above it; they are situated very far forward on the hinge or are subterminal. The specimen is broken, so that it can not be ascertained whether or not the beaks are quite terminal, though they appear not to be. The oblique height or axis of the body is equal to about twice the oblique width or length of the body. The anterior margin is apparently nearly vertical and is slightly rounded. The ventral margin is deeply convex. Most of the posterior margin of the shell is included in the wing. The hinge extremity is approximately directly over the posterior extremity of the body. The left valve described and figured is somewhat crushed from front to back, but even so it is only of moderate convexity and not ventricose. The wing is concave. The front slope of the body to the anterior margin is abrupt. The point of maximum convexity is on the middle of the body. Ligamental features, dentition, and muscular scars unknown.

The internal mold is marked on the middle and hinder portion of the body by coarse low radial ribs, the number of which is indistinct but is apparently eight or nine, as in *L. pauciplicata;* certainly not greater than ten or twelve. Near the ventral margins the ribs become obsolescent, and this portion of the shell is marked dominantly by concentric striæ of growth. Compare similar senile obsolescence of radial ornamentation in *Limoptera ala* (Barrande);[3] *Limoptera macroptera* (Conrad),[4] *Ectenodesma birostratum* Hall,[5] and *Tiogana chemungensis* (Conrad).[6] Such more or less abrupt senile obsolescence of radial ornamentation, usually accompanied by increasing dominance of the concentric striæ, is a very common feature in radially ribbed pterinoid and aviculoid shells. The anterior portion of the body is without any distinct radial ornamentation. The wing on the internal mold is also without radial ornamentation and is marked by concentric lamellose striæ of growth, which occasionally becomes varicose. Con-

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, pp. 243 et seq., 1884.

[2] Idem, p. 244, pl. 26, figs. 1–4; pl. 92, figs. 1–3. See also Kindle, E. M., The Devonian fossils and stratigraphy of Indiana: Indiana Dept. Geology and Nat. Res. Twenty-fifth Ann. Rept., p. 664, pl. 13, fig. 6, 1900. Kindle mentions its occurrence in the Jeffersonville ("Corniferous") limestone, as well as in the Sellersburg limestone, of Hamilton age.

[3] Barrande, Joachim, op. cit., pl. 218, figs. 21, 22.

[4] Hall, James, Paleontology of New York, vol. 5, pt. 1, pl. 92, fig. 9.

[5] Idem, pl. 84, fig. 20.

[6] Idem, pl. 16, fig. 10.

centric striæ also cross the body, but at greater intervals. On the external mold the wing is ornamented with fine radial lines, eight or nine in the space of 5 millimeters. These radial lines are separated by interspaces two or three times their width; they are crossed by concentric elevated lamellose lines which arch forward in the interspaces. These concentric lamellose lines are closely set and continuous, 16 having been counted in the space of 5 millimeters. They also cross the body of the shell, especially in the hinder portion, where they are visible in the interspaces between the ribs and on the forward portion of the body. On the external mold the radial ribs on the body are seen to be very much narrower than their broad interspaces; on the forward part of the body the ribs appear to be obsolescent, concentric striæ being more dominant. Ten or twelve principal ribs may be counted on the body, and in a couple of interspaces on the hinder part of the body a finer rib is intercalated. The concentric striæ crossing the ribs are imbricose.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59802.

Comparisons.—The shell agrees with the Helderbergian *Limoptera pauciradiata* (Hall) in having the height greater than the length; in the very slight obliquity (only 15° or 20° from the perpendicular); the radial ribs on the body few in number (less than 10); the wing large, as high as long, and, on the internal mold or cast, without radial ribs but with strong concentric markings, etc.

Apparently the same species is represented by the shell termed "*Pterinea intercostata*" Clarke, from the Eo-Devonic fauna of Dalhousie, New Brunswick. In the Dalhousie shell the wing is not quite so high as in the Chapman and New Scotland forms of *L. pauciradiata*. The Chapman shell has the high wing of the New York type, but is smaller, more nearly of the size of the Dalhousie fossil. All three, if they do not actually represent a single species, may be closely associated in a characteristic group of limopteroid shells.

Genus PREAVICULA gen. nov.

Some shells, the external characters of which are very close to those of *Megambonia oblonga* Hall, are here separated from the genus Megambonia Hall and placed in a new generic group, Preavicula. The type species I have supposed to be identical with Hall's species *Megambonia oblonga*, but the material on which the genus is founded is from the Chapman sandstone. In case Hall's incompletely understood species on further investigation proves to represent a different shell the specific name *Preavicula oblonga* will remain as the designation of the Chapman species.

The shells are heteromyarian or monomyarian shells, having the anterior muscular scar deep and distinct, though minute, and situated in the rostral (umbonal) cavity rather than on the ear; the posterior scar large, well defined, situated below and back of the middle, and distant about its own width from the posterior margin. The outline is characteristic, differing from that of normal Aviculidæ in that both the anterior and posterior margins are convex throughout, the latter retrorse and obtusely curving into the very short hinge line, so that the outline corresponds more nearly with that of the Cyrtodontidæ. There is, therefore, in these shells no true aviculoid alate wing, nor is there any true aviculoid or pterinoid auricle. An anterior end in front of the umbones is well developed, but it merges into the gibbous body and is not separable from the body by any byssal sinus or marginal insinuation of outline, nor does either the anterior or the posterior margin become concave just below the hinge line. This last-mentioned feature serves to distinguish the shells from Rutotia and indicates that the shells, though of large size, represent a condition in outline, equivalve convexity, and musculature present in the embryonic forms in the more recent Avicula. The fossils in outline, in convexity, and in ligament might easily be mistaken for members of the Cypricardites-Cyrtodonta group, but the muscular scars prove their heteromyarian character. The generic diagnosis is as follows:

Equivalved, inequilateral, oblique; the umbones full, directed anteriorly, and in the typical forms situated more than one-third the length of the hinge line from the front. Anterior end large, rounded, not separated from the body by any byssal sinus or marginal insinuation of the outline; anterior margin convex throughout and rounding into the hinge line. The body of the shell is inflated below the umbones, and oblique (when oriented with the hinge line, horizontal). Posterior margin retrorse, convex throughout, rounding into the hinge line. Hinge line short; in typical specimens continuously straight in front of and behind the beaks. The portion behind the beaks is slightly longer than the anterior portion. Both valves are highly inflated and apparently equivalve, but the two have not been observed in conjunction. Two isolated left valves viewed in profile from the anterior end show appearances of a slight gape of 1 to 1.5 centimeters below the hinge, but whether an actual gape really existed can not be determined.

On the interior the forward muscular scar is distinct, though minute, and is deeply impressed about the apex of the umbonal cavity, rather than on the anterior end of the shell. The posterior scar is 4 or 5 millimeters broad, is situated back of and slightly below the middle, and is separated by about its own width from the posterior margin. Pallial line strongly developed on clean internal molds; simple. Two very low, faint ridges diverge from the umbo on the interior of the valves and terminate, respectively, at the front and at the back of the posterior muscular scar. Ligament external; observed on only a single specimen, where it was striated and about a millimeter in width. The hinge is apparently edentulous. The shell is of moderate thickness, pearly on the interior, surface smooth or with tenuistriate lines of growth. The Chapman shells here identified with *Megambonia oblonga* Hall are selected as the type of the genus.

In the convex posterior margin and absence of the real aviculoid or pterinoid wing the genus Preavicula represents a primitive or embryonic type of Avicula comparable with a few Ambonychidæ and with the genus Rhombopteria Jackson. From the Ambonychidæ Preavicula may be distinguished by its distinct, rather large anterior end and by the presence of a distinct anterior muscular scar. From Rhombopteria Jackson Preavicula differs in ornamentation; in Rhombopteria the anterior end has the character of the usual aviculoid or pterinoid auricle, whereas in Preavicula the anterior margin is convex throughout without a marginal sinus to form an "auricle." Rhombopteria is described as having teeth, the posterior laterals elongated. Preavicula apparently lacks posterior lateral teeth, and no cardinal teeth have been discovered in it. Finally, Rhombopteria is pronouncedly inequivalve. Rhombopteria was noted by Jackson as being one of the most primitive aviculoids known. Preavicula appears to be an even more primitive type, for not only is the normal aviculoid posterior wing absent, but the aviculoid "auricle" as such is also absent, the shell having much the outline and external appearance of the dimyarian Cypricardites-Cyrtodonta group. Posidonomya conforms with Preavicula in having no true auricle; and in *Posidonomya becheri* Brown the posterior margin is often convex or nonalate throughout. The Posidonomyidæ are, however, thinner and much more compressed shells and have narrower ligaments. Typically also in Posidonomya the posterior margin is concave for a short distance just below the hinge line.

The affinities of Preavicula appear to be with the nonauriculate, nonalate, edentulous, concentrically marked Posidonomya Brown, ?Aucella Keyserling, and Rutotia De Koninck.

Besides the type species, the genus Preavicula probably includes *Rutotia elliptica* Whidborne,[1] from the Eifelian or Meso-Devonian and from the Cuboides zone or lower Neo-Devonian of Lummaton and Woolborough, England; *Modiola? annulosa* De Koninck,[2] from the Carboniferous of Vise, Belgium; and probably *Pterinea? mytiloides* Clarke,[3] from Dalhousie, New Brunswick, in Eo-Devonian rocks. The last-named species may not be specifically distinct from the type species.

[1] Whidborne, G. F., A monograph of the Devonian fauna of the south of England, pt. 1, vol. 2, p. 55, pl. 5, figs. 2-9 (not pl. 4, figs. 9-10, which show a mytiloid), London Paleontogr. Soc., 1892.

[2] De Koninck, L. G., Faune du calcaire carbonifère de la Belgique, pt. 5, Lamellibranches, p. 180, pl. 29, fig. 18, 1885.

[3] Clarke, J. M., Some new Devonic fossils: New York State Mus. Bull. 107, p. 208, fig., 1907.

PREAVICULA OBLONGA (Hall).

Plate XXV, figures 21, 22, 25, 26; Plate XXVI, figures 11, 15, 16.

(?) 1859. *Megambonia oblonga*. Hall, Paleontology of New York, vol. 3, p. 277, pl. 50, fig. 5.
Helderberg shaly limestone: Schoharie County, N. Y.
(?) 1907. *Pterinea? mytiloides*. Clarke, New York State Mus. Bull. 107, p. 208, fig.
Lower Devonic: Dalhousie, New Brunswick.

The Chapman sandstone specimens here identified with Hall's species display the following characters:

Shell rather large, inequilateral, obliquely narrow ovoid, with the body obliquely inclined at an angle of 45°, more or less, from the short hinge line. Umbone subcentral, situated at about the anterior two-fifths the length of the hinge, directed forward and protruding somewhat above the hinge line. Anterior to the beaks the hinge line is straight, continuous with the portion posterior to the beaks and rounding forward into the anterior margin. The anterior margin is convexly rounded throughout; for the uppermost centimeter it is commonly vertical and perpendicular to the hinge line, though occasionally it is vertical for only a few millimeters. Below this vertical portion the anterior margin swings backward and downward in a broad, shallow curve, swinging abruptly into the retrorse posterior margin without the intervention of any definable ventral margin. The anterior extremity of the shell is 2 to 10 millimeters below the hinge line; the lowest point of the margin is far back, either directly below or, more commonly, posterior to the hinder hinge extremity. The posterior margin is retrorse and convex throughout, with the hindmost extremity near the postventral angle, approximately midway in height between the ventral margin and the base of the posterior muscular scar. The lower three-fourths of the anterior margin forms with the posterior margin an oblique symmetrical elongate semiellipse. The hinge extremity is obtusely rounded. The hinge margin and the portion of the shell immediately below were apparently thin; they are rarely preserved. The hinge line appears to have been short and straight or nearly straight. Both valves are ventricose, especially over the middle of the body and in the umbones. The umbones project somewhat above the hinge line. There is no flattened posterior aviculoid wing, the postumbonal slope being convex and very steep. For 1 or 2 millimeters below the hinge line the postumbonal slope becomes less steep, but this portion of the shell is broken off in the great majority of specimens. Just back of the beaks the posterior slope is very steep, nearly vertical. The slope to the anterior margin is also steep. Occasionally a portion of the anterior end of the shell which includes the supposed gape appears to be faintly inflated like an aviculoid "auricle." The anterior portion immediately in front of the beaks was depressed convex but is usually broken off in the specimens. The point of maximum depth is over the center of the shell. The depth of each valve is equal to a quarter of the length from beak to postventral extremity.

A profile examination from the anterior end of four or five internal molds of isolated valves, both right and left, shows a gape 1 or 2 millimeters deep in each valve. This gaping portion of the shell extends along the anterior margin for about 1.75 centimeters below the hinge line. The appearance suggesting this slight gape has been observed only on isolated valves in internal molds when viewed in profile from the anterior end. I have seen no specimens with both valves in conjunction; and the appearances, if not deceptive, may possibly be only accidental. On one of the specimens from Edmunds Hill the hinge line is preserved with a striated ligamental area a little over 1 millimeter in width. This area is inclined at a low angle to the plane of the margin. Dentition not observed. Several clean internal molds indicate probable absence of posterior lateral teeth. The anterior scar is a pit about 1 millimeter in width in large shells, deeply sunken into the forward part of the umbonal cavity, near the margin between the cavity and the anterior portion of the shell. The position of the anterior scar is in the umbonal cavity rather than on the anterior end or auricle. The posterior scar is situated entirely back of and below the middle of the shell. It is 4 to 6 millimeters in width in mature and large shells, and it is separated by its own width from the posterior margin and also from the middle of the shell. The posterior scar is strongly impressed, though less so than the anterior scar. The dorsal and anterior margins and to some extent the ventral margins of the posterior scar are well defined and impressed into the shell; the hind margin of the posterior scar is not definable.

Clean internal molds of the interior of both valves show a low, rounded, faint radial fold extending from the forward extremity of the posterior muscular scar toward the umbones and similar fold extending from the postdorsal corner of the scar toward the umbones. Pallial line simple, rather deeply impressed into the shell. The pallial line reaches the postventral portion of the posterior scar, so that most of the scar is included within the pallial line.

The surface ornamentation is variable. A few specimens appear smooth or with faint concentric undulations, but most of them are concentrically striate, and fascicles of growth may be elevated into low incomplete undulations, or into several lamellose varicles of growth. The striæ appear to be most strongly impressed on the forward part of the body and especially on the pseudo auricle.

A nearly mature specimen has a length of 33 millimeters from beak to postventral extremity. In large and mature specimens this distance is from 49 to 54 millimeters.

Locality.—Chapman sandstone, 2 miles west of Presque Isle Stream (locality 1099 J); several small specimens from locality (1099 K) 2½ miles west of Presque Isle Stream; Chapman Township, Aroostook County, Maine. Some large imperfect casts found loose on Edmunds Hill (localities 1099 C, C′) seem to belong to the species; one of them which is figured shows the ligament.

U. S. National Museum, catalogue Nos. 59803, 59804, 59805.

Comparisons.—The specimens as ordinarily preserved present the external aspect of the New Scotland *Megambonia oblonga* Hall, agreeing in every essential particular except in lacking the broad, shallow sinus which Hall described as occurring in the ventral margin of the New York shell. However, it may be that this described insinuation in *Megambonia oblonga* is not real. The lines of growth represented in Hall's figure show that the anterior margin in the New York types was, as in the Maine shells, convex throughout, and that the apparent insinuation is due to incompleteness of the specimens.

Pterinea? mytiloides Clarke,[1] from Dalhousie, New Brunswick, also appears to represent a closely similar if not the same specific type. The Dalhousie fossil was figured as having a modiomorphoid ventral insinuation. It is smaller than the Maine specimens and, as figured, has a longer posterior hinge line and is more oblique. *Preavicula elliptica* (Whidborne) is easily distinguished from the Chapman forms in outline, and especially in having the anterior and posterior portions of the hinge line discontinuous. In *Preavicula annulosa* (De Koninck) the body is much broader than in the Chapman shells.

PREAVICULA BREVIS sp. nov.

Plate XXVI, figures 8, 9.

Two specimens associated in the same rock with *Preavicula oblonga* differ from that species, being much less extended along the line of the umbonal slope, so that the outline is broadly oval, with the length scarcely greater than the width. In the umbonal portion, the cardinal slope, and the general form of the upper portion of the shell *P. brevis* is very similar to the more common species. Comparison is made difficult by the fact that only two specimens, both left valves, of *P. brevis* are available. Possibly they represent a short variety of the more common shell, but until more specimens are obtained the separate name may stand.

Locality: Chapman sandstone, in a calcareous sandstone 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59806.

Genus LEIOPTERIA Hall.

The genus Leiopteria was founded by Hall to include some concentrically striated, oblique aviculoid shells, such as *Leiopteria dekayi* and *L. rafinesqui* Hall and nearly a dozen other species from the Hamilton; *Avicula lævis* Hall, from the Marcellus; *Avicula chemungensis* Vanuxem

[1] Clarke, J. M., New York State Mus. Bull. 107, p. 208, fig., 1907.

and *L. linguiformis* Hall, from the Portage (Ithaca shale member) and the Chemung; and *L. torreyi*, from the higher sandstones and conglomerates of the Chemung formation near Panama, N. Y. In the left valves the shells are superficially indistinguishable from *Pterinea lævis* Goldfuss, the genotype of Pterinea, conforming with Pterinea s. str.[1] in the obliquity, convexity, small rounded ear, well-developed byssal sinus, long oblique body, well-developed wing, with deeply sigmoidal posterior margin, and concentric ornamentation. Leiopteria is distinguished from Pterinea, however, in having the right valve always convex and frequently almost or quite equal in size to the left valve; the ligamental area is narrower than in Pterinea, and the lateral teeth, if present, are close under the hinge line, not oblique. Leiopteria is also closely allied to the genus Pteronitella Billings, agreeing with it in having the right valve convex and frequently nearly or quite equal to the left valve, and in having the posterior lateral teeth close under the hinge line. The shells of both genera are also concentrically ornamented. Leiopteria differs from Pteronitella in being always more oblique, not erect, and in having the byssal sinus generally better developed. Anatomically Leiopteria differs from Pterinea, Pteronitella, and the pterinoids in lacking the definable anterior muscle on the ear; the pallial line ends in the umbonal apex. Leptodesma Hall is distinguishable from Leiopteria by its greater obliquity, smaller size, and generally less definite byssal sinus; moreover, as suggested by Hall, the anterior end is rounded and auriculate in Leiopteria and usually pointed and nasute in Leptodesma.

A full generic diagnosis of Leiopteria Hall is as follows:

Shell obliquely aviculoid; biconvex; right valve convex, equal to the left in many specimens, but generally a little less convex; never resupinate. Auricle distinctly developed, rounded, usually not pointed; separated from the body by a well-developed byssal sinus. Body of the shell elongated ovoid; oblique, generally about 30° from the vertical, rarely if ever 45° or more; deeply rounded below. The umbones are near the anterior end but never terminal and are directed forward. The posterior wing is distinctly developed, flat to concave, and with a concave posterior margin. The body of the left valve is of moderate convexity; the wing is flat to concave; the auricle is convexly rounded; and the byssal sinus is typically represented on the surface as well as in the margin. Ligament external, extending the length of the hinge line; usually very thin or linear and marked by only a single striation (*Leiopteria lævis, conradi, greeni, rafinesqui, sayi, bigsbyi, mitchelli,* and *gabbi* Hall); occasionally slightly broader and with two or three striations (*L. dekayi* and *linguiformis* Hall), rarely with several striæ (*L. riesiana*). No cardinal teeth yet reported or observed. Posterior lateral teeth not generally observable, but in a few shells apparent traces of a ridge or posterior lateral tooth have been recorded by Hall close under the ligament. Posterior muscular scar large, broadly oval to subcircular, situated mainly or entirely upon the body of the shell (*L. linguiformis* Hall). The anterior scar has been observed only in the Chapman species *L. riesiana*, where it is minute and not very well impressed and is situated in the forward part of the rostral cavity (compare Glyptodesma, Leptodesma, Limoptera) and not upon the auricle, as in Pterinea, Cornellites, Follmannella, Actinopterella, and Pteronitella. In Hall's description of *L. dekayi* Hall, the genotype of Leiopteria, he mentions a low, septum-like ridge between the auricle and rostral cavity. This may possibly be the posterior boundary of a small anterior muscular scar; if so, it would seem to indicate that the scar is really situated on the auricle. Pallial line simple. Shell thin.

The surface ornamentation consists of concentric striæ, strongest on the posterior half of the body and on the wing. No radial ornamentation except, very rarely, a few faint radial lines on the body of the right valve.

More than a dozen species of Leioptera, ranging from the lowest Meso-Devonian (Marcellus) to the highest Neo-Devonian (higher sandstone and conglomerates of the Chemung near Panama, N. Y.), were described by Hall.[2] The genus seems to attain its maximum development in species, individuals, and varieties in the Hamilton formation throughout the calcareous facies of western New York, the shaly facies of central New York, and particularly the arenaceous

[1] Williams, H. S., On the revision of the mollusk genus Pterinea Goldfuss: U. S. Nat. Mus. Proc., vol. 34, pp. 83-90, 1908.
[2] Hall, James, Paleontology of New York, vol. 5, pt. 1, 1884.

facies of eastern New York. It is common also in the Hamilton type of fauna, which continues into the Ithaca shale member of the Portage formation in eastern New York. It is rare at Ithaca and in the Chemung. The genus passes down below the Marcellus into the Oriskany, where it is represented by *Megambonia (Leiopteria) lamellosa* Hall,[1] from the Oriskany sandstone of Oriskany Falls, Oneida County, and the Helderberg Mountains in Albany and Schoharie counties, N. Y., a very large form of Leiopteria aspect. Hall neither figured nor described the right valve, the hinge, nor the internal structure, but the fact that he included the species in Megambonia, which is equivalve or nearly so, indicates that the right valve, if it has been seen, is convex as in Leiopteria. The genus occurs also in the lower and middle parts of the Helderberg group and as low as the Rochester shale member of the Clinton formation of the Niagara group. It is apparently unknown in the Ordovician.

Above the highest Devonian Leiopteria occurs, as reported by Herrick and by Miller and Gurley, in the Mississippian ("sub-Carboniferous") faunas of the Mississippi Valley, but these post-Devonian so-called species of Leiopteria [2] are small, very oblique shells, with broad, undefined byssal sinus, and ought for the most part to be included in Leptodesma Hall. *Avicula subspatula* Herrick [3] however, from the Mississippian of Newark, Ohio, seems to be a typical Leiopteria in outline and convexity. In Europe Leiopteria is reported from the Carboniferous by De Koninck,[4] who records 21 species from étages II and III of Belgium and equivalent British rocks. Of these *L. phillipsi* (De Koninck),[5] *L. lunulata* (Phillips),[6] and *L. maccoyi* (De Koninck),[7] approach Leiopteria only remotely; the other species described by De Koninck are, as in the American Carboniferous, typical Leptodesma—very oblique shells of small size, with broad, undefined byssal sinus. Hind also confused the genus Leptodesma with Leiopteria. *Leiopteria grandis* Hind,[8] from the Carboniferous limestones of Yorkshire and Derbyshire, England, seems to be the only really typical described form of Leiopteria in the British Carboniferous; the remaining seven species described and figured by Hind are either the usual small, very oblique, typical Leptodesma (*L. thompsoni, L. hirundo, L. longirostris*) or intermediate Leiopteria-Leptodesma shells (*L. lunulata* pars, *L. laminosa* pars), except *Leiopteria obtusa* (McCoy), which appears to be a small Ptychopteria. The genus Leiopteria therefore probably extends up into the Carboniferous, though it is very rare above the Devonian.

As to the Devonian and Silurian distribution outside of New York, the genus Leiopteria has been recorded by Walcott [9] from the Lower Devonian of the Eureka district, Nev., and by Clarke [10] (*L. hawkinsi* Clarke) from the Lower Devonian of the Rio Curua, Para, Brazil.

In the English Devonian the genus appears to be unrecognized. The so-called *Leiopteria lingulata* Whidborne [11] is a pectenoid shell of the genus Crenipecten, or possibly Streblopteria or some allied form. Leiopteria is, however, well developed in the French Devonian, where it is represented by *Avicula gervillei* Oehlert,[12] *Avicula pseudolævis* (Oehlert) s. str.,[13] *Avicula pulchella* Oehlert,[14] *Pterinea kerfornei* Oehlert,[15] *Leiopteria picta* Oehlert,[16] *Leiopteria viennayi* Oehlert,[17] and *Leiopteria leucosia* Oehlert.[18]

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[1] Hall, James, Paleontology of New York, vol. 3, p. 467, pl. 109, figs. 5, 6, 1859.
[2] See Weller, Stuart, A bibliographic index of North American Carboniferous invertebrates: U. S. Geol. Survey Bull. 153, p. 318, 1898.
[3] Herrick, C. L., The geology of Licking County, Ohio, pt. 4: Denison Univ. Sci. Lab. Bull., vol. 4, p. 30, pl. 5, fig. 11, 1888.
[4] De Koninck, L. G., Faune du calcaire carbonifère de la Belgique; Lamellibranches: Mus. royal hist. nat. Belgique Annales, vol. 11, pp. 187 et seq., pl. 30, 1885.
[5] Idem, pl. 30, fig. 8.
[6] Idem, pl. 30, fig. 4.
[7] Idem, pl. 30, fig. 3.
[8] Hind, Wheelton, A monograph of the British Carboniferous Lamellibranchiata, vol. 2, pt. 1 (London Paleontogr. Soc. Pub., vol. 55), p. 19, pl. 3, figs. 12-15; December, 1901.
[9] Walcott, C. D., Paleontology of the Eureka district [Nevada]: U. S. Geol. Survey Mon. 8, p. 166, pl. 5, fig. 10, 1884.
[10] Clarke, J. M., The Paleozoic faunas of Para, Brazil, pt. 2, Devonian Mollusca: Mus. nac. Rio de Janeiro Arch., vol. 10, p. 49, fig., 1899 (author's English ed., 1900).
[11] Whidborne, G. F., A monograph of the Devonian fauna of the south of England, vol. 2, pt. 2, p. 78, pl. 10, fig. 1, 1892.
[12] Oehlert, D. P., Documents pour servir à l'étude des faunes dévoniennes dans l'ouest de la France: Soc. géol. France Mém., 3d ser., vol. 2, p. 22, pl. 3, fig. 4, 1881. Lower Devonian, Nehou, La Manche.
[13] Idem, p. 23, pl. 3, fig. 5. Nehou.
[14] Idem, p. 24, pl. 3, fig. 6. Nehou.
[15] Oehlert, D. P., Note sur quelques pélécypodes dévoniens: Soc. géol. France Bull., 3d ser., vol. 16, p. 642, pl. 14, fig. 1, 1888.
[16] Idem, p. 643, pl. 14, fig. 3.
[17] Idem, p. 643, pl. 15, fig. 3.
[18] Idem, p. 644, pl. 14, fig. 2.

In the German Devonian several species of Leioptera, probably distinct, are called by Frech[1] *Avicula crenatolamellosa* Sandberger var. *pseudolævis* Oehlert. *Avicula schrenki* Frech[2] is also a Leiopteria. All are from the Eo-Devonian. *Avicula* (*Leiopteria*) *winteri* Frech[3] is from the lower Meso-Devonian (Calceola beds). Frech calls Leiopteria the "group of *Avicula winteri*," considering Hall's genus a synonym of Avicula. Avicula (Leiopteria) sp. Frech,[4] from the Belgian Gedinnian, appears to be a poorly preserved Actinopteria or Actinopterella; it shows traces of radiate ornamentation on the body.

In the Bohemian basin the genus Leiopteria is fairly well developed in both the Silurian and the Eo-Devonian. To it are referable *Avicula opportuna* Barrande,[5] which appears to be a large typical member of the genus; *A. carens* Barrande,[6] *A. impotens* Barrande,[7] and *A. serviens* Barrande,[8] all from the Silurian étage E ^{2} (Aymestry or Ludlow equivalent); and *Avicula imperfecta* Barrande,[9] *A. invisa* Barrande,[10] and *A. gratior* Barrande,[11] from the Eo-Devonian or Hercynian étage F^2.

Leiopteria riesiana sp. nov.

Plate XIX, figure 21.

This species is characterized by its equivalve, depressed convexity, slight obliquity, and very small ear; by the posterior margin of the wing being not at all or only slightly concave, and with an obtusely angled posterior hinge extremity; and by the absence of lamellæ of growth.

Shells vertically elongate, aviculoid, with height (perpendicular to the hinge line) generally a sixth greater than the horizontal length, rarely as much as a fourth. Beaks compressed, not protruding above the hinge line, prosogyrate, situated very near the anterior end, from which they are separated by a minute auricle. The hinge line is decidedly less than the length of the shell, the portion behind the beaks equaling half to three-fifths the horizontal length of the body. The posterior hinge extremity is angular, the upper posterior margin directly under the hinge being parallel with the oblique axis of the shell. The posterior margin is hardly or not at all sigmoidal, the upper part straight or slightly convex, rarely slightly concave. The greater portion of the posterior margin is distinctly convex, with the hindmost extremity at the inferior third or two-fifths the height above the base. Ventral margin deeply bellied down, with the inferior extremity toward the rear, generally at the posterior third or fourth, rarely just back of the middle. The ventral margin rises in a broad sweep into the convex anterior margin. The anterior margin continues convex for two-thirds to three-fourths the height; then develops a fairly long but shallow byssal sinus in the margin, and is again convex over the small rounded auricle. The anterior margin, for the upper third of the height of the shell, is inclined to the hinge line at a right angle or at a slightly obtuse angle. The forward extremity of the shell is on the body above the midheight. The obliquity from the perpendicular varies from 18° to 23° but is generally nearer the latter. Shell equivalve; depressed convex. The body strongly depressed over the greater portion, slightly more convex over the umbones. The byssal sinus is shallow and hardly discernible on the surface. The wing is concave, nearly flat, and fairly well marked off from the body. The thickness, with both valves in conjunction, varies between two-sevenths and two-fifths the length ("width"). Ligament and dentition unknown. The anterior end of the pallial line ends in the rostral cavity, not on the auricle. The anterior muscular scar is minute and not very deeply excavated. The posterior scar is much larger, subcircular in outline, 1 centimeter in diameter, and is situated entirely upon the body of the

[1] Frech, Fritz, Die devonischen Aviculiden Deutschlands: Abh. geol. Specialkarte Preussen, vol. 9, pt. 3, p. 51, pl. 4, figs. 5, 5a (?), 5b, 5c, 13, 13a, 13b.
[2] Idem, p. 56, pl. 4, figs. 8, 8a.
[3] Idem, p. 47, pl. 4, fig. 11.
[4] Idem, p. 48, pl. 7, fig. 4.
[5] Barrande, Joachim, Système silurien du centre de la Bohême, pt. 1, vol. 6, pl. 223, box III, 1881.
[6] Idem, pl. 225, box V.
[7] Idem, pl. 229, box I.
[8] Idem, pl. 223, box II.
[9] Idem, pl. 222, box I, fig. 12.
[10] Idem, pl. 222, box I, fig. 13.
[11] Idem, pl. 217, box III.

shell, at the midheight and extending just back of the center. The pallial line is strongly impressed on internal molds and is radially wrinkled in the lower portion. It extends vertically downward from the rostral cavity in a depressed convex arch, sweeps backward in its lower portion to a point below the posterior muscular scar, and rises for a short distance upward and backward to the scar. The scars and pallial line somewhat resemble those of *Myalina maureriana.*

Internal molds are commonly smooth; a "sculpture cast" shows fine obsolescent concentric striæ of growth, with no conspicuous varices. The striæ are a little finer and more even on the wing.

The size is indicated by the following dimensions:

Dimensions of typical specimens of Leiopteria riesiana.

Height (millimeters).	Length (millimeters).	Thickness (millimeters).
45	38	
43	36	
42	33.5	11
35	30	11.5

Locality: Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59807.

Comparisons.—The species closely resembles *Leiopteria hawkinsi* Clarke from the Eo-Devonian Rio Curua fauna of Para, Brazil; but in the Maine species the posterior margin of the wing is not at all or only slightly concave, and the angle formed at the posterior hinge extremity, like the angle formed by the hinge line with the upper anterior margin, is obtuse, not acute. These features, especially the obtuse posterior hinge angle, will also distinguish the species from many of the other forms of Leiopteria.

Family MYALINIDÆ Frech.

Genus MYALINA De Koninck.

In his discussion of the Devonian Aviculas of Germany Frech[1] proposed the name Myalininæ as a subfamily under Aviculidæ, to include Myalina De Koninck, Mytilarca Hall, and Plethomytilus Hall. The genus Myalina is subdivided, according to Frech, into three groups, as follows: (1) Myalina s. str., "Gruppe der *Myalina rhenana* Frech" = Plethymytilus Hall; (2) "Gruppe der *Myalina bilsteinensis* (F. Roemer)" = Mytilarca Hall (pars); (3) "Gruppe der *Myalina lodanensis* Frech."

On the other hand, Dall,[2] in revising the classification of Pelecypoda, places the genus Myalina De Koninck in a family Mytilinidæ Frech, separate from Mytilarca and Plethomytilus Hall, which he places in the family Ambonychidæ Miller. Mytilus Linnæus is placed by Dall in still another family, Mytilidæ Fleming, in a different section (Dysodonta Neumeyer) of the Prionodesmacea. These are extremes of classification resulting from different points of view, the two authors giving different relative values to the several characters of the genera described. To open the question as to which classification is more true to nature (whether the boundaries of the genus Myalina are considered to be subordinate to the family Myalinidæ, or wide enough to include the families Ambonychidæ Miller, Mytilidæ Fleming, and Myalinidæ Frech), is scarcely pertinent to the present treatise.

[1] Frech, Fritz, Die devonischen Aviculiden Deutschlands: Abh. geol. Specialkarte Preussen, vol. 9, pt. 3, p. 137, 1891.

[2] Dall, W. H., Pelecypoda, in Zittel, K. A., Text-book of paleontology, revised English ed., vol. 1, pt. 1, pp. 368–369, 372, 385, 1896.

Myalina maureriana sp. nov.

Plate XVIII, figures 1–6, 8, 11; Plate XIX, figures 22, 26.

Height greater than the length, in the proportion of 100:72, or about 11:8, as shown below.

Dimensions of typical specimens of Myalina maureriana.

Height (millimeters).	Length (millimeters).	Ratio of height to length.
50	36	100:72
49	35	100:71
44	32.5	100:73
[a] 22.5	16.5	100:73
34.5	25.5	100:74
49.5	35	100:71

[a] Young specimen.

Greatest length a trifle below the midheight. Greatest height near the midlength. Beaks rarely quite terminal; a very narrow and steeply inclined auricular portion usually discernible in front. Hinge line straight, rigid, always shorter than the length of the shell, the proportion varying from 2:3 to 10:11. The posterior hinge extremity is pointed. The upper part of the posterior margin near the hinge is usually very depressed convex, or nearly straight, and makes with the hinge line an angle of 115°. Rarely the upper portion, instead of being straight or depressed convex, is slightly concave, producing a faintly Avicula-alate appearance; generally, however, the posterior margin continues convex to the hinge. The hindmost extremity of the shell is a trifle below the midheight, whence the posterior margin curves into the deeply arched ventral and antero-ventral margins, which together include a deep paraboloid semicircle. The lowest point of the shell is near or just back of the midlength. The anterior margin for the lower three-fifths of the height of the shell it situated in advance of the umbones; the most forward point of the shell varies from slightly below to slightly above the midheight; the anterior margin in the upper two-fifths recedes toward the beaks, producing a usually concave or constricted outline; occasionally the extreme upper anterior margin at the beaks is again gently convex, producing a faint, narrow, auricle-like expansion. The shells are nearly erect, the obliquity from the vertical being less than 10°—in some specimens almost imperceptible. The shells are apparently equivalved. The body of the shell is of moderate or depressed convexity; the shell is never inflated. In the most strongly convex specimens the depth of the single valve does not attain one-fifth of the height, and the usual depth of the valve (in the internal mold) is one-sixth to two-fifteenths of the height. The point of maximum convexity is on the umbones, whence the surface slopes very gradually toward the ventral margin, very steeply to the concave portion of the anterior margin, and less steeply to the posterior part of the shell. A subalate upper posterior portion is roughly separated from the body by its more depressed convexity. The anterior margin along the concave portion of the front outline is deflected or curled inward in the better-preserved specimens. Hinge structure edentulous; but in one of the specimens the hinge line appears to be marked along its middle by a fairly long horizontal ridge or tooth in the left valve, fitting into a long, narrow trough or socket in the right. This structure may, however, be only accidental. The other specimens are edentulous. The ligamental area is of moderate width (for Myalina) and is inclined to the plane of the margin at an angle of less than 45°, varying from 10° to about 40°, generally nearer the former. The regular sharp, parallel striæ or corrugations which traverse the length of the ligament in typical species of Myalina have been observed in only a single mold. In most specimens the ligamental area is only obscurely striate horizontally, and there are also observable faint striations, vertical or slightly oblique in the direction parallel to the front margin of the ligament. These striations are unknown in the typical species of Myalina and are probably an initial advance toward the divided ligament of Perna and its allies. Just beneath the ligamental strip is sometimes developed a smooth, flat space, somewhat as in Leiomyalina Frech. The anterior muscular scar is minute and very deep and is situated under the umbones close to the hinge line. It is impressed on the floor of the valves, about 5 or 6 millimeters (in mature shells) from the front edge of the hinge line. The posterior muscular scar is single or undivided, subcircular, and about 10 centimeters wide; less strongly impressed than the anterior muscular scar, but usually discernible; its posterior and ventral margins inclose a semicircle; the upper and inner semicircumference is irregular. The posterior scar is situated at the midheight or slightly below. It is entirely posterior to the center, but is nearer to the center than to the posterior margin; from the latter the impression is separated by two-thirds to seven-eighths its width. The pallial line is simple and well developed. From the small umbonal scar it extends downward and slightly forward for about half the height of the shell, then sweeps backward in a broad curve and reaches, near the posterior scar, a point within two-fifths or one-third the height of the shell above the base, or on a level with the lower margin of the posterior scar; the pallial line then rises slightly and reaches the scar on the lower part of the inferior anterior quarter. The pallial line is nowhere pitted or pustulose. It is most strongly impressed on the portion extending downward and slightly forward from the umbonal scar. In mature shells it is 5 millimeters or more from the margin. From the posterior and upper portion of the large muscular scar there extends upward to the low hinge a low faint ridge, marked by a shallow groove in the internal mold.

The shell is 2 millimeters thick, or a trifle more, over the body. To the naked eye and under a hand lens no prismatic structure is apparent, the shell structure appearing plainly lamellose or flaky, or else crystalline with an oblique cleavage into thin laminæ. Meek and Hayden[1] have shown that the shell structure of the genus Myalina (*M. angulata*) is prismatic. The prisms, however, are exceedingly minute or microscopic, only one-seventieth to one three-hundred-and-fiftieth of a millimeter in width. To the naked eye and even under a hand lens the prismatic structure is not discernible, and the species of Myalina when the shell is well preserved present a strongly lamellose or flaky shell structure, similar to that of the present species.

Internal molds are smooth and completely devoid of ornamentation. The exterior was marked by very faint tenuous lines of growth or very obscure wrinkles, leaving the surface approximately smooth, except for one or two strong lamellose or imbricating varices near the lower margin in old shells. Where the upper anterior margin was inflected, the inflected portion is marked by numerous closely crowded, imbricating lamellæ of growth, the ornamentation on this portion being more pronounced than anywhere else on the shell.

Mature specimens have a height of about 49 or 50 millimeters and a width or length of 35 to 36 millimeters.

The distinguishing features of this fossil are its vertically elongate tall form with very deep ventral margin; erect outline nearly vertical or with obliquity less than 10°; anterior margin convex for the lower three-fifths of the height and extending downward and forward below the umbones, concave for only a short distance in the upper portion; shell narrow, with height equal to $1\frac{3}{8}$ times the length, or two or more times the length of the hinge line; hinge line and upper posterior margin forming an angle of 115°; deeply arched ventral margin; shell apparently equivalved and closed; convexity moderate, or more typically depressed; posterior muscular scar subcircular, undivided, and situated near the midheight; ligamental band wide, slightly inclined, and marked by faint, tenuous striæ or scratches.

This species is associated at Presque Isle Stream with shells having a broader, less deep ventral margin, to which may be applied the name variety *lata*.

Locality: Chapman sandstone, abundant in the sandstones and some shaly layers on Presque Isle Stream (localities 1099 A, 1099 L) and $2\frac{1}{2}$ miles west of Presque Isle Stream (locality 1099 B[3]), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59808, 59809.

[1] Meek and Hayden, Report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country: Rept. U. S. Geol. Survey of Territories, vol. 3, p. 68, 1876.

Comparisons.—*Myalina maureriana* very closely resembles *Clionychia excavata* Ulrich, from the higher Ordovician beds at Richmond, Ind., a species which differs from the normal Clionychias in having the muscular scar situated much lower down (at the midheight and just back of the center) and apparently undivided. The hinge line of *C. excavata* is also shorter than usual, giving the shell a more vertically elongate appearance. In all these characters this Ordovician species agrees with *Myalina maureriana.* The genus Clionychia, however, is described by Ulrich,[1] its founder, as having a linear ligament; and the ligament in all the species described and figured is much narrower than in *Myalina maureriana. Clionychia excavata* Ulrich also differs in some minor points of outline from *M. maureriana*; the concave portion of the anterior margin is much longer and the shell is proportionately somewhat wider.

The English Ludlow shell figured by Salter [2] as *Mytilus mytilimeris* (Conrad) bears some resemblance in outline to *M. maureriana* but is much more oblique, the erect form of the Maine shell easily distinguishing it from the English fossil.

The original "*Inoceramus mytilimeris*" Conrad,[3] from the shaly limestone? of the Helderberg group [New Scotland] of New York, is ereot and has an outline closely similar to that of *Myalina maureriana.* Conrad's shell, however, is ventricose and has a prominent apex and belongs to Mytilarca or to Plethomytilus.

Among the Myalinas *M. maureriana* is closely related to the Eo-Devonian *M. goëensis* Kayser, the higher Devonian *M. egregia* Whidborne, the Mississippian *M. subquadrata* Shumard, and the late Permian so-called *Promyalina hindi* Kittl, from all of which it differs in having the anterior margin more convex and the forward extremity of the shell much higher. There are also other minor points of distinction from each of these species.

Myalina maureriana sp. nov. var. lata var. nov.

Plate XVIII, figures 7, 9, 10, 12; Plate XIX, figure 28.

Associated at Presque Isle Stream with the high, narrow typical form of *Myalina maureriana* above described, and nearly as abundant, are some wider shells characterized by the broadly outward-curving margin of the shell below and in front of the umbonal region, the relative proportion of the length to the height being greater than in *M. maureriana.* Excepting for this characteristic wide bulging out of the lateral margins and the consequent shallowing and broadening of the ventral margin and greater proportionate length, the variety agrees with the typical form. In the erect outline, short hinge, anterior margin convex for the greater part of the height and protruding in advance of the beak, shell closed and apparently equivalved or very nearly so, depressed convexity, muscular scars, pallial line, and ornamentation, both forms are alike. Intermediate forms occur but are rare.

Locality: Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine. More than a dozen specimens have been found at Presque Isle Stream, where it is abundant, along with the typical form.

U. S. National Museum, catalogue No. 59810.

Myalina maureriana sp. nov. var. pterinæoides (Clarke).

Plate XIX, figures 24, 27.

?1848. *Mytilus mytilimeris* (not Conrad). Salter, Geol. Survey Great Britain Mem., vol. 2, p. 365, pl. 20, fig. 7. Ludlow: Golden Grove, Llandilo (not May Hill or Dudley).

1907. *Myalina pterinæoides.* Clarke, New York State Mus. Bull. 107, p. 214, figs. Lower Devonic: Presque Isle Stream, Chapman Township, Aroostook County, Maine.

Clarke's name "*pterinæoides*" may be used in a varietal sense to include specimens of *Myalina maureriana* that are more oblique than the typical form. The typical forms are by

[1] Ulrich, E. O., New and little-known Lamellibranchiata from the Lower Silurian rocks of Ohio: Ohio Geol. Survey, vol. 7, p. 651, pl. 51, figs. 4, 5, 1894. "Upper beds of the Cincinnati group, Richmond, Ind."

[2] Salter, J. W., Geol. Survey Great Britain Mem., vol. 2, p. 365, pl. 20, fig. 7, 1848.

[3] Conrad, T. A., Observations on the Silurian and Devonian systems of the United States, with descriptions of new organic remains: Acad. Nat. Sci. Philadelphia Jour., vol. 8, p. 246, pl. 13, fig. 10, 1842 (read Jan. 18, 1842). "Middle Silurian shale," Helderberg Mountain and near Schoharie, N. Y.

far the dominant representatives of the species in the Chapman sandstone, as Clarke recognized in the descriptive text of his "species." The more oblique shell figured as *Myalina pterinæoides* may therefore be considered the variety, and the specific name may be applied to the characteristic form of the species. *Myalina maureriana* var. *pterinæoides* may possibly prove identical with the "*Mytilus mytilimeris* Conrad" cited by Salter from the English Ludlowian Silurian.

Locality: Chapman sandstone, Presque Isle Stream (localities 1099A, 1099L) and 2½ miles west of Presque Isle Stream (locality 1099B³), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59812, 59813, 59814.

Family MODIOLOPSIDÆ Fischer.

Genus MODIOMORPHA Hall.

The genus Modiomorpha was founded by Hall[1] in December, 1869. It was described in 1885 as follows:[2]

> Modiomorpha Hall. Type, *Pterinea concentrica* Conrad. Shell equivalve, very inequilateral, subovate in outline, largest posteriorly. Anterior end rounded, forming a projecting lobe of greater or less extent beyond the beak. The valves are crossed obliquely by a more or less distinctly defined cincture passing from the beak to the base, and constricting the basal margin. Beaks small, compressed. Surface of the shell marked by rugose or undulating concentric striæ. Hinge furnished with a strong wedge-form tooth in the left valve and a corresponding cavity in the right. No lateral teeth have been observed. Ligament external, attached to the thickened margin of the shell, which is longitudinally grooved for its reception. Anterior muscular impression situated within the anterior extension of the shell. Posterior impression large and superficial, situated on the posterior slope. Pallial line simple. Examples: *M. concentrica* (Pl. XXXVI, figs. 1–18), *M. mytiloides* (Pl. XXXVIII, figs. 1–16).

The genus was later revised and the internal structure more profusely elucidated by Beushausen,[3] who has shown that only a few among the German Eo-Devonian species referable to Modiomorpha have the dentition described by Hall—that is, a single tooth in the left valve fitting in a socket in the right valve. According to Beushausen an additional socket for the reception of a tooth of the right valve is commonly found behind the tooth of the left valve; in a few species the structure is reversed, the tooth being in the right valve and the socket in the left. The dentition is therefore highly variable. The ligament is shown by Beushausen, and also by Ulrich, to be internal, not external.

The agreement in superficial expression between Modiomorpha and the older genus Modiolopsis is so remarkable that Ordovician species of Modiolopsis are practically indistinguishable externally from Devonian species of Modiomorpha. The Ordovician species referable to Modiolopsis s. str. are regarded as edentulous by Beushausen, Ulrich, and others, whereas Devonian shells of this type have been found to be conformable with Modiomorpha Hall. Hence Modiolopsis is apparently unknown in the Devonian, and the distinction commonly accepted is that the upper Paleozoic modiolopsoids are dentate (=Modiomorpha), whereas the lower Paleozoic shells of this type are edentulous and conformable with Modiolopsis.

Nevertheless modiolopsoid shells from the Ordovician occasionally show traces of Modiomorpha-like dentition.[4] In the Ordovician modiolopsoid shells of the middle Western States the tooth in the left valve described for *Modiomorpha concentrica* is mentioned by Ulrich as occasionally not entirely lacking, but "rather it is but little developed, since an obscure thickening of the hinge plate between the muscular impression and the beak is noticeable in many species of Modiolopsis" from these Ordovician beds. In the Ordovician beds of France, also, among the normally edentulous modiolopsoids, an occasional species shows Modiomorpha-like dentition (*Modiolopsis dollfussi*[5]), and as low down as the Cambrian one of the earliest modiolopsoids, *M. thecoides* Matthew,[6] has a thin hinge platform and the appearance of a socket in

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1 Hall, James, Preliminary notice No. 2 of the fossil lamellibranchiate shells of the Upper Helderberg, Hamilton, Portage, and Chemung groups, December, 1869; republished with 16 additional pages, January, 1870.

2 Hall, James, Paleontology of New York, vol. 5, pt. 1, p. xxiii, 1885.

3 Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, pp. 11–15, 1895.

4 Ulrich, E. O., Geology of Minnesota, vol. 3, pt. 2, p. 504, 1894.

5 Bigot, A., Note sur quelques pélécypodes des grès siluriens de l'ouest de le France: Soc. géol. France Bull., 3d ser., vol. 17, pp. 791–796, pl. 22, 1889.

6 Matthew, G. F., Preliminary notice of the Etcheminian fauna of Newfoundland: New Brunswick Nat. Hist. Soc. Bull. 18 (vol. 4), p. 191, pl. 1, fig. 7, 1899.

the right valve. In the Silurian Guelph dolomite of Ontario, *Goniophora crassa* Whiteaves [1] is a modiolopsoid with a well-defined cardinal tooth or fold and is therefore referable to Modiomorpha. Hence it must be apparent that the dentate modiolopsoids (=Modiomorpha Hall) are by no means confined to the upper Paleozoic but also pass down into the lowest rocks and are coextensive with the supposedly edentulous modiolopsoids. This brings up the question, Are the latter really edentulous and distinguishable from Modiomorpha? Complications arise from the fact that Hall, in his original description of Modiomorpha in 1869, stated that he thought he had observed in *Modiolopsis modiolaris*, the genotype of Modiolopsis, a dentition similar to that occurring in the group now associated about Cyrtodonta-Cypricardites; so that Fischer, on page 990 of his "Manuel," describes Modiolopsis as having one to four cardinal teeth and one or two posterior laterals and distinguishes Modiomorpha from Modiolopsis by the absence of posterior laterals and the occurrence of only one wedge-shaped tooth in the left valve and a socket in the right. This supposed distinction between Modiolopsis and Modiomorpha is repeated by Nettelroth.[2] However, the great majority of authors describe the Ordovician shells referable to Modiolopsis as edentulous. Few species of such shells are reported in which the hinge line has been observed, and such as have a hinge line generally appear to be edentulous, never with the Cypricardites type of dentition. Hence, if *Modiolopsis modiolaris* Hall is synonymous with Cypricardites Conrad, the name Modiolopsis will have to be confined to the first-mentioned species called Modiolopsis in the list cited by the author when describing the genus,[3] which are not Cypricardites, and these shells, it is believed, will be edentulous or nearly so (=Modiolopsis of authors). On the other hand, the consensus of opinion seems to be that when Hall in 1869 described the supposed dentition of Modiolopsis and *M. modiolaris* he had some other nonmodiolopsoid shell at hand. In either case the name Modiolopsis becomes available for edentulous modiolopsoid shells, which are the more common, at least in the lower Paleozoic.

Most Ordovician modiolopsoid shells have little or no trace of teeth; in the upper Paleozoic, shells having the modiolopsoid shape are generally dentate and agree with *Modiomorpha* Hall, emend. Beushausen. Modiomorphoid (or dentate-modiolopsoid) shells, however, occur throughout the Paleozoic, apparently as far down as the Cambrian, but in the Ordovician such shells generally lack the broader hinge platform, and the dentition is less strongly developed than in Modiomorpha. Ulrich has pointed out the fact that the Ordovician modiolopsoids also have a narrow linear ligament, sometimes internal, sometimes external, whereas in true Modiomorpha the ligament is very much broader. Both Beushausen and Ulrich regard the ligament of Modiomorpha as being internal, a view opposed to that of Hall. Although there seem to be gradations between Modiomorpha and Modiolopsis, Modiomorpha may be regarded as having a stronger hinge than Modiolopsis, both as regards dentition and ligament; and the typical forms of Modiolopsis are edentulous.

The range of Modiomorpha is from Upper Ordovician (?) to Carboniferous. The great bulk of the upper Paleozoic shells of these types belong to Modiomorpha and those of the lower Paleozoic to Modiolopsis. Modiomorpha as currently interpreted is a dominant lamellibranch genus of the Devonian.

Beushausen has shown that the predominant type of dentition in Modiomorpha includes two cardinal teeth in the left valve and one in the right. In number, position, strength, and general development the teeth are comparable with those of the genus Matheria Billings,[4] which has 11 years' priority over Modiomorpha. Billings describes Matheria as follows:

> Transverse; equivalve; inequilateral; beaks near the anterior end; dorsal and ventral margins subparallel; two small obtuse cardinal teeth; two muscular impressions; ligament external.

The only species described by Billings is *M. tener*, from the Trenton limestone of Blue Point, Lake St. Johns. Ulrich [5] records four or five species, all small and all from the American Trenton limestone (Ordovician) except *Modiolopsis recta* Hall, which is from the Niagara group (Silurian).

[1] Whiteaves, J. F., Paleozoic fossils of Canada, vol. 3, pt. 1, p. 9, pl. 2, fig. 3, 1884.
[2] Nettelroth, Henry, Kentucky fossil shells: a monograph of the fossil shells of the Silurian and Devonian rocks of Kentucky, p. 216, 1889.
[3] Hall, James, Paleontology of New York, vol. 1, p. 157, 1847.
[4] Billings, Elkanah, Canada Geol. Survey Rept. Progress for 1857, p. 188, fig. 18, 1858.
[5] Ulrich, E. O., op. cit., p. 563.

Although Modiomorpha Hall was described as having an external ligament, Ulrich (1894) and Beushausen (1895) maintained that the ligament is really internal, and this character will serve to distinguish Modiomorpha from Matheria, in which the ligament is decidedly external in a fairly long open escutcheon behind the beaks.[1] Ulrich [2] also calls attention to the external ligament of Matheria, which is well illustrated in *M. rugosa* Ulrich.

Whether the ligament is external or internal in Modiomorpha is therefore a matter of some little consequence. Ulrich [3] says:

> Another feature is observed in *Modiomorpha concentrica* that may be of importance, namely, the hinge plates posterior to the beaks * * * extend inwardly and at the same time diverge, probably for the reception of a strong internal ligament, the removal of the thin plate leaving a sharp slit a little within the cardinal edge of casts of the interior. The value of the character is to be tested only by its persistence in other species referred to Modiomorpha.

Beushausen [4] also calls attention to a long excavation on the inner margin of the hinge line, which might be mistaken for a long posterior lateral-tooth socket were it not for the fact that it occurs in both valves. Beushausen's figures of *Modiomorpha elevata* Krantz [5] clearly indicate an internal ligament, the occurrence of which in Modiomorpha he strongly emphasizes. Moreover, in the only uncrushed Modiomorpha known preserving the exterior of the cardinal line with both valves in conjunction (*Modiomorpha submissa* Barrois [6]) the dorsal edges of both valves meet and close the shell, so that the ligament must have been internal. Although the interior is unknown, the fossil has the exterior form of Modiomorpha or Modiolopsis. Examination of large numbers of *Modiomorpha concentrica, M. macilenta, M. mytiloides*, and other New York Devonian species showed in none of them any positive evidence of an external ligament, but the material was not well enough preserved to warrant the assertion that the ligaments are internal. There is, therefore, evidence sufficient to suggest that the ligament of Modiomorpha is internal; but unfortunately for such an assumption, Hall figures what seems to be an external escutcheon in *Modiomorpha macilenta* [7] *M. affinis*,[8] *M. mytiloides*,[9] and *M. concentrica*.[10] These specimens, however, are mostly internal molds, and it is not impossible to consider the supposed escutcheon as the impression, on the internal mold filling in the shell, of the convex base of an internal ligament; indeed, in view of Ulrich's and Beushausen's studies, such an explanation seems probable. If Modiomorpha really has an external ligament, as stated by Hall, then its dentition as elucidated by Beushausen shows that it is synonymous with the earlier genus Matheria Billings, which has two teeth in the left valve and one in the right. Modiomorpha Hall would possibly then be restricted in a subgeneric sense to the shells which have only one tooth in the left valve and apparently only a socket and no tooth in the right valve. But the studies just cited seem to indicate that Modiomorpha has a true internal hinge and is therefore distinct from Matheria.

Two other genera in main characters like Modiomorpha differ from Modiolopsis in the presence of strongly developed cardinal teeth. Curiously enough, both of these genera were founded in the same year and were given the same name (Modiolodon). The Modiolodon of Ulrich [11] includes some American Ordovician marine modiolopsoid shells having two or three strongly radial cardinal teeth in each valve. The Modiolodon of Netschayew [12] includes some Russian fresh-water (?) Permian modiolopsoid shells having two or three cardinal teeth in each valve, but differing from the American Ordovician shells in having the teeth horizontal instead of radial. Both genera differ from Modiomorpha in having more numerous cardinal teeth.

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[1] Compare Billings, Elkanah, op. cit., fig. 18 A.
[2] Ulrich, E. O., op. cit., pl. 36, fig. 30.
[3] Idem, p. 504.
[4] Beushausen, Louis, op. cit., pl. 1, fig. 11.
[5] Idem, pl. 3, fig .11c.
[6] Barrois, Charles, Faune du calcaire d'Erbray, Loire-Inférieure: Soc. géol. Nord Mém., vol. 3, p. 176, pl. 12, figs. 2a, 2b, April, 1889.
[7] Paleontology of New York, vol. 5, pt. 1, pl. 39, fig. 21, 1885.
[8] Idem, pl. 37, fig. 14.
[9] Idem, pl. 38, fig. 13.
[10] Idem, pl. 36, fig. 13.
[11] Ulrich, E. O., The Lower Silurian Lamellibranchiata of Minnesota: Geology of Minnesota, vol. 3, pt. 2, p. 521, June 16, 1894; New and little-known Lamellibranchiata from the Lower Silurian rocks of Ohio: Ohio Geol. Survey, vol. 7, pt. 2, p. 652, 1894 (subsequent to June 16, 1894; not 1893, date of title-page).
[12] Netschayew, A., Die Fauna der permischen Ablagerungen des ostlichen Theils der Europäischen Russlands [in Russian]: Soc. Naturalists Imp. Univ. Kazan Works, vol. 27, pt. 4, pp. 239 et seq., 1894 (month of publication unknown; preface bears date March 1, 1894). It is interesting to note that several apparently edentulous modiolopsoid shells from the Permian are called Modiolopsis in this work.

MODIOMORPHA cf. M. PROTEA Clarke.

Plate XXI, figure 16; Plate XXVI, figure 14.

cf. 1907. *Modiomorpha protea*. Clarke, New York State Mus. Bull. 107, p. 220, upper figure (not lower figure= *M. aroostooki* sp. nov.).
Lower Devonic [Chapman sandstone]: Edmunds Hill, Chapman Township, Aroostook County, Maine.

A couple of fragments of a Modiomorpha found in loose blocks of the Chapman sandstone on Edmunds Hill indicate a depressed species of transversely rectangular form, with cardinal line long, nearly straight, and ascending very slightly, nearly parallel with the basal margin, which is almost straight. The posterior margin is retrorse. The shell is depressed, rather flat, and marked by a conspicuous umbonal ridge. The ornamentation is pronounced on the internal mold (? "sculpture cast") where it consists of tenuistriate lines of growth occasionally strengthening into narrow concentric undulations.

Locality: Chapman sandstone, Edmunds Hill (locality 1099 C′), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59815.

MODIOMORPHA AROOSTOOKI sp. nov.

Plate XXI, figures 2–7, 10–13.

1907. *Modiomorpha protea* (pars). Clarke, New York State Mus. Bull. 107, p. 220 (lower figure only).
Lower Devonic: Presque Isle Stream, Chapman Plantation, Aroostook County, Maine.
cf. 1907. *Modiomorpha vulcanalis* (pars). Clarke, idem, p. 219 (left figure only).
Lower Devonic [Chapman sandstone]: Edmunds Hill, Chapman Plantation, Aroostook County, Maine.

In one of the layers of the Chapman sandstone on Presque Isle Stream occurs in abundance more or less crushed and macerated shells and internal molds of a large species of either Cypricardella or Modiomorpha. These shells or molds are usually found with both valves in conjunction, but in this condition, though abundant, they are too fractured, crushed, or otherwise imperfect for description. A well-preserved sculpture cast of a left valve from this layer of rock is taken as the type of the species *M. aroostooki*. It is equivalved, inequilateral, closed. The length of the shell is 1⅝ times the height; the maximum length is situated at the inferior third of the height and the maximum height is situated indefinitely posterior to the middle. The beaks, which are at the anterior fifth or slightly farther back, are directed forward; they are depressed to the hinge line and do not protrude beyond it. The anterior end of the shell is well developed, and the forward extremity is nearly opposite the midheight of the shell. Just in front of the beaks the antero-dorsal margin is faintly concave. Ventrally the anterior margin swings backward in a shallow curve into the ventral margin. In the type specimen and in one or two other specimens there is a faint constriction or straightening of the ventral margin back of the middle; but in the majority of specimens the ventral margin is slightly convex throughout, without trace of byssal insinuation or constriction. The ventral extremity of the shell is near the posterior end. The ventral margin in the postventral region recurves in a broad swing into the retrorse posterior margin. The posterior margin is convex throughout, vertical for nearly the lower half and swinging back in the upper half at an angle of 120° to 135° to the hinge line. Hinge extremity subangular. The hinge line is gently arched and is equal in length to only three-fourths the height of the shell, or three-fifths the total length of the shell; it ascends slightly in its anterior half and descends a little in its posterior half. Owing to the descending ventral margin the shell expands in height posteriorly. Specimens with both valves in conjunction are usually compressed and show a prominent postumbonal ridge, but the type specimen and some others show no umbonal ridge. The body of the shell is slightly inflated above the midheight and descends in a broadly arched surface to the anterior margin and to the forward half of the ventral margin. The greatest depth of the shell is situated above the middle—at the midlength, two-fifths the height below the hinge—and is equal to a fourth the height in each valve in the uncompressed condition. The depth of the compressed specimens, with both valves in conjunction, is only about one-third the height.

Ligament internal. A narrow incision occurs on the internal mold just below the line extending from the beak toward the hinge extremity, and becomes obsolescent before reaching the hinge. At first sight this incision resembles the impression of a posterior lateral tooth or socket, but the structure occurs on the molds in both valves at the same height, and the two ridges do not meet, but slightly diverge.

No posterior lateral teeth or cardinal teeth are visible. The muscular scars are both large and deeply impressed. The anterior scar has a height of 8 to 10 millimeters or nearly one-fourth the height of the shell. It is situated close to the anterior margin, much closer than to the beaks. A small deep retractor scar is usually observable in the concave space in front of the beak. The posterior scar has hardly twice the linear dimensions of the anterior scar. It is situated near the posterior margin and extends down to or slightly beyond the midheight of the shell. The pallial line is simple and moderately strong. It begins at the antero-ventral corner of the anterior scar and ends on the posterior margin of the posterior scar, leaving the greater portion of both muscular scars within the line. The pallial line is radially striate in its posterior portion. Shell substance very thick.

The surface is covered with coarse concentric striæ of growth, strongest posteriorly.

A small specimen has a height of 29 millimeters and a length of 41.75 millimeters. The type specimen, a large individual, has a height of 40 millimeters and a length of 56 millimeters, which is only slightly larger than the usual size of the specimens.

The distinguishing features of this fossil are its high form, with length equal to about 1⅜ times the height; beaks well back, commonly at the interior fifth or farther back; well-developed anterior end; faint expression, or in fact, usual absence of ventral insinuation; retrorse posterior margin; hinge line less than height of the shell; large muscular scars; posterior scar barely twice the dimensions of the anterior and extending down to the midheight or lower; coarse concentric striæ of growth.

Locality: Chapman sandstone, Presque Isle Stream, at the end of Tweedy road (locality 1099 L), in a layer 150 feet below the top of the section at this point, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59816.

Comparisons.—The type specimens present some resemblance to the New York Hamilton shell *Modiomorpha alta* Hall,[1] from which, however, they are easily distinguished. *M. alta* has a much more fully developed ventral insinuation and a smaller anterior end. In general proportions, general character of the ventral margin, and relative size and position of the muscular scars, *M. aroostooki* bears some resemblance to *Modiomorpha complanata* Hall, from the Onondaga ("Corniferous") limestone of New York, but Hall's species is larger and has the umbones farther forward.

Clarke[2] described under the name *Modiomorpha protea* two distinct species from the Chapman sandstone. One form, illustrated in the upper figure, is a narrow, transversely elongate shell with long hinge line, apparently from the Edmunds Hill locality. To this transversely elongate form I would restrict the name *Modiomorpha protea* Clarke. The second species is illustrated in Clarke's lower figure and is from Presque Isle Stream. In proportions, manner of preservation, and general aspect it agrees with *M. aroostooki*, and it comes from the same locality. Clarke's specimen, as figured, shows the ventral margin ascending to the postventral extremity rather more strongly than is usual in this variable species.

The convex ventral margin and the general shape of the shell suggest the genus Anodontopsis, and the fossils may really be congeneric with *Anodontopsis maccoyiana* (see Pl. XXIV, fig. 16), rather than with the genus Modiomorpha. Indeed, the solitary specimen (from locality 1099 L) identified with *Anodontopsis maccoyiana* and showing the cardinal teeth may perhaps be a young individual of *Modiomorpha aroostooki*.

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[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 278, pl. 37, figs. 1-2, 4-12, 15, 16, 1885.
[2] Clarke, J. M., New York State Mus. Bull. 107, p. 220, 1907.

MODIOMORPHA sp. indet.

A fragment of a Modiomorpha in the collections shows a rounded oval species, with anterior end oval, high, but very short; ventral margin convex throughout; shell expanding in height posteriorly; anterior muscular scar large; surface evenly rounded. The fragment represents a species about 35 millimeters in height, with a general resemblance in outline and appearance to the New York Onondaga ("Corniferous") limestone species *Modiomorpha complanata* Hall or *M. schoharie* Hall,[1] but it is too imperfect for closer determination and description.

MODIOMORPHA (cf. ENDODESMA) CHAPMANI sp. nov.

Plate XX, figures 1–7.

Shell large, closed, equivalve, very inequilateral, transversely extended, rectangular-trapezoidal. Greatest height one-third the length from the front; greatest length about one-third the length from the base. Length nearly twice the height, the dimensions varying from 60:31 millimeters to 70:36.5 millimeters. Beaks broadly depressed, directed forward, situated one-seventh to one-ninth the length from the anterior extremity. Cardinal line posterior to the beaks, very long, one-third to three-sevenths greater than the height of the shell; slightly convex; rising slightly from the beak to the point of maximum height, thence gently declining to the posterior margin so that the posterior extremity is only about one-ninth or one-tenth the height below the umbo. Cardinal extremity angular, obtuse. Posterior margin retrorse, straight, or slightly convex from the cardinal extremity to the point of maximum length, including a distance equal to about half the length of the cardinal line; postero-basal region rounded angular, the upper portion and the lower or postbasal margin forming an obtuse angle of about 120°; the upper side of the posterior margin is about twice as long as the lower. The lower side curves off rather abruptly into the basal margin, which is broadly though very slightly insinuated, almost straight for a distance equal to about the length of the cardinal line, to which it is parallel, thence rising forward in a broad curve to the anterior extremity, which is evenly rounded, though the upper portion has a shorter radius of curvature than the lower. The most forward part of the shell is at the midheight. The anterior portion is separated from the umbones by a short concave lunule. Isolated single valves have a depth equal to two-sevenths the length. The point of greatest convexity in well-preserved specimens is posterior to the middle on the rounded postumbonal ridge, about one-fourth the height of the shell below the cardinal line, occasionally near the midheight. The umbones are broad, convex, and depressed upward and forward; the beaks are incurved. There is no clearly defined post-umbonal angulation, this portion of the surface as far as the posterior basal margin being broadly rounded. The central area of the shell is broadly insinuated, very slightly concave or flat to a point just below the beaks, where the surface descends into the anterior portion.

The surface is covered with faint concentric lines of growth, occasionally aggregated into undulating concentric ridges or folds. These folds are best developed on the anterior portion, particularly just under the lunule. There are no traces of radial lines. Neither muscular nor pallial scars have been observed in any of the specimens, which are nearly all internal sculpture casts or internal molds.

The average shell is about 61 millimeters long, and each valve is between 8 and 9 millimeters deep. The largest specimen figured is 36.5 millimeters high and 71 millimeters long.

The present forms are remarkable among the modiomorphoid shells, for the cardinal line which, instead of rising posteriorly as is common, is almost parallel to the basal margin or slightly reclining posteriorly. Other characteristic features are the obtusely angular (not broadly rounded) cardinal extremity; the retrorse, nearly straight upper posterior margin; the transversely elongate outline, with length twice the height; the extreme anterior point at about the midheight; the broad insinuation; the absence of muscular scars; and the ornamentation obsolescent over the general surface but aggregated into concentric folds under the well-developed lunule.

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[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, pl. 34, figs. 13, 14, 1885.

In the specimens from the locality west of Edmunds Hill the postumbonal slope to the cardinal line is slightly steeper than it is in those from Edmunds Hill. Consequently the point of greatest depth of the valve is about one-fourth the height below the cardinal line in the specimens from the locality west of Edmunds Hill, whereas in those from Edmunds Hill the point of maximum convexity or depth of the valve is generally nearer the midheight.

Locality: Chapman sandstone, common at Edmunds Hill and west of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59817, 59818.

Comparisons.—The species more or less closely resembles the common early Mississippian *Modiomorpha hyalea* Hall [1] in its transversely elongated outline, with length barely less than twice the height the "parallel" cardinal and basal margins, with the cardinal margin slightly reclining, the absence of scars, and in the surface ornamentation. In the Maine forms, however, the beaks are much more anterior (only one-eighth the length) from the anterior margin, compared with one-third the length in *M. hyalea,* and the cardinal line is therefore proportionately much longer. The extreme anterior point is at or above the midheight in the Maine specimens; in *M. hyalea* it is below the midheight. The two forms are specifically distinct, though closely associated in the same generic or subgeneric group, which differs from the normal Modiomorpha in having a transversely elongated outline with cardinal and basal margins very nearly parallel, and in having the cardinal line slightly reclining.

One of the nearest allies to *Modiomorpha (?Endodesma) chapmani* is Salter's *Mytilus platyphyllus* var. *β*,[2] from the Tilestones of South Wales, which, however, has a more pronounced ligamental groove, an ascending, not reclining cardinal line, and the anterior end lower dorsoventrally than in the Maine form.

The Ordovician genus Endodesma was founded by Ulrich [3] for modiolopsoid or modiomorphoid shells without muscular or pallial scars; with the length twice the height or more, and with the cardinal line not ascending, but, instead, parallel with the basal margin or very slightly reclining, and with a wide sinus. There is no escutcheon,[4] the ligament is internal, and, in the type species (*E. cuneatum* Ulrich), a long internal posterior septum or ridge is developed under the cardinal line—presumably for the attachment of the ligament, though in the other species, except possibly in *E. undosum* Ulrich,[5] no such ligamental septum is apparent. This group of species, including *Endodesma compressum* Ulrich,[6] *Endodesma orthonotum* (Meek and Worthen),[7] and *Endodesma gesneri* (Billings)[8] forms a series of Ordovician shells to which the Maine species under discussion bears close resemblance. In the same group may also be included the Silurian "*Modiolopsis*" *antiqua* Barrande (pars), noted below. In all there is the same peculiar expression caused by the broad umbones, with the beaks only about one-eighth the length from the front; the maximum height about one-third the length from the front; the cardinal line slightly convex, almost straight, and parallel with the basal margin, or very slightly declining, but never appreciably ascending; the angular or subangular cardinal extremity and retrorse, slightly convex, or nearly straight upper posterior margin; the broad, oblique, shallow, undefined ventral insinuation; the distinct but broadly rounded, not carinated umbonal ridge, with the point of maximum depth situated on it above the midheight; the short anterior lunule and absence of conspicuous posterior ligamental groove; the absence of muscular scars; and similar obsolescent concentric ornamentation. With this group of shells the species at hand appears to be congeneric, and for that reason the generic name Endodesma has been used, though cognizance has been taken of the fact that the internal ligamental septum occurring in the original

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 292, pl. 41, figs. 28–30, 1885.

[2] Salter, J. W., Geol. Survey Great Britain Mem., vol. 2, pt. 1, p. 364, pl. 20, fig. 14 (cet. excl.?), 1848.

[3] Ulrich, E. O., The Lower Silurian Lamellibranchiata of Minnesota: Geology of Minnesota, vol. 3, pt. 2, p. 525, pls. 36, 37 (in part), June 16, 1894.

[4] *Endodesma postlatum* Ulrich (idem, p. 527, pl. 37, figs. 5, 6), from the upper Galena (Ordovician) of Dubuque, Iowa, probably does not belong to Endodesma, for not only is the cardinal line ascending, but, in addition, an escutcheon-like groove is developed for the ligament; the species is much shorter than all the other Endodesmas.

[5] Idem, pl. 36, fig. 38.

[6] Idem, pl. 36, figs. 35–37.

[7] Idem, pl. 37, figs. 1, 2.

[8] Idem, pl. 37, figs. 3, 4.

type species of Endodesma has not been observed in the present species nor, indeed, in most of the Ordovician Endodesmas.

Mordiomorpha (*Endodesma?*) *chapmani* is easily distinguished, superficially, from this group of Endodesmas by being proportionately shorter; the length is barely twice the height, whereas in the Ordovician species it is more than twice and as much as three times the height.

In the upper Silurian of Arisaig occurs a group of three species similar to the Ordovician Endodesmas named, but having a few irregular radial striæ in addition to the concentric marking. These Arisaig species are *Orthonota incerta*, *O. simulans*, and possibly also *O. speciosa*, all described by Billings.[1]

Among the other fossils which may in some respects be regarded as similar to *Modiomorpha* (*Endodesma?*) *chapmani* may be mentioned the Eo-Devonian *Megalodon curvatus* of Krantz (pars),[2] from the Siegen graywacke of Menzenberg, in which, however, the umbones are much higher and more inflated, the cardinal line declines more rapidly, and the umbonal ridge is less broadly rounded than in the Maine species.

The Sanguinolites sp. of Reed,[3] from the Bokkeveld sandstone of Ceres, Cape Colony, is also similar, but its cardinal line is slightly concave instead of slightly convex, the surface is less insinuated, the umbones are more tumid, and the anterior extremity is much smaller than in the Maine species.

Finally may be mentioned *Modiolopsis antiqua* Barrande,[4] ranging from the Silurian (étage E^2) to the Konieprussian Eo-Devonian (étage F^2), some forms of which, particularly those shown in Barrande's figures 9 and 10 from the Silurian étage E^2, are with difficulty distinguishable from *Modiomorpha* (*Endodesma?*) *chapmani*. Barrande's species, however, is, like the Ordovician Endodesmas previously discussed, more elongated than the Maine species and the umbones are also slightly more anterior. The Bohemian specimens just mentioned are apparently congeneric with the Ordovician group of Endodesma discussed in the preceding pages; and, together with Billings's Arisaig shells, indicate the continuance of the genus Endodesma to and apparently through the Silurian. If the Maine form is, as seems apparent, to be regarded as congeneric with the Ordovician group of Ulrich's species of Endodesma referred to, the Silurian species may serve as a connecting link in the stratigraphic interval between the Ordovician and the Chapman sandstone.

Genus GONIOPHORA Phillips.

The generic name Goniophora was proposed by Phillips[5] in 1848 for the Silurian *Cypricardia cymbæformis* Sowerby. In the midst of some broad generalizations on the systematic position of the lower Paleozoic lamellibranchs, with special reference to Conrad's Orthonota and the lower Paleozoic Cypricardias, regarded as nearly allied to Mytilus and Modiola, Phillips stated:

> If, as I suppose, *Cypricardia cymbæformis* be distinct, generically, and include species of the Mountain limestone, the name *Goniophora* seems suitable. It is, however, doubtless a mytiloid shell.

The genus Goniophora was thus founded without any indication whatever of any diagnostic characters, nor was the type precisely indicated. The two or more forms called *Cypricardia cymbæformis* by Sowerby and authors (one form from the "Lower Old Red" at Felindre, the second from the Upper Ludlow at Ludlow) are apparently not cospecific; indeed, they are not known to be strictly congeneric. Phillips[6] himself gave the name *Goniophora cymbæformis* to shells of this general type, ranging from the Wenlock shales through the Tilestones, and one might easily infer that the types of Phillips's Goniophora were Carboniferous (Mountain limestone) shells like *Goniophora rhombea*, rather than *Cypricardia cymbæformis*.

Considering the meager description of the genus, the indefiniteness of the types, and the obscure position of its publication in the midst of a paragraph of generalizations on other fossils,

[1] Billings, Elkanah, Paleozoic fossils of Canada, vol. 2, pt. 1, pp. 130-131, pl. 8, figs. 2, 4, 3, respectively, 1874.
[2] Naturh. Ver. preuss. Rheinlände Verh., vol. 14, p. 161, pl. 11, fig. 4a (not fig. 4b), 1857.
[3] South African Mus. Annals, vol. 4, pt. 6, p. 254, pl. 31, fig. 4, 1904.
[4] Barrande, Joachim, Système silurien du centre de la Bohême, pt. 1, vol. 6, pl. 260, box IV, figs. 2-11, 1881.
[5] Phillips, John, The Malvern Hills compared with the Paleozoic districts of Abberley: Geol. Survey Great Britain Mem., vol. 2, pt. 1, p. 264, 1848.
[6] Idem, p. 267.

it is no wonder that the genus Goniophora was at first entirely overlooked. Curiously enough, McCoy [1] discusses to some length the genera Orthonota Conrad, Cypricardites, etc., and the same fossils which first attracted the attention of Phillips, but does not mention Goniophora. McCoy unites these fossils under one generic name—his Orthonotus, altered from Conrad's Orthonota—and gives a short generic description. The first species described under the genus—therefore strictly the genotype—is Sowerby's *Cypricardia cymbæformis*. There is no recognition nor mention of Phillips's name Goniophora, founded four years before, although McCoy frequently refers to Phillips's work on the Malvern Hills. However, it seems that the term Orthonotus has no greater claim than Goniophora to be applied to *Cypricardia cymbæformis*, for the reason that Orthonotus was applied by McCoy to three different shells (*Orthonotus cymbæformis* = Goniophora; *Orthonotus nasuta* = Modiolopsis; *Orthonotus semisulcatus* = ?Grammysoidea) representing three widely separated genera; that he gave no explicit designation of the genotype; and, finally, that the generic description of Orthonotus given by McCoy was so general as to be in itself of small value. The priority of four years possessed by Goniophora Phillips, 1848, over Orthonotus McCoy, 1852, must therefore be considered sufficient cause for the retention of the former name in preference to the latter, unless, indeed, it can be shown that the shells called *Orthonotus cymbæformis* by McCoy are not congeneric with those designated *Goniophora cymbæformis* by Phillips. This has not yet been shown, so that we must, at least for the present, regard Orthonotus McCoy, 1852, as a strict synonym of Goniophora Phillips, 1848.

The term Goniophora was recognized in 1854 by Salter,[2] who mentions *Goniophora cymbæformis* as being one of the dominant members of the Upper Ludlow fauna, but he gave no description of the genus, nor of any of the internal or diagnostic characters of the type species.

The Sandbergers, when they wrote their classic work on the fossils of the Rhenish series in Nassau,[3] seem, like McCoy, to have been utterly unaware of the existence of the genus Goniophora, for they described their now well-known *Goniophora acuta* (not Hall, 1870) as a Cypricardia, without in any way mentioning the name Goniophora.

In 1864 Honeyman [4] mentioned but did not describe a fossil, called *Goniophora cymbæformis*, from the upper Arisaig beds of Nova Scotia.

As pointed out by Barrande, Chenu does not mention Goniophora in his "Manuel," and Hall,[5] in 1870, seems not to have recognized the term, for he described under the generic name Sanguinolites a large number of species which he later referred to Goniophora.

In 1874,[6] for the first time, the generic name Goniophora was used for species other than *G. cymbæformis*. The Arisaig shell called *Goniophora cymbæformis* by Honeyman was described as *G. consimilis* by Billings, who also described as new the species *Goniophora transiens*, *G. bellula*, and *G. mediocris*, from the upper Arisaig (late Silurian), as well as *G. mediocris*,[7] from the Gaspe limestone No. 8 at Gaspe, Quebec, the name *G. mediocris* being unintentionally applied to two different species. All these forms have the angular umbonal ridge commonly regarded as characteristic of Goniophora. Billings did not give any description of the genus, nor did he indicate any important internal or other diagnostic generic characters; in fact he was not quite sure of the correctness of his usage of the term Goniophora, for he said: [8]

> The genera Orthonota (Conrad), 1841, Sanguinolites (McCoy), 1844, and Goniophora (Phillips), 1848, seem to be all closely related to each other. The following references to these genera are, therefore, to be regarded as merely provisional.

He then described and referred five species to Orthonota, two to Modiolopsis, and four to Goniophora. Billings's contribution is important as being the first general adoption of the now well-known term Goniophora, and also because he used the term not only for the short,

[1] Sedgwick, Adam, and McCoy, Frederick, British paleozoic rocks and fossils, 1852-1855.

[2] Murchison, R. I., Siluria, 1st ed., p. 135, pl. 23, 1854.

[3] Sandberger, Guido and Fridolin, Versteinerungen des rheinischen Schichtensystems in Nassau, 1850-1856.

[4] Honeyman, D., On the geology of Arisaig, Nova Scotia: Geol. Soc. London Quart. Jour., vol. 20, p. 344, 1864.

[5] Hall, James, Preliminary notice of the fossil lamellibranchiate shells of the Upper Helderberg, Hamilton, and Chemung groups, pt. 2, pp. 35-43, January, 1870.

[6] Billings, Elkanah, On some of the fossils of the Arisaig series of rocks, Upper Silurian, Nova Scotia: Paleozoic fossils of Canada, vol. 2, pt. 1, pp. 134-137, pls. 8, 9, 1874.

[7] Idem, p. 50, fig. 21.

[8] Idem, p. 129.

square or trigonal, highly inflated shells of the type of the original *G. cymbæformis* and of *G. consimilis*, etc., but also for those much flatter and transversely elongate forms represented by *G. transiens* Billings, *G. hamiltonensis* (Hall), *G. chemungensis* (Vanuxem), and *G. carinata* (Conrad). To Billings is due the credit for the general acceptance and prevalent usage of the term Goniophora.

In 1875 Woodward recognized the genus in his "Manual of conchology." Two years later Goniophora was accepted by Miller,[1] who used the term for Hall's Devonian *Sanguinolites acuta* and *S. hamiltonensis*, Conrad's *Cypricardites rugosa*, and all of Billings's Goniophoras. Miller's usage of Goniophora was repeated in 1878 by Bigsby.[2]

At about the same time Hall prepared his classic work on the Devonian lamellibranchs,[3] which did not appear in public until 1883. In September, 1878, at the Paris meeting of the Congrès géologique Hall showed to Barrande the plates and presumably the manuscript of this volume, so that in 1881, when Barrande issued his work on the lamellibranchs,[4] he felt himself constrained out of courtesy to Hall to refrain from giving a description of the genus Goniophora.

Barrande named and figured seventeen species of what he regarded as Goniophora—three species (*Goniophora retrorsa* Barrande, *G. scalena* Barrande, and *G. zephyrina* Barrande) from étage E^1, one species (*G. phrygia* Barrande) common to étages E^1 and E^2, eleven species confined to étage E^2, none in étage F^1, and two species in the Hercynian or étage F^2. Most of these species are not really Goniophoras. *G. retrorsa*, from étage E^1; *G. phrygia*, from étages E^1 and E^2; and *G. imperfecta*, *G. reluctans*, *G. soror*, and *G. testis*, from étage E^2, are radially ribbed schizodiform shells which belong apparently in Barrande's genera Matercula (Maminka) and Amita (Tetinka). *G. scalena*, from étage E^1, is comparable with forms of the Lower Devonian Kochia Frech (=Onychia Sandberger) and resembles externally Ulrich's genera Plethocardia and Whitella,[5] as does also *G. minax*, from étage E^2. Of the seventeen species named and figured by Barrande, only five can with any degree of certainty be referred to Goniophora. These are *G. binotata*, *G. media*, *G. pugio*, and *G. rara*, all four from étage E^2 (equivalent of Aymestry and Guelph), and *G. secans* (under which several distinct species are apparently aggregated), from the Konieprus étage F^2 (Hercynian).

In 1883 appeared the advance or preliminary issue of Hall's work, dealing with the Devonian (Onondaga to Chemung) lamellibranchs of New York,[3] and in 1885 the work was completed by a descriptive text and published in its final form. In this work, more than 35 years after the genus Goniophora was founded, appears the first description of the genus.

The main features of Goniophora, as described by Hall, are the strong angular ridge extending from the beak to the postinferior margin; truncate posterior extremity; long, straight hinge line; rhomboidal or trapezoidal outline; broad undefined sinus over the central or anterior part of the shell constricting the basal margin; and the concentric ornamentation, with, in a few species, radial lines between the sinus and umbonal ridge. With regard to the hinge and muscular structures, it should be emphasized that Hall's description of the genus was drawn up from American material, chiefly his *Goniophora glauca* of the Hamilton, and not from *G. cymbæformis* (Sowerby), the Silurian type of the genus Goniophora. According to Hall,[6] there are no lateral teeth, and only a short oblique cardinal fold or tooth in the left valve and a corresponding depression or socket in the right valve. The ligament is external, strong, and inclosed in a well-developed escutcheon; anteriorly there is a deep lunule and well-developed lunette. The anterior muscular scar is feebly impressed, fairly large, and surmounted by a small retractile scar; the posterior scar is hardly ever discernible, but is larger and is situated on the postumbonal slope.

Hall described a large number of species of Goniophora from the "Corniferous," Hamilton, Portage (Ithaca shale member), and Chemung, and his beautiful figures have helped to make the genus well known.

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[1] Miller, S. A., The American Paleozoic fossils, p. 192, Cincinnati, Ohio, 1877.
[2] Bigsby, J. J., Thesaurus devonico-carboniferus, 1878.
[3] Hall, James, Paleontology of New York, vol. 5, pt. 1.
[4] Barrande, Joachim, Système silurien du centre de la Bohême, pt. 1, vol. 6.
[5] Ulrich, E. O., Geology of Minnesota, vol. 3, pt. 2, pp. 564, 575, 1894.
[6] Hall, James, op. cit., pl. 46, figs 13, 14.

Though this genus is commonly regarded as having no posterior lateral teeth, as exemplified in some of the more elongated and flatter Devonian shells referred to Goniophora (*G. glauca*, etc.), the original type, as represented by *G. cymbæformis* (Sowerby), from the Tilestones of Felindre,[1] has posterior laterals, to judge from the figure cited. Traces of a posterior lateral are also apparently indicated in *Goniophora perangulata* Hall [2] and in the flatter *G. applanata* Beushausen.[3] At first sight it would hardly seem credible that the small, short, highly inflated shell of the Silurian *cymbæformis* type, apparently showing one or two long, well-developed posterior laterals, should be congeneric with the more depressed, transversely elongated type represented by *Goniophora glauca* Hall, *G. hamiltonensis* (Vanuxem), and *G. bipartita* (F. Roemer), having no posterior laterals. Not only does Sowerby's figure of the Tilestone *Goniophora cymbæformis* seem to indicate the existence of posterior laterals, but McCoy,[4] in his description of Sowerby's species, says that the hinge line is "slightly elevated (the margins simple and erect [meaning, presumably, without escutcheon], with a moderately slender lateral tooth extending a little below it)." On the preceding page, under the description of the genus Orthonotus, McCoy states that there is an internal cartilage plate running beneath the long hinge line, and a few lines below he again emphasizes this point in stating that these shells "must not be confounded with * * * Grammysia (Vern.) and Sanguinolites (McCoy), in which the dorsal margins are inflected at right angles"—that is, producing a strong escutcheon. "They are, in fact, a sort of elongate Edmondia," continues McCoy. Edmondia has an internal ligamental septum, as in Mytilus. Thus it would appear that *Goniophora* (*Orthonotus* McCoy) *cymbæformis* (Sowerby) seems to have posterior laterals and an internal ligament, but no escutcheon. The real type of Goniophora may, therefore, be a very different shell from that indicated by the prevalent interpretation of the genus. It is, in fact, quite possible that Goniophora, based on Sowerby's *Cypricardia cymbæformis*, is more closely identifiable with Mecynodus of authors than with Goniophora of authors. Unfortunately these English Silurian lamellibranchs have been wholly neglected since the pioneer days of Murchison, Sowerby, and McCoy, so that hardly anything is known of the real structure of the fossils. The absence of English specimens at the present writing makes it impossible to shed any further light on the matter.

Therefore, although I suspect that the real types of *Goniophora cymbæformis* may be shells having apparently two long posterior laterals in the right valve (as figured by Sowerby), and one in the left (?) valve (as stated by McCoy), and thus being, so far as known, congeneric with the shells included under the genus Mecynodon Keferstein (written Mecynodus by Beushausen), still, in the absence of more definite knowledge, I am conforming with the prevalent conception of Goniophora and regarding it as edentulous except for the short diagonal cardinal in the left valve and the corresponding socket, with sometimes a small anterior cardinal, in the right valve. If there is an internal rather than external ligament in *G. cymbæformis*, as stated by McCoy, then *G. cymbæformis* must be quite distinct from both Mecynodon and Goniophora of authors.

Finally, it may be stated that the apparent existence of lateral teeth in some forms of Goniophora seems to have been noted by Beushausen,[5] who, in his description of this feature in Goniophora, says: "Lateral teeth absent. Toward the interior of the shell the hinge line is set off with a septum of which the impression on the internal mold is represented by a furrow. The ligament is external in a long groove behind the beak." Beushausen's mention of a "furrow" has very much the appearance of an attempt to explain Sowerby's figure in conformity with the common conception of Goniophora. Moreover, Beushausen's *Goniophora applanata* [6] is apparently the only form indicated by him which shows this furrow below the hinge line, and this form is not known to possess an external ligament. The *Goniophora perangulata* of Hall, previously indicated as showing a similar furrow, has, however, a strong escutcheon and lunette, which places the species in Mecynodon.

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1 Murchison, R. L., The Silurian system, pt. 2, pl. 3, fig. 10a, 1839.

2 Hall, James, Paleontology of New York, vol. 5, pt. 1, pl. 34, fig. 1, 1885.

3 Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, pl. 17, figs. 18-20, 1895.

4 Sedgwick, Adam, and McCoy, Frederick, British Paleozoic rocks and fossils, p. 275, 1852. McCoy's material was from the Tilestones of Horeb Chapel, Llandovery, South Wales; and from the Upper Ludlow of Burton and Brockton, near Wenlock.

5 Beushausen, Louis, op. cit., p. 196.

6 Idem, pl. 17, figs. 18, 18a.

Drevermann[1] describes several forms of Goniophora and gives some interesting notes on the genus. Drevermann states among other things that a long posterior septal ridge or tooth (posterior lateral) is present in "some species" of Goniophora in the left valve.

Whidborne[2] mentions a long posterior lateral tooth in his Devonian *Goniophora obliqua* from Woolborough, but the species is apparently not a Goniophora.

I shall therefore follow, temporarily at least, those authors, including Hall, Neumayr, Beushausen, and Drevermann, who regard Goniophora as being without posterior lateral teeth and as having presumably an external ligament. The two or three species of Goniophora present in the Chapman fauna are unfortunately too poorly preserved in these respects to shed any additional light on the subject.

Among the shells most likely to be confused with Goniophora are those belonging to the genus Mecynodon Keferstein.[3] The following is a translation from the German of the original diagnosis of Mecynodon:

> Shell longish, thin [really rather thick, as pointed out by Beushausen and as may readily be seen from the figures of the species], concentrically striated or smooth, divided by a blunt or sharp diagonal keel into a front and posterior portion. Hinge without hinge plate; in each valve, almost parallel with the hinder margin, there is a long, high cardinal tooth, and in the right valve a deeper groove behind it; in the left valve, where the tooth is along the the cardinal margin, there is a groove in front of it. A long lateral tooth on the posterior portion of each valve; that of the right inclosing that of the left. Anterior muscular impression almost on the hinge line, deeply impressed, especially the posterior portion; just behind it is the deep imprint of a small pedal muscle. Posterior muscular scar somewhere near the middle of the posterior margin. Pallial impression simple. Ligament external, short.
>
> The genus is founded on species of Megalodus of Goldfuss which have already been differentiated into several groups by Von Gruenewaldt[4] at the instigation of Beyrich. The genus Mecynodon embraces the second and third groups of Von Gruenewaldt.

Keferstein then describes *Mecynodon carinatus* (which must be taken as the genotype of Mecynodon), *M. oblongus*, and *M. auriculatus*—all three species from the Eifelian limestone at Paffrath, described originally by Goldfuss under Megalodus.

Keferstein describes the genus as having only one posterior lateral in each valve. As a matter of fact there are two in the right valve inclosing the single posterior lateral of the left. Beushausen[5] describes the genus and the type species *M. carinatus* Goldfuss as having two cardinals in each valve. This does not appear in the illustrations of the hinge structure of the fossils, except that the small narrow depression in the right valve in front of the anterior tooth and between this tooth and the anterior muscular scar may be occupied by a small narrow tooth or ridge situated in the left valve between the anterior large socket and the muscular scar.[6]

Megalodon oblongus Goldfuss can not belong to Mecynodon, for it has two posterior laterals in the left valve, apparently three cardinals in the left valve and two in the right, and a surface expression entirely different from that of Mecynodon. This species appears to be a Pleurophorus. The group of *M. auriculatus* also should probably be separated from Mecynodon on account of the distinctive superficial expression.

The shells belonging to Mecynodon are rhomboidal in outline, with a typical goniophoroid umbonal ridge in the type species. They have concentric markings and a general expression almost indistinguishable from several of the modifications of typical Goniophora, and the muscular markings and cardinal dentition are the same in each genus. Goniophora and Mecynodon are apparently distinguishable only on hinge features. Mecynodon differs in having two well-developed long posterior laterals in the right valve, inclosing the one of the left valve.

Posterior laterals are, as has been indicated, supposed to be absent in Goniophora, but the typical figure of the typical *G. cymbæformis*[7] appears to show two posterior laterals in the

[1] Drevermann, F., Die Fauna der Untercoblenzschichten von Oberstadtfeld bei Daun in der Eifel: Palaeontographica, vol. 49, pp. 88 et seq., 1902.

[2] Monograph of the Devonian fauna of the south of England, vol. 2, pt. 1, p. 17, pl. 3, fig. 1, 1892.

[3] Keferstein, Christian, Ueber einige deutsche devonische Conchiferen aus der Verwandschaft der Trigoniaceen und Carditaceen: Deutsch. geol. Gesell. Zeitschr., vol. 9, p. 158, 1857.

[4] Deutsch. geol. Gesell. Zeitschr., vol. 3, p. 252, 1851.

[5] Beushausen, Louis, op. cit., pp. 188, 192-193.

[6] Idem, pl. 16, figs. 17, 18 (*M. carinatus*); compare also the anterior cardinals in *M. oblongus* Goldfuss, shown in Beushausen's pl. 16, figs. 25, 26.

[7] Murchison, R. I., The Silurian system, pt. 2, pl. 3, fig. 10a, 1839.

right valve inclosing one in the left, as in Mecynodon. In *G. cymbæformis*, according to McCoy, the ligament is internal and the cardinal margin not inflected. These two distinctions, if they really exist, will separate typical Goniophora from Mecynodon. The Devonian shells commonly passing under the name Goniophora are generally without posterior laterals and are distinguishable in this respect from Mecynodon; but have apparently an escutcheon or a strongly inflected cardinal margin or both. (See *G. hamiltonensis* Hall,[1] *G. acuta* Hall (not Sandberger),[2] *G. rugosa* Hall,[3] *G. modiomorphoides* Grabau,[4] and *G. secans* Barrande[5] (only a short but broad escutcheon, beyond which the margin is not inflected). In Mecynodon there is a well-developed though short escutcheon for the ligament, which is external, and the cardinal margin is usually inflected. There is also a very well developed lunule and lunette.

In the American faunas *Goniophora perangulata* Hall,[6] from the "Corniferous" limestone, seems to be a Mecynodon. In Europe Mecynodon occurs in the Middle Devonian of the Eifel and in England.

The more depressed-convex, transversely elongated species of Goniophora resemble Modiomorpha in the muscular markings, cardinal detention, general outline, concentric ornamentation, and ventral insinuation and in the absence of posterior laterals, but Goniophora is easily distinguished by the presence of the angular umbonal ridge or keel and the usual change in ornamentation posterior to it. In the absence of the angular umbonal ridge and in the presence or absence of posterior laterals the group of *Mecynodon auriculatus* Goldfuss, *M. concentricus* Archiac and De Verneuil, etc., bears the same relation to Modiomorpha that the typical Mecynodon (group of *M. carinatus* Goldfuss) bears to Goniophora of authors. In the first pair the umbonal ridge is absent and the outline similar. In the second pair the angular ridge is present and the common outline is distinct from that of the first pair. The first member in each pair has posterior laterals; the second has not.

The features above mentioned also distinguish these Goniophoras from Cypricardella, which lacks both the angular umbonal ridge and the ventral insinuation of Goniophora. In Cypricardella the anterior muscular scar is much farther removed from the cardinal teeth than in Goniophora and Mecynodon, and there is generally no discernible pedal muscular scar. Cypricardella usually has the umbonal ridge fairly well developed, though not nearly so well as in Goniophora.

In the European Triassic occur some small corbuliform shells (*Nucula gregaria* Münster,[7] = *Corbula gregaria* Schauroth;[8] *Astartopsis* (*Myophoriopis*) *richthofeni* Stur)[9] of rhomboid outline and highly inflated convexity, having a strong angular umbonal ridge; they are truncate and more or less finely striated posteriorly. These little shells are with difficulty distinguishable superficially from certain small Devonian Goniophoras such as *G.* (ex. *Cypricardia?*) *acuta* Sandberger[10] (not Hall) and *G.* (ex. *Isocardia*) *cælata* Sandberger,[11] from the Rhenish Middle and Lower Devonian, and *G. minor* Hall,[12] an Upper Devonian fossil from the Ithaca shale member of the Portage formation; but they differ in internal structure.

Hind[13] has proposed the new name Mytilimorpha to replace Goniophora Phillips, on the ground that the latter is preoccupied by a generic name previously applied by Agassiz to some crinoids. As Agassiz's crinoid genus is Goniophorus, not Goniophora, the name Goniophora should not be considered preoccupied. Hind's Mytilimorpha is founded on the Carboniferous *Goniophora rhombea*, which is without posterior lateral teeth. Should the genotype of Gonio-

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, pl. 43, figs. 15, 17, 20, 1885.
[2] Idem, pl. 43, fig. 2.
[3] Idem, pl. 43, fig. 7.
[4] New York State Geologist Sixteenth Rept. (for 1896), p. 254, figs. 1, 2, 1897.
[5] Système silurien du centre de la Bohême, pt. 1, vol. 6, pl. 255, figs. 2, 9, 13, 1881.
[6] Hall, James, op. cit., p. 293, pl. 34, figs. 1-6; pl. 42, figs. 1-2.
[7] Goldfuss, August, Petrefacta Germaniæ, pt. 2, p. 144, pl. 124, fig. 12, 1863.
[8] Schauroth, C., Deutsche geol. Gesell. Zeitschr., vol. 9, p. 120, pl. 6, fig. 17, 1857.
[9] Bittner, Alexander, Lamellibranchiaten der alpinen Trias, pt. 1: K. k. geol. Reichsanstalt Wien Abh., vol. 18, p. 112, pl. 13, fig. 10, 1895. Broili, Ferdinand, Palaeontographica, vol. 50, p. 217, pl. 27, figs. 3-14, 1903.
[10] Sandberger, Guido and Fridolin, Die Versteinerungen des rheinischen Schichtensystems in Nassau, p. 263, pl. 27, fig. 12, 1850-1855.
[11] Idem, p. 260, pl. 27, fig. 11.
[12] Paleontology of New York, vol. 5, pt. 1, p. 305, pl. 42, figs. 4-6, 1885.
[13] Hind, Wheelton, A monograph of the British Carboniferous Lamellibranchiata, pt. 4: London Paleontogr. Soc. Pubs., vol. 53, p. 338, 1899.

phora (*G. cymbæformis*) be found to possess posterior laterals, the name Mytilimorpha may be applied to those shells commonly called Goniophora which lack such teeth.

The oldest known species of Goniophora is the fossil called *Modiolopsis carinata* Hall,[1] from the Trenton limestone (Ordovician) of Middleville, N. Y. (not *Goniophora carinata* (Conrad, 1841),[2] from the Middle Devonian; the two species appear to be congeneric, however, and as Hall's specific name is therefore preoccupied, I would suggest the name of *G. trentonensis* for Hall's Ordovician fossil). The next oldest species, *G. speciosa* Hall,[3] occurs in the upper Niagaran (Silurian) shales of Waldron, Ind. These two rare fossils are the only species of Goniophora described from the Ordovician and Silurian of the American continent except the Nova Scotian Silurian forms. *Goniophora crassa* Whiteaves,[4] from the Guelph dolomite of Ontario, Canada (equivalent of English Aymestry), is not a Goniophora; it is a modiolopsoid shell with a well-developed cardinal tooth or fold, and is therefore referable to Modiomorpha Hall. Beushausen[5] also has shown that the shell is not Goniophora. The species is still included in Goniophora by Whiteaves in his "Revised list of the fossils of the Guelph formation."[6] *Goniophora dubia* (Hall?)[7] is doubtfully a Goniophora. The species occurs in the Manlius limestone of New York and also at Peach Point, Put-in-Bay Island, Lake Erie, and at Middletown,[8] Ohio, in strata supposed to be of the same age.

In Europe Goniophora is unknown in the Ordovician and makes its first appearance in the Gotlandian Silurian, in the brachiopod shales of which occurs *Goniophora carpomorpha* (Dalman).[9] This species is very similar to *G. cymbæformis* and was considered probably identical with it by Sowerby himself.[10] Goniophoras occurring in the English Wenlock group, Lower Ludlow and Aymestry limestone, have been reported[11] as *G. cymbæformis* Sowerby. In the Bohemian Silurian Goniophora makes its first appearance in étage E², the equivalent of the Guelph and Aymestry.

Beginning with the Upper Ludlow and Tilestone faunas, in which *Goniophora cymbæformis* is an abundant and characteristic fossil, Goniophora is fairly common. *G. cymbæformis*, of which the late Silurian *Goniophora consimilis* Billings, from Arisaig, Nova Scotia, already cited, appears to be a synonym, is reported by Lindström[12] from Gotland and by Schmidt[13] from the island of Oesel.

Goniophora attains the acme of its development throughout the Devonian, particularly in the Siegen and Coblenzian graywackes of the German Lower Devonian, from which 15 or 20 species have been described, including the shells described and figured by Beushausen[14] as *Leptodomus latus* Krantz, *L. posterus* Beushausen, *L. barrosi* Beushausen, and perhaps *Cardiomorpha alata* Sandberger, which may be a Mecynodon. The genus is also highly developed in the Hamilton or Middle Devonian of New York, from which almost as many species are known. The members of the genus are fewer and less abundant in the Upper Devonian. Goniophora continue into the British and Belgian "sub-Carboniferous."

As to the distribution of Goniophora in America, attention has already been directed to *Goniophora trentonensis* nom. nov. (= *Modiolopsis* (*Goniophora*) *carinata* Hall, 1847, not Conrad's sp., 1841), from the Trenton limestone, and *Goniophora speciosa* Hall, from the Silurian Waldron shale of Indiana. *Goniophora crassa* Whiteaves, from the Guelph dolomite, is a Modio-

[1] Hall, James, Paleontology of New York, vol. 1, p. 160, pl. 35, fig. 11a-c, 1847.
[2] Idem, vol. 5, pt. 1, p. 301, 1885.
[3] Hall, James, Albany Inst. Trans., vol. 10, p. 17, 1879; described and figured in Indiana State Geologist Eleventh Rept., p. 317, pl. 27, figs. 26, 27, 1881.
[4] Whiteaves, J. F., Paleozoic fossils of Canada, vol. 3, pt. 1, p. 9, pl. 2, figs. 3-3c, March, 1884.
[5] Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 199, 1895.
[6] Paleozoic fossils, vol. 3, pt. 4, p. 329, September, 1906.
[7] Whitefield, R. P., Geol. Survey Ohio, vol. 7, p. 415, pl. 1, figs. 24-26, 1893.
[8] Whitfield said "Middletown, Marion County," but Middletown is in Butler County, a long distance from Marion County.
[9] *Cardites carpomorphus* Dalman, Acta Acad. Holmiæ, p. 372, pl. 4, fig. 2, 1824; *Cardium carpomorphum*, Hisinger, Petrificata Sveciæ, p. 63, pl. 19, fig. 5, 1837-1841; *Goniophora carpomorpha*, Lindström, Fragmenta silurica, pl. 19, 1880.
[10] Murchison, R. I., The Silurian system, p. 602, 1839.
[11] Phillips, John, The Malvern Hills: Geol. Survey Great Britain Mem., vol. 2, pt. 1, p. 267, 1848.
[12] Nomina fossilium siluriensium Gothlandiæ, p. 3, 1867.
[13] Schmidt, Friedrich, Untersuchungen ueber die silurische Formation von Ehstland, Nord-Livland und Oesel: Archiv Naturk. Liv-, Ehst- und Kurlands, 1st ser., vol. 2, pp. 173, 209, 1858.
[14] Beushausen, Louis, op. cit., pls. 24, 25.

morpha, not a Goniophora. Goniophora is unknown in America in the Salina formation (hydraulic limestones and shales), except for the Goniophora sp. indet. of Weller,[1] from the Decker limestone of New Jersey, which corresponds with the extreme top of the Salina formation and is just below the horizon of the Cobleskill limestone. The genus is also unknown in the Cobleskill limestone and the Rondout water lime. *Goniophora dubia* (Hall?) Whitfield, from the Manlius limestone of New York and from corresponding beds in Ohio, is doubtfully a Goniophora. In the Upper Ludlow faunas of Arisaig, Nova Scotia, several species of Goniophora are very common.

From the Helderberg and Oriskany faunas of New York and their equivalents no Goniophora has yet been described, and the genus, if it occurs at all, is very rare in these rocks. Schuchert[2] in his list of the Helderbergian fauna includes a Goniophora sp. nov. from the shaly New Scotland limestone of New York. Another undetermined form is doubtfully indicated by Weller from the *Balmanites dentatus* zone ("Trilobite beds") of the Port Jervis section.

In the Lower Coblenzian fauna, or zone of *Spirifer hercyniæ*, Goniophora is represented by *G. mediocris* Billings,[3] from the Grande Greve or Gaspe limestone No. 8 of Indian Cove, Gaspe, Quebec.

In the Schoharie grit and "Corniferous" limestone Goniophora occurs occasionally; in the Marcellus shale the genus is extremely rare; in the Hamilton Goniophoras become very common, both in species and individuals, throughout New York State, occurring in the arenaceous sediments of the eastern part of the State as abundantly as in the calcareous rocks of the western part. In the Tully limestone Goniophora is rare; it is unknown in the Genesee shale and in the Portage formation, except in the Ithaca shale member, where it is fairly common, the interesting little *Goniophora minor* Hall being a characteristic fossil of the upper half of the Ithaca member. Goniophora continues into the Chemung of eastern New York and is rarely found in the Chemung of central and western New York.

No Goniophora is known from faunas higher than the Chemung in North America. The species described from the Warsaw shale under the name *Cypricardella plicata* and often cited under the generic name Goniophora does not belong to that genus, but is more nearly related to Pleurophorus.[4] In Great Britain and in Belgium, however, Goniophora continues into the Carboniferous, being represented by *Cypricardia glabratus* Phillips,[5] *Cypricardia rhombea* Phillips,[6] and *Cypricardia acuticarinata* Armstrong.[7] Additional references to these species are given by De Koninck[8] under Sanguinolites. In the heteromorphous assemblage of species included by De Koninck in the genus Sanguinolites, especially his Group I, the species with only a single radial carina, there are many forms externally similar to the Devonian fossils that commonly pass under the genus Goniophora. Besides the three species just noted, the following are a few of De Koninck's "Sanguinolites" that are referable to Goniophora: *S. bipartitus* De Koninck,[9] *S. præsectus* De Ryckholt,[10] and *S. lyellianus* De Ryckholt,[11] from the Viseán or étage III; and *S. angulatus* De Koninck,[12] *S. cuneatus* De Koninck,[13] and *S. constrictus* De Koninck,[14] from étage II.

Goniophora kayseri sp. nov.

Plate XIX, figure 18.

Length (54 millimeters) two and two-thirds times the height (20.5 millimeters); greatest length near the midheight. Umbones broad, incurved, depressed, hardly extending above

[1] Weller, Stuart, Paleontology of New Jersey, vol. 3, p. 246, 1903.
[2] Schuchert, Charles, Geol. Soc. America Bull., vol. 11, p. 286, 1900.
[3] Billings, Elkanah, Paleozoic fossils of Canada, vol. 2, pt. 1, p. 50, fig. 21, 1874.
[4] See Hall, James, Albany Inst. Trans., vol. 4, p. 18, 1856; Whitfield, R. P., Am. Mus. Nat. Hist. Bull., vol. 1, p. 66, pl. 7, fig. 39, 1882; and Hall, James, Indiana Dept. Geology and Nat. Hist. Twelfth Ann. Rept., p. 341, pl. 30, fig. 39, 1883.
[5] Phillips, John, Illustrations of the geology of Yorkshire, vol. 1, p. 209, pl. 5, fig. 25, 1836.
[6] Idem, p. 209, pl. 5, fig. 10.
[7] Armstrong, James, Geol. Soc. Glasgow Trans., vol. 2, p. 28, pl. 1, fig. 3, 1865.
[8] De Koninck, L. G., Faune du calcaire carbonifère de la Belgique, vol. 3, pt. 5, pp. 61, 63, 68, pl. 15, 1885.
[9] Idem, p. 69, pl. 15, fig. 27.
[10] Idem, p. 67, pl. 15, fig. 37.
[11] Idem, p. 64, pl. 15, fig. 39.
[12] Idem, p. 71, pl. 16, figs. 4, 18.
[13] Idem, p. 71, pl. 16, figs. 14, 15.
[14] Idem, p. 72, pl. 16, fig. 17.

the cardinal line; beaks situated between the anterior fourth and fifth, directed forward. The cardinal line extends posteriorly in a straight line parallel to the base or longitudinal axis for a distance equal to about one and one-fourth or one and one-third times the height; the cardinal extremity appears to be broadly rounded and merges at the posterior fourth or fifth of the length of the shell into the posterior margin. The posterior margin makes an unsymmetrical curve, convex throughout, retrorse above, nearly vertical in the lower half. The extreme lower part of the posterior margin extends slightly forward, so that the extreme posterior point of the shell is at one-third or two-fifths the height above the base. The postventral extremity is marked by the foot of the umbonal carina and is slightly nasute, so that the posterior third of the ventral margin is concave and rises anteriorly, though only very slightly so. The basal margin as a whole is constricted or very nearly straight to a point below the beaks, from which it curves into the rounded anterior portion. The anterior margin is strongly rounded; the upper portion has a shorter radius of curvature than the lower, reaches to a point more than two-thirds the height above the base, and is separated from the beak by a shallow lunule. The extreme anterior point of the margin is at the midheight. The principal features of the convexity of the shells are the steep convex slope above and behind the carina, a slight concavity in front of and below the carina, depressed convexity over the central regions of the surface, thence declining in a more strongly convex slope to the beak and anterior margin. The point of greatest depth of the valve is on the umbonal carina near the midlength, one-fifth or one-sixth the height below the cardinal line. This depth is equal to one-third the height (6.75 millimeters) of the single valve. From the beak toward the midlength the surface is very steep or perpendicular to the cardinal line, the slope becoming more and more gentle posteriorly. The umbonal carina is well developed, sharp umbonally, less so postventrally. It is somewhat accentuated by the slight concavity in front of it and by the steep declivity posteriorly to the cardinal line and posterior margin. The carina is not sigmoidal (except possibly at the lowest extremity, which is indistinct in the specimen) and extends in a shallow arch, convex with respect to the center of the surface. Hinge, muscular, and shell structures unknown.

The surface ornamentation, so far as it can be described from an internal mold, consists of very faint, obsolescent, concentric lines of growth, leaving the specimen practically smooth.

Length 54 millimeters, height 20.5 millimeters, depth of the left valve (the only specimen), 6.75 millimeters.

The distinguishing features of the genus are its transversely elongated nonoblique form; the length two and two-thirds times the height; the long, straight, horizontal, cardinal line; the rounded posterior margin, vertical in the lower half; the nasute postventral angle; the umbones depressed, beaks at the anterior fourth or fifth; dorsal carina convex, hardly sigmoidal; surface slightly concave in front of the carina, and steeply convex behind; depth of valve equal to one-third the height and one-eighth the length.

I take pleasure in naming this species after Prof. Emanuel Kayser as a slight token of my deep appreciation of his many years of fruitful labor on the Devonian. The name may also serve to emphasize the very close relationship between this species and a species of the same genus described by Prof. Kayser.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59819.

Comparisons.—The species described above under Goniophora shows considerable resemblance to Kayser's *Goniophora trapezoidalis*[1] from the Taunus quartzite of "Katzenloch." The two forms agree in the elongate outline, with length two and two-thirds times the height; depressed umbones and long cardinal line, one and one-third or more times the height; convex, curving posterior margin; nasutely extended postventral extremity; and convex, nonsigmoidal umbonal carina, with a convex slope back of it and an obscure concavity or depression in front of it. The Chapman fossil differs from *G. trapezoidalis*, however, in the following particulars:

[1] Kayser, Emanuel, Ueber einige neue Zweischaler des rheinischen Taunusquarzits: K. preuss. geol. Landesanstalt Jahrb. 1884, p. 19, pl. 2, fig. 4, 1885. See also Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 205, pl. 17, fig. 34, 1895.

The postinferior portion is slightly nasute and less extended than the European form; the lower half of the posterior margin is more nearly vertical; the cardinal line is shorter in proportion to the height; the anterior end is longer; and the beaks are at the anterior one-fourth or one-fifth, instead of at the anterior one-seventh.

Goniophora kayseri agrees with Roemer's *G. bipartita*, from the Siegen graywacke, in the nasute extension of the postinferior portion of the shell and the nearly vertical position of the lower half of the posterior margin, but *G. bipartita* is much shorter, and the umbones are situated much nearer the front than in *G. kayseri*.

GONIOPHORA OMEGA sp. nov.

Plate XXIV, figures 13, 15.

Length (more than 56 millimeters, apparently about 60 millimeters) about two and a half times the height (24 millimeters). Greatest length slightly below and near the midheight; greatest height near the middle. Umbones broad, very depressed, not extending beyond the cardinal line. The anterior end is destroyed in the type specimen, but the beaks appear to be at about the anterior fourth and directed forward. The cardinal line extends posteriorly in a slightly convex, nearly straight horizontal line parallel to the longitudinal axis and base for a distance equal to about one and three-fifths times the height of the shell. The postcardinal extremity is subangular and situated at the posterior tenth or twelfth of the length. The posterior margin is convex throughout, retrorse, the most posterior point being below the midheight. The lower half of the posterior margin is approximately vertical. The postventral extremity is marked by the base of the umbonal carina and is apparently not nasute. The basal margin is nearly straight. The most striking features of the convexity are the steep convex slope back of the carina, uninterrupted by any insinuation or flexure and a broad, slightly concave depression marking the general surface of the shell and sloping markedly downward from the elevated umbonal carina as far forward as the anterior end, which appears to have been convex as usual. The umbones are depressed and the slope from the umbonal ridge to the cardinal line, just back of the beaks, is steep but hardly vertical. The umbonal carina is sharp, especially in the lower half; it appears to be sigmoidal, convex in the upper portion, slightly concave toward the middle, and straight in the lower half. The depth of the type specimen, a right valve, is 9 millimeters, or three-eighths of the height and three-twentieths of the length; the point of greatest depth is on the umbonal carina at the midheight, and at the posterior third or two-fifths of the length of the shell. Hinge and muscular structure unknown. The specimen at hand preserves the shell; this interesting feature in Goniophora, I believe, has never before been described. The shell is of medium thickness and is composed in the main of a porcelaneous or earthy and seminacreous, laminated calcium carbonate. The outermost layer is very thin, membraneous, rather continuous, and slightly different in color from the inner layers; it is much rougher than the inner layers and contains faint traces of fine and coarse lines of growth. This thin outer membrane may possibly have been the epidermal layer or periostracum. It effervesces under acid though apparently somewhat less strongly than the inner layers. The latter are nacreous or semiporcelaneous, slightly or faintly vitreous, and composed of large, smooth, thin flakes; like the outer layer, they are of a pale-yellowish russet color. No distinctly prismatic layer is observable.

The surface is essentially smooth, especially posterior to the carina. Anteriorly there are indications of obsolescent lines of growth, occasionally aggregated into faint concentric ridges and hollows 1 millimeter or less in width. Length more than 56 millimeters, apparently about 60 millimeters; height, 24 millimeters; depth (of the right valve), 9 millimeters.

The distinguishing features of this Goniophora are the length, which is two and a half times the height; the long, horizontal, very slightly convex hinge line, equal to one and three-fifth times the height of the shell; the postcardinal extremity at the posterior tenth or twelfth; the posterior margin rounded convex throughout, with the lower half vertical; the straight or concave ventral margin; the sigmoid carina, becoming sharper below; the convex surface back of the carina; the broadly concave general surface sloping downward from the carina to the anterior end, which is convex, as normal; and the practically smooth surface.

Three specimens of this species obtained since the foregoing description was written show the characteristic broad ventral concavity, smooth convex postumbonal slope, shell structure, outline, and sigmoidal carina as described above. Two of the specimens are 18 and 21 millimeters high, respectively.

Locality: Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59820.

Comparisons.—The nearest ally to this species is *Goniophora kayseri*, described above. In *G. kayseri* the postcardinal extremity is farther forward and more obtusely rounded than in *G. omega*, and the postbasal extremity is more nasute. In *G. omega* the carina is apparently sigmoid and becomes sharper below; in *G. kayseri* it is convex throughout and less sharp below than umbonally. The most important distinction observed is the broad concavity in *G. omega* over the general surface in front of the carina, extending over the central part of the shell to a point just below the position of the beak. In *G. kayseri* the central part is faintly convex, the concavity being limited to a narrow space immediately in front of the carina. The broad concavity is one of the most distinguishing features of *G. omega*. The nearest allies in this and several other respects are *Goniophora trigona* Hall,[1] from the Upper Devonian Chemung formation, near Franklin, Delaware County, N. Y., which differs chiefly in having the posterior slope concave instead of convex, the umbones extending over the cardinal line and the cardinal line shorter in proportion to the height of the shell. The Goniophoras figured by Hall [2] from the Hamilton of Schoharie County, N. Y., are also similar, but have the posterior margin more abruptly truncate and straight and the posterior slope concave instead of convex.

Genus SPHENOTOMORPHA gen. nov.

A well-preserved interior mold of a modiomorphoid shell from the Chapman sandstone of the Presque Isle Stream area presents some peculiar features that seem to require generic as well as specific separation from previously described forms. On account of combination of characters of the two genera Sphenotus and Modiomorpha the name Sphenotomorpha is proposed. Sphenotomorpha differs from Modiomorpha in having the hinge line rigid, straight, not ascending, but horizontal or slightly declining; it also lacks the ventral insinuation or constriction characteristic of Modiomorpha and the modiolopsoids in general. The hinge features are those of Modiomorpha—a long, narrow escutcheon, with a low triangular cardinal tooth in the left valve fitting into a groove in the right. The external expression will at once distinguish Sphenotomorpha from Modiomorpha. This external expression corresponds with that of the well-known genus Sphenotus Hall in outline, curvature, and markings, but the ventral insinuation present in the common and characteristic species of Sphenotus is absent in Sphenotomorpha. The hinge features are entirely distinct in the two genera, Sphenotus having two cardinals in the right valve and one or two lateral teeth, whereas Sphenotomorpha has only one cardinal in the left valve, apparently no teeth in the right valve, and no posterior laterals. The generic diagnosis is as follows:

Shells having the superficial features of Sphenotus but without ventral insinuation and having the dentition of Modiomorpha Hall; transversely elongate, apparently closed, equivalve, except that in the right valve there is generally a posterior longitudinal furrow and in the left valve an elevated ridge or riblet, between the umbonal ridge and the hinge line; very inequilateral, length about double the height; ventral and dorsal margins parallel; the ventral margin convex, without insinuation; dorsal margin long, straight, horizontal, or slightly declining posteriorly; posterior margin truncate; anterior end rounded, short but distinct, and separated by a small shallow lunule from the beaks, which are anterior, prosogyrate; convexity

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 302, pl. 42, fig. 12; pl. 44, fig. 9, 1885.

[2] Idem, pl. 42, figs. 14, 15. These shells are misnamed *Goniophora subrecta* Hall, for the originals of that species are from the Chemung of Delaware County and are figured on pl. 44, figs. 19, 21. Figs. 14 and 15 on pl. 42 show Hamilton shells apparently of the same species as that represented in fig. 11, pl. 42, and figs. 6–8, pl. 44; that is, *G. carinata* Conrad.

moderate; umbonal ridge rounded, fairly prominent; between the umbonal ridge and the hinge line there occurs a slight narrow radial groove or ridge, the ridge frequently occurring in the left valve and the groove in the right valve. There is a long, narrow escutcheon for an external (?) ligament and a low thick short cardinal tooth in the left valve fitting into a socket in the right valve, but no other cardinal or lateral teeth. Muscular scars and pallial line unknown. Ornamentation, concentric low obsolescent narrow ridges or undulations of growth.

The type is *Sphenotomorpha rigidula* sp. nov., from the Chapman sandstone. The species *Sphenotus bodenbenderi* Clarke,[1] from the Lower Coblenzian (Eo-Devonian) fauna of Rio Maecuru, Para, Brazil, appears to be congeneric, as does also *Cytherodon? socialis* Billings,[2] from the late Silurian fauna at Arisaig, Nova Scotia. The geologic horizon of the genus appears to be uppermost Silurian and Lower Devonian.

SPHENOTOMORPHA RIGIDULA gen. et sp. nov.

Plate XXIV, figure 9.

Length (30 millimeters) two and one-half times the height (12 millimeters); dorsal and ventral margins parallel, so that the greatest height is indefinitely near the middle, greatest length near the base. Umbones depressed, not extending beyond the hinge line, prosogyrate beaks situated between the anterior fifth and sixth, nearer the latter. Hinge line long, rigid, straight, horizontal, or slightly declining; equal in length to $1\frac{1}{3}$ or $1\frac{1}{4}$ times the height of the shell. Posterior hinge extremity distinct, subangular, very obtuse. The posterior margin is strongly retrorse; almost straight, as far down as the respiratory angle, making an angle of 135° with the hinge line. Posterior extremity at the respiratory angle, at the inferior third of the height. Ventral margin nearly horizontal; not insinuated; convex throughout, though only slightly so over the greater portion; curving upward more strongly into the rounded postinferior or respiratory angle and into the rounded anterior end. The anterior end is lower than the posterior end but includes about three-fourths the height of the shell. There is a shallow, very small lunule. The shell is of moderate depth; convex throughout, especially over the middle; slightly more depressed posteriorly, ventrally, and toward the umbones, though nowhere complanate or compressed. There is an undefined, broadly rounded umbonal ridge, prominent umbonally, less distinct lower down. There is no ventral insinuation; between the umbonal ridge and hinge line there is a faint radial groove in the right valve on the internal mold. Point of greatest depth at the middle; depth of single right valve 2.85 millimeters, or one-fourth the height. A narrow groove extends the length of the hinge line posterior to the beak, gradually tapering posteriorly, and apparently representing a narrow external (?) escutcheon. On the internal mold of the right valve there is a broad, low triangular or domelike elevation just beneath the beak, which apparently represents a similarly shaped single cardinal tooth in the left valve and a corresponding socket in the right. No evidence of any other teeth is found. Muscular scars and pallial line not discernible.

The internal mold shows evidence of concentric, obsolescent, low rounded undulations of growth. These undulations are strongest on the anterior end of the shell to a point below the umbones; posterior to the rounded umbonal ridge they disappear and the surface is essentially smooth.

Type and only specimen, a right valve in internal mold, 30 millimeters long, 12 millimeters high, and 2.85 millimeters thick.

The distinguishing features of the fossil are the transverse outline, length two and one-half times the height; parallel basal and dorsal margins, the latter horizontal or very slightly declining, rigidly straight, and one and one-third times the height of the shell; basal margin slightly convex, not insinuated; posterior margin retrorse, making an angle of 135° with the hinge line; posterior extremity at the respiratory angle in the lower third; anterior margin rounded and three-fourths the height; umbones between the anterior fifth and sixth; convexity

[1] Clarke, J. M., The Paleozoic faunas of Para, Brazil; Devonian Mollusca: Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 8, figs. 25, 26; pl. 5, fig. 17, 1899 (author's English ed., p. 58, 1900).

[2] Billings, Elkanah, Paleozoic fossils of Canada, vol. 2, pt. 1, p. 138; pl. 8, fig. 12, 1874.

moderate, uniform, the shell nowhere insinuated or compressed except for an extremely faint radial groove between the hinge line and the umbonal ridge; umbonal ridge broadly rounded, hardly discernible; no muscular scars visible; low concentric undulations of growth, most conspicuous on the anterior end, the posterior slope nearly smooth; a long, narrow, but distinct escutcheon (posterior ligamental groove), and a solitary short domelike cardinal tooth in the left valve and a socket in the right; shell apparently closed.

Locality: Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine, with *Chonetes striatissimus*.

U. S. National Museum, catalogue No. 59821.

Generic and specific relations.—The generic position of this shell is perplexing. In the ligament, single low cardinal tooth in the left valve and socket in the right valve, and transverse outline with rounded undefined umbonal ridge, it would seem to find its nearest affiliations with Modiomorpha Hall; but the shell is easily distinguished from Modiomorpha and the modiolopsoids by the uniform convexity below the umbones and by the absence of any insinuation or compression. In the modiolopsoids also, the hinge line is ascending, the shell becoming markedly wider behind, unlike *Sphenotomorpha rigidula.*

The outline of the present species is, with the exception of the ventral margin, that of typical Sphenotus. The genus Sphenotus was founded by Hall,[1] who described it as follows:

> SPHENOTUS, n. g. (Typical species, *Sanguinolites arcæformis* Hall and *Cypricardia contracta* Hall.)
>
> Shell equivalve, very inequilateral, elongate subtrapezoidal or cylindrical in outline. Anterior end short. Posterior end usually obliquely truncate. Beaks subanterior. Cardinal line long and nearly straight. Umbonal ridge defined, extending from the beak to the postinferior extremity. Postcardinal slope marked in all the characteristic species by a median ridge. Valves crossed from the beak to the base by a more or less defined, broad cincture, which often produces a constriction in the ventral margin.
>
> Surface marked by concentric striæ of growth and rarely by fine radiating lines. In a single species (*S. solenoides*) the surface is further ornamented by fine, irregular, elevated vascular lines on the posterior half of the shell, especially above the umbonal ridge.
>
> Hinge narrow, with two short, narrow cardinal teeth beneath the beak of the right valve, and with one or two extremely slender lateral teeth. Ligament external, contained in a slender groove along the cardinal line. Anterior muscular scar strongly marked, situated close to the anterior margin. Posterior scar shallow. Pallial line simple.
>
> The species united under the preceding generic description have been referred to several genera by various authors. The genus Sanguinolites, by an unwarrantable extension of its true characters and the disregard of the type, has heretofore included many species of this group. Also, a few forms have been placed in the genus Allorisma. They differ from both these genera in the umbonal and postcardinal ridges, their trapezoidal form, in the cincture crossing the valves, and in the characters of the hinge.
>
> Examples: *Sphenotus arcæformis*, Pl. LXV, figs. 7-11; *Sphenotus contractus*, Pl. LXVI, figs. 1, 3-9, 11-13, 15; Pl. XCIV, fig. 2.

The genus includes narrow, transversely elongated shells with nearly parallel basal and dorsal margins, marked by a rather conspicuous umbonal ridge between which and the dorsal line occur one or occasionally two or more radial grooves or riblets, or commonly one or more riblets in the left valve and the groove structure in the right valve. In *Sphenotus contractus* Hall, one of the type species of Sphenotus, there are in the right valve "two short, narrow cardinal teeth, beneath the beak * * * and one or two extremely slender lateral teeth." There is a long escutcheon. Sphenotus is easily recognized by its transverse outline with prominent umbonal ridge, and particularly by the longitudinal furrow or riblet between the umbonal ridge and cardinal line. This furrow or riblet is present in all the typical forms, though it is sometimes discernible only with difficulty. In Sphenotus, as in the modiolopsoids, there is a ventral insinuation or constriction.

Sphenotomorpha agrees with Sphenotus in outline and superficial appearance, sharing with it the characteristic posterior riblet or groove, but Sphenotomorpha lacks the ventral insinuation or constriction of both Sphenotus and Modiomorpha. The posterior radial riblet or furrow is very faint. In *Sphenotomorpha rigidula* it is almost invisible, and is represented by a faintly impressed line midway between the umbonal ridge and cardinal line or a trifle nearer the former. Clarke's figures of *Sphenotus* [*Sphenotomorpha*] *bodenbenderi* indicate a similar

[1] Hall, James, Palcontology of New York, vol. 5, pt. 1, p. xxxiii, 1885.

extremely faint posterior furrow in the right valve, whereas Billings's figure of *Cytherodon* [*Sphenotomorpha*] *socialis* shows a riblet in the left valve. This would indicate that in Sphenotomorpha, as is common in Sphenotus, the posterior riblet is in the left valve and the furrow is fainter and in the right valve, the two valves being otherwise apparently equal.

Sphenotus bodenbenderi Clarke and *Cytherodon? socialis* Billings are included in Sphenotomorpha because of their agreement with the new genus in its superficial aspect, differing from Sphenotus in the convex, noninsinuated ventral margin. Their dentition is unknown at present.

In the sphenotomorphoid aspect and convex noninsinuated ventral margin Sphenotomorpha agrees closely with the Carboniferous genus Pleurophorella of Girty,[1] but that shell is a closed allerismoid with strongly granulated surface and a deep lunule. *P. papillosa*, the genotype, seems to show a single dental socket under the beak of the left valve, according to Girty, who is, however, not certain of this feature. In Sphenotomorpha the lunule is exceedingly small and the surface apparently nongranulose; there is a single cardinal tooth in the left valve with a socket in the right valve.

Superfamily NAIADACEA.

Family CARDINIIDÆ Zittel.

Genus ANODONTOPSIS McCoy, 1852.

The genus Anodontopsis McCoy is discussed at length in the present paper in connection with the genus Cypricardella (pp. 239–244). It is there pointed out that if the term Anodontopsis is to be used at all, it must be restricted in its application to shells congeneric with the Upper Ludlow *Anodontopsis angustifrons* McCoy,[2] the genotype. Unfortunately, however, it is at present rather difficult to determine just what shells are congeneric with the genotype, because of uncertainty as to its real structure.

Anodontopsis maccoyiana, described beyond, so closely resembles McCoy's genotype in outline, convexity, and ornamentation that the two might easily be considered as the same species. Because of this nearly specific identity, for the present I am referring the Chapman shells to the genus Anodontopsis; future elucidation of the English type may or may not prove them congeneric.

If the Chapman and British shells are regarded as congeneric, the genus Anodontopsis McCoy may be defined as including cyrtodontiform, concentrically striate, dimyarian shells having the umbones in front of the middle and prosogyrate; the anterior end distinctly developed and round; the posterior portion of the shell expanding in height, owing to the ascending hinge line; the posterior margin retrorse; the ventral margin rounded and without trace of byssal sinus or constriction. No lunette or escutcheon. Dentition unknown; but apparently the hinge plate must have been thin, if developed at all. The shells conform in outline and general superficial expression with the Cyrtodonta-Cypricardites group but have no escutcheon; the hinge plate, if developed at all, is decidedly weaker than in that group; and the stronger posterior teeth of that group are certainly lacking. Anodontopsis is also more depressed than the gibbous and ventricose species of Cyrtodonta, etc.

ANODONTOPSIS MACCOYIANA sp. nov.

Plate XXIV, figure 14; Plate XXVI, figures 2, 3, 5, 6, 7, 10, 12, 13.

cf. 1855. *Anodontopsis angustifrons*. McCoy, British Paleozoic rocks and fossils, p. 271, pl. 1, K, figs. 14, 15.
Upper Ludlow: Benson Knot and Kirkby Moor, Kendal, Westmoreland.

Outline triangular or wedge-shaped, expanding behind; cyrtodontiform; total length of the hinge line, both in front of and behind the beaks, slightly less than or barely equal to the height of the shell perpendicular thereto; beaks at approximately the anterior third, directed forward and not protruding above the hinge line. Anterior portion of the shell well developed;

[1] Girty, G. H., New molluscan genera from the Carboniferous: U. S. Nat. Mus. Proc. No. 1372, vol. 27, pp. 728 et seq., pl. 45, figs. 4–6; pl. 46, fig. 5, June 1, 1904.

[2] Sedgwick, Adam, and McCoy, Frederick, British Paleozoic rocks and fossils, p. 271, pl. 1, K, figs. 14, 15, 1852.

equal to a quarter or a third of the total length, and attaining four-sevenths to five-sevenths the total height. There is a definable lunule in front of the beaks; the anterodorsal margin swings into the posterior hinge line in a broad curve. The anterior portion of the shell is convexly rounded throughout, with the shortest radius of curvature anteroventrally, at the point whence the anterior margin descends in a broad arch into the ventral margin, which continues in a regular descending, shallow, convex curve nearly to the postventral or respiratory angle. Only near the posterior extremity is the ventral margin horizontal or faintly ascending; it swings in an abrupt retrorse curve into the posterior margin. Both the lowest and the hindmost points of the shell are therefore near the respiratory angle. The posterior margin of the shell is retrorse in a shallowly convex arch which swings forward a little more rapidly as it approaches the hinge line. The posterior margin of the shell, up to the hinge extremity, and the posterior two-thirds of the ventral margin are approximately symmetric with reference to a line drawn from the postventral extremity to the beak. The hinge line is slightly convex; its length behind the beaks is equal to from one-half to three-fifths that of the posterior margin. The hinge line and the ventral margin converge forward at an angle varying between 12° and 28°, generally nearly 25°. The shells display a rounded postumbonal ridge on which the point of greatest depth is situated between one-third and one-half the distance from beak to postventral extremity. This is posterior to the middle. The postumbonal slope is steep and flat, becoming slightly concave in profile near the hinge line. Anterior to the beaks the shell is depressed convex. The umbones are depressed down to the hinge line. The depth of the valve with both valves in conjunction appears to have been equal to only one-third the distance from beak to respiratory angle, and in internal molds was only two-sevenths this distance or less.

The anterior muscular scar is large and impressed with moderate distinctness. It is situated on the floor of the valve on a line between the beak and forward extremity of the shell, and is equal in length to one-third this distance or a trifle more. It is variably oval, ovate, or semicircular, the posterior portion more deeply impressed into the shell than the anterior. The posterior muscular scar is not distinctly impressed on any of the specimens and must have been extremely faint. The pallial line begins at the anteroventral margin of the anterior muscular scar, so that nearly all the muscular scar is behind the mantle attachment. The pallial line extends parallel with the ventral margin, 2 or 3 millimeters distant from it, and is strongly impressed for about one-half to two-thirds the length of the ventral margin, beyond which it gradually weakens posteriorly and becomes invisible. The portion of the shell below the pallial line is conspicuous on internal casts and appears to have been thickened and convex on the interior.

No trace of posterior lateral teeth have been seen in *Anodontopsis maccoyiana* sp. nov., unless a very faint incision on the internal mold of the left valve and a similar faint mark on the internal mold of the right valve may be so regarded. This faint line becomes gradually fainter posteriorly, diverges somewhat from the hinge line, and is not distinct (if discernible at all) beyond half the length of the dorsal margin, where it is 2 or 3 millimeters below the dorsal edge, and produces a more or less definable flat strip at the dorsal edge. This line may possibly indicate a hinge platform or posterior tooth, but more probably it represents either the insertion of an internal (?) ligament or the dorsal insertion of the mantle, or both. None of the specimens from the locality 2 miles west of Presque Isle Stream are well enough preserved to show cardinal teeth if they had been developed. A single internal mold of a left valve from Presque Isle Stream showing an interesting type of cardinal dentition may prove not to belong to the present species. This specimen indicates the presence of two or three radial very faint cardinal teeth in the left valve and one less in the right; these teeth and their corresponding sockets are very weak in front and increase in strength going backward, so that the hindmost tooth of the left valve is fairly well developed. The cardinal teeth are directed radially toward a point a little above the postventral extremity. This specimen may be a young individual of *Modiomorpha aroostooki* rather than an adult of *Anodontopsis maccoyiana.*

Ligament unknown, possibly linear, or, judging from the faint line, internal. Shell moderately thick; smooth (devoid of growth lines) on the interior; structure not examined.

The surface of the shell is covered with concentric raised lines and impressed striæ of growth, which are best developed posteriorly just below the hinge line and anteriorly near the front margin. About 20 of these striæ were counted in a space of 4 millimeters near the postdorsal extremity of one specimen. On some well-preserved shells these striæ are covered by still finer extremely minute concentric striations that are visible only under a magnifying glass.

The smallest specimen observed was 9.75 millimeters long and 9 millimeters high. Three of the largest specimens were 30 millimeters long and 24 to 28 millimeters high.

The distinguishing features of this fossil are the cyrtodontiform outline, with large, well-developed anterior end; posterior end expanding in height; beaks at about the anterior third, not projecting above the hinge line; absence of lunule or concavity in front of the beaks; relatively depressed convexity compared with Cyrtodontidæ; point of maximum depth on the rounded postumbonal ridge; fairly large and distinctly impressed anterior muscular scar situated near the anterior margin; usually nondiscernible posterior scar; pallial line strongly impressed in the forward half, with the shell thickened on the interior below the pallial line; absence of posterior teeth; moderately thick shell; and concentric lines best developed near the posterior hinge line and near the anterior margin.

Locality: Chapman sandstone, 2 miles west of Presque Isle Stream (locality 1099 J), Aroostook County, Maine, where the species appears to be abundant. A single specimen was found on Presque Isle Stream at the end of the Tweedy road (locality 1099 L).

U. S. National Museum, catalogue Nos. 59822, 59823.

Comparisons.—This shell, as has been stated, may easily be confused with *Anodontopsis angustifrons* McCoy, from the Upper Ludlow-Downtonian grits of Kendal, Westmoreland. The Chapman shell, however, is rather higher posteriorly, and has the posterior margin a trifle less retrorse than in the English shell. The ornamentation is rather finer and sharper in the Chapman specimens than in the sculpture casts of the British fossils, but this may possibly be due to a difference in conditions of preservation rather than to any original difference. McCoy, in describing the anterior of *Anodontopsis angustifrons,* stated that "The posterior lateral tooth or plate extends almost to the end of the hinge line and close to it." In the American shell this tooth is indefinite beyond the midlength of the hinge.

Clarke [1] has described a large Anodontopsis (?) from the Chapman sandstone of Edmunds Hill under the name *Modiomorpha vulcanalis. Anodontopsis maccoyiana* hardly attains half the size of the gigantic Edmunds Hill species and shows some minor differences in details of outline. Clarke's shell may be congeneric with *Anodontopsis maccoyiana,* but it is not a Modiomorpha.

A. maccoyiana also resembles the so-called *Cypricardella pohli* Clarke,[2] from the Lower Coblenzian fauna of Rio Maecuru, Para, Brazil. The Brazilian shell differs specifically from the Chapman fossils in being more narrowly cordate in outline, with a shorter anterior end, and in having slightly more prominent umbones and coarser and more distant surface markings. It is described as being "somewhat inflated." If *Cypricardella pohli* Clarke is not a member of the Cyrtodonta-Cypricardites group, it may be congeneric with *Anodontopsis maccoyiana.*

Superfamily TRIGONIACEA.

Family TRIGONIIDÆ Lamarck.

Genus SCHIZODUS King, 1844.

SCHIZODUS ? PRUNUM sp. nov.

Plate XX, figure 9.

A sculpture cast of a right valve represents a bivalve of vertically elongate, plum-shaped outline, having an obscure schizodiform postumbonal ridge, more obscure than is indicated in the figure. Behind this ridge the surface descends in a sloping plane to the dorsal margin. In

[1] Clarke, J. M., New York State Mus. Bull. 107, p. 219, figs., 1907.

[2] Clarke, J. M., Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 6, fig. 10, 1899 (author's English ed., p. 64, 1900).

front of the carination the surface is moderately and evenly convex. The umbone is broad, slightly in advance of the middle, faintly prosogyrate, and hardly protrudes above the dorsal edge. The oblique height, or distance from beak to respiratory angle, is one-fourth greater than the oblique length (measured in a direction at right angles to the oblique height). The surface is marked by concentric lines of growth, which are faint on the posterior slope.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

Comparisons.—The vertical elongation of the shell would seem to suggest a relationship with similarly elongate shells for which Miller [1] has proposed the generic name Angellum, but the contour of the surface of the Chapman shell precludes any close affiliation with the peculiar Angellum, the genotype of which is *Angellum cuneatum* Miller, from the upper part of the Cincinnatian series at Richmond, Ind. In Angellum the surface of the shells is uniformly and deeply inflated; there appears to be an anterior byssus and a posterior alation; the umbones are elevated, arch over the dorsal line, and are pronouncedly prosogyrate.

The Chapman shell conforms more nearly with the peculiar elongate bivalve described and figured by Kayser as *Modiomorpha? subrectangularis*,[2] from the German basal Devonian or Taunus quartzite at Katzenloch, near Idar. The German species is less oblique and has a less well-defined carination posteriorly than the Chapman shell and is of slightly different outline, but the two forms are evidently closely related and probably belong to the same genus. Kayser figures two nearly equal muscular scars and describes a probable small tooth under the beak. These characters, with the outline, would seem to indicate that the genus is neither Modiomorpha nor Schizodus, but more probably allied to Cypricardella, from which the shells differ conspicuously in the vertical elongation.

Cf. SCHIZODUS sp. indet.

Plate XXIV, figure 8.

A small schizodiform shell from the Chapman sandstone of Edmunds Hill is represented by a sculpture cast of a right valve 23 millimeters high and 20 millimeters long. The umbones are at or in advance of the anterior third, are depressed to the hinge line, and are directed vertically or faintly prosogyrate. The forward end of the shell is high but short; the ventral margin is gently curved; the anterior and basal margins from beak to respiratory angle form a rather regular arch slightly deeper than a semicircle. The posterior margin is convex, retrorse, and equal in length to the hinge line, which descends backward from the beaks. The umbonal carination is very faint. The depth of the single valve is about one-fourth its height.

Locality: Chapman sandstone, west side of Edmunds Hill (locality 1099 M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59824.

Order TELEODESMACEA.

Superfamily ASTARTACEA.

Family ASTARTIDÆ D'Orbigny.

Genus CYPRICARDELLA Hall (MICRODON Conrad), 1856–1858.

The genus Microdon was founded by Conrad in 1842 for the well-known *Microdon* (*Cypricardella*) *bellastriata*[3] Conrad, from the Hamilton formation of New York. Conrad's original diagnosis [4] of the genus is as follows:

Shell bivalve, equivalve; hinge with a slender oblique tooth in the left valve. The genera of many of the bivalves of the Paleozoic rocks are very little known. Casts of the hinge and teeth are rare, and the external form, though it

[1] Miller, S. A., Description of a new genus and eleven new species of fossils, with remarks upon others well known from the Cincinnati group: Cincinnati Soc. Nat. Hist. Jour., vol. 1, p. 105, pl. 3, fig. 11, 1878; in North American geology and paleontology, p. 462, fig. 774, 1889.

[2] Kayser, Emanuel, Ueber einige neue Zweischaler des rheinischen Taunusquarzits: K. preuss. geol. Landesanstalt Jahrb. 1884, p. 18, pl. 2, fig. 3, 1885.

[3] The spelling of the specific name *bellastriata* as here given is according to the author's usage. In the following pages the correct form *bellistriata* will be used.

[4] Conrad, T. A., Observations on the Silurian and Devonian systems of the United States, with descriptions of new organic remains: Acad. Nat. Sci. Philadelphia Jour., vol. 8, p. 247, pl. 13, fig. 12 (shows only external form of *Microdon bellastriata*), 1842 (read Jan. 18, 1842).

sometimes may afford a clue to the generic relations of a bivalve, is often useless for that purpose. In the present instance a provisional generic name is given, because I can not refer the shell to any published genus; but I must acknowledge that the casts of the hinge and teeth which I have yet seen are not very clear or satisfactory.

In 1851 McCoy [1] proposed the generic name Anodontopsis for certain English fossils. His description of Anodontopsis follows:

Synonym, Microdon? Conrad (not Agassiz nor Meigen).

General character: Equivalve, inequilateral, compressed, general form rotundato-quadrate or subtrigoral; posterior side wide, round or obliquely subtruncate, anterior end slightly contracted in front of the beak; beaks small, prominent, nearer to the anterior than to the posterior end; hinge line shorter than the shell, with a posterior long, slender lateral tooth, or cartilage plate, extending just below it (double in the right valve), and another similar but shorter one in front of the beaks; anterior and posterior muscular impressions simple, ovate, the latter longer and stronger than the anterior; occasionally a slight clavicular ridge extends from in front of the beak behind the anterior adductor impression, leaving a furrow in the cast; pallial impression entire (occasionally one small cardinal tooth beneath the beak); surface smooth or concentrically lined.

Except in their small size and marine habits these little fossils resemble the recent Anodons, from which there being but two simple adductor impressions separates them. They differ from Modiolopsis (or Cypricardites) in their rotundato-quadrate compressed form and the posterior adductor impression like the anterior one, and they have no trace of the byssiferous sinus so common in that group between the body of the shell and the anterior side; from Schizodus (Myaphoria), with which Prof. King seems to have blended them, they are distinguished by the long, slender posterior cartilage plate or lateral tooth, a little below the hinge line. Except in form they are identical with Clidophorus, and should be considered but as a subgenus thereof, distinguished from those long narrow types by their broad, rounded or oblique axlike form, more prominent beaks, and less marked clavicular ridge. From the figure of *Microdon bellistria[ta]* (Conrad), I should have imagined it belonged to the present genus, but his description of the hinge renders it probable that this genus is different, and I accordingly give a description of my own clear types; besides which the name Microdon was applied long previously to a genus of fish and one of insects.

McCoy included five heteromorphous species in his genus Anodontopsis. All are from the Upper Ludlow and Tilestone faunas of Britain. The genotype, *Anodontopsis angustifrons* McCoy, resembles Microdon or Cypricardella but differs in having the cardinal line ascending rather strongly, giving the shell the outline of the Cyrtodonta-Cypricardites groups. The second species, *Anodontopsis bulla* McCoy, is a circular shell which would now be placed probably in the genus Paracyclas Hall, or possibly in Cycloconcha Miller. The third species, *Anodontopsis lævis* or *Pullastra lævis* Sowerby,[2] has apparently the expression of a typical "Microdon." The last two species, *Anodontopsis quadratus* McCoy and *Anodontopsis securiformis* McCoy, are schizodiform shells, and *A. securiformis* has been made the type of Salter's genus Pseudaxinus.[3]

In Hall's original account[4] of the new well-known dwarfed fauna in the so-called "sub-Carboniferous" (Mississippian) limestones about Spergen Hill, Ind. (now known as the Spergen limestone), he described a new genus of little lamellibranchs under the name Cypricardella, as follows:

Shell ovate or subelliptical and subquadrate (subequilateral), closed. Surface concentrically striated; hinge of right valve having two cardinal teeth; the anterior tooth directly beneath the beaks, somewhat strong, triangular, slightly directed backward [nearly vertical]; posterior tooth more slender and turned obliquely backward, very nearly horizontal, leaving a triangular pit which is probably occupied by a tooth in the other valve. Anterior cardinal margin with a long, narrow groove, apparently for the reception of a slender projection of the other valve; posterior side beveled from above, edge thin, ligament external, occupying a deep cavity; muscular impressions distinct, shallow, equal in size or very nearly equal; pallial impression simple.

Of the four species of Cypricardella here described by Hall, *C. subelliptica*, *C. nucleata*, *C. oblonga*, and *C. plicata*, only the first three belong to Hall's genus. Figures of *Cypricardella nucleata* and of the genotype, *Cypricardella subelliptica*, showing the hinge structure of the latter, were given in the "Geology of Iowa" in 1858.[5] No reference was made by Hall to Microdon Conrad, and it was not until 25 years later that Whitfield announced the identity of Cypricardella and Microdon.

[1] Annals and Mag. Nat. Hist., 2d ser., vol. 7, pp. 53–54, 1851. See also Sedgwick, Adam, and McCoy, Frederick, British Paleozoic rocks and fossils, p. 270, 1852.

[2] Murchison, R. I., The Silurian system, pl. 3, fig. 1a, 1839.

[3] Salter, J. W., Note on the fossils from the Budleigh-Salterton pebble bed: Geol. Soc. London Quart. Jour., vol. 20, p. 298, 1864.

[4] Hall, James, Description of new species of fossils from the Carboniferous limestones of Indiana and Illinois: Albany Inst. Trans., vol. 4, p. 17 read Nov. 27, 1856.

[5] Iowa Geol. Survey, vol. 1, pt. 2, pp. 663–664, pl. 23, figs. 10–12, 1858.

In 1869–70 Hall [1] used the name Microdon and described, besides Conrad's *M. bellistriata*, four new species—three (*M. gregaria, M. tenuistriata, M. complanatus*) from the Hamilton, Portage (Ithaca shale member), and Chemung formations of New York and one (*M. reservatus*) from the Mississippian of Ohio.

In 1873 Hall [2] figured the generic features of "Microdon," showing a left valve of *M. tenuistriata* Hall with the teeth and muscular markings, and a right valve of *M. bellistriata* exhibiting similar features. These are the first illustrations of the generic characters of the Devonian shells of the genus Microdon of Conrad.

In 1877 Miller [3] called attention to the fact that Microdon was preoccupied by Agassiz (1833) for a genus of fish and also by Mergen (1803) for a genus of insects. Miller rejected the name Microdon Conrad but did not propose any new name. In an appendix to Miller's work Hall [4] proposed a few new names for some that were preoccupied, among these being Eodon Hall, 1877, proposed for Microdon Conrad.

In 1881 Oehlert [5] described and figured a little "Microdon" from the Lower Devonian limestones of Néhou, Le Manche, Normandy, which he incorrectly identified with *M. bellistriata* Conrad. Oehlert noticed the preoccupancy of Microdon Conrad, as indicated by Miller in 1877, but apparently overlooked the appendix to Miller's work, in which Hall had proposed the name Eodon, for he suggested the new generic name Microdonella for Conrad's genus. In view of the existence of Eodon Hall, 1877, Microdonella Oehlert, 1881, can have no value.

In 1882, in the revised descriptions of the faunas of the Spergen limestone, Whitfield [6] introduced some "observations of the genera Microdon Conrad and Cypricardella and Eodon Hall." He figured [7] and redescribed the original Cypricardellas from Spergen Hill and also redescribed the genus and showed it to be identical with Microdon Conrad except that the Carboniferous Cypricardellas are much more gibbous than the compressed Hamilton Microdons, owing, Whitfield believed, to crushing of the Microdons in the shales, whereas the Carboniferous forms are preserved uncompressed in limestones.

That the difference in convexity between the ventricose Carboniferous Cypricardellas and the compressed Devonian Microdons is not structural but may be explainable, as suggested by Whitfield, is indicated by the fact that Oehlert's *Microdonella bellistriata* as preserved in the Lower Devonian limestones of Normandy is very gibbous, whereas in the Ithaca member *Microdon tenuistriata* Hall and *M. gregaria* Hall occur in various stages of compression—the least-compressed forms being almost as strongly convex as the Carboniferous Cypricardellas, though they are apparently of the same species as the nearly flat specimens occurring in the surrounding arenaceous shales.

While Whitfield was working on the Spergen fauna Hall was preparing a report on the same fauna, which appeared in 1883.[8] In this report Hall redescribed the species of Cypricardella, as well as the genus itself, and inserted Whitfield's plates of illustrations. He noted the similarity of the Spergen Cypricardellas to Microdon (whether following Whitfield or independently is not indicated) but regarded the knowledge of the hinge of Microdon as too meager to warrant uniting the two genera.

This opinion was still held by Hall in 1883,[9] when he figured *Microdon* (*Microdonella*) (*Eodon*) *gregarius* Hall, *M.* (*M.*) (*E.*) *bellistriatus* Conrad, *M.* (*M.*) (*E.*) *tenuistriatus* Hall, and *M.* (*M.*) (*E.*) *complanatus*, from the Hamilton of New York; *M.* (*M.*) (*E.*) *gregarius* Hall and *M.* (*M.*) (*E.*) *bellistriatus* Conrad, from the Chemung; and *M.* (*M.*) (*E.*) *reservatus* Hall, from the

[1] Preliminary notice of the lamellibranchiate shells of the Upper Helderberg, Hamilton, and Chemung groups, pt. 2, pp. 30–33, 1870.
[2] Hall, New York State Mus. of Nat. Hist. Twenty-third Ann. Rept., pl. 14, figs. 7 and 8, 1873.
[3] Miller, S. A., North American Paleozoic fossils, 1st ed., p. 194, 1877.
[4] Idem, pp. 243–245.
[5] Oehlert, D. P., Documents pour servir à l'étude des faunes dévoniennes dans l'ouest de la France: Soc. géol. France Mém., 3d ser., vol. 2, pp. 26, 27, pl. 4, figs. 4–4b, 1881.
[6] Whitfield, R. P., On the fauna of the Lower Carboniferous limestone of Spergen Hill, Indiana, with a revision of the descriptions of its fossils hitherto published and illustrations of the species from the original types: Am. Mus. Nat. Hist. Bull., vol. 1, No. 3, pp. 63 et seq., pl. 7, Oct. 20, 1882.
[7] Idem, pl. 23.
[8] Indiana Dept. Geology and Nat. Hist. Twelfth Ann. Rept., pp. 319–375, 1883.
[9] Paleontology of New York, vol. 5, pt. 1, preliminary edition of plates, pls. 73, 74, 1883.

Mississippian of Ohio. As he made no mention of Cypricardella, it is quite apparent that he still considered the Devonian large compressed Microdons distinct from the Carboniferous small gibbous Cypricardellas.

Hall abandoned this opinion two years later,[1] however, and united Microdon Conrad (Eodon Hall, 1877; Microdonella Oehlert, 1881), and Cypricardella Hall, 1856, describing the New York Devonian species and the Mississippian species already cited and, in addition, a new species, *Microdon (Cypricardella) major* Hall, from the "Corniferous" of Ohio, the first species occurring in America below the Hamilton.

After Whitfield's work on the Spergen fauna De Koninck,[2] in his monograph on the lamellibranchs of the Belgian Carboniferous limestones, recognized Microdon Conrad as a synonym of Cypricardella. He states, apparently through inadvertence, that the name Cypricardella had been proposed by Hall to replace Microdon Conrad because the latter name had been preoccupied. Such, of course, was not the real state of affairs. De Koninck described 15 species of Cypricardella from étages II and III (Viséan), and showed the hinge structure of several of them.

As a result of the work of Whitfield, Hall, and De Koninck, Microdon has been abandoned and Cypricardella, originally proposed for Carboniferous shells, has come into general use for the Devonian shells also. In 1895 appeared Beushausen's work on the lamellibranchs of the Rhenish Lower Devonian,[3] in which he described nine species of typical Microdon Conrad as Cypricardella and elucidated the hinge structure of several of these species.

The fine illustrations of Hall and of Beushausen show that the Devonian Microdons are not distinguishable by any definite characters from Cypricardella, although the facts that the Devonian Microdon is large and compressed, while the Carboniferous Cypricardella is ventricose and smaller, as already explained, and that Microdon seems to be thinner shelled, suggest a doubt as to their positive identity. The doubt is augmented by the fact that the Carboniferous species, instead of being larger than the more primitive Devonian Microdons, are in both Europe and America invariably smaller. Moreover, continuing into the Pennsylvanian and Permian, the small Cypricardellas lose the umbonal carination and become evenly rounded and trigonal, as in Astarte, and the teeth become stronger, also as in Astarte. Cypricardella is evidently a forerunner of Astarte and toward the close of the Paleozoic becomes hardly distinguishable from it; but "Microdon" seems not at all related to this group. However, the positive characters of the Devonian Microdon and the typical Carboniferous Cypricardella do not indicate any substantial generic differences.

On the assumption, therefore, that the Devonian forms of the type of Conrad's Microdon and the Carboniferous forms called Cypricardella by Hall are generically the same the genus may be described as follows:

Bivalve, equivalve, closed throughout.

Outline in general rotundo-quadrate, with the length greater than the height but less than twice the height. Umbones depressed, not extending appreciably beyond the cardinal line, prosogyrate, situated anterior to the middle and separated from the narrower rounded anterior end by a concave lunule. The cardinal line is distinct; nearly horizontal, sometimes declining, rarely slightly ascending; shorter than the length of the shell; slightly convex or nearly straight. The postcardinal extremity is rounded subangular. The posterior margin is slightly retrorse or nearly vertical; rounded, convex. The ventral margin is always rounded, convex, and without any insinuation or flattening; it curves into the anterior end, which is always distinct, narrower than the body, and separated by a concave lunule from the beaks. The shells are compressed, biconvex, but when occurring in limestone are generally more deeply convex. A low and persistent though undefined umbonal ridge is more or less conspicuous, though never angular; it is also never sigmoid nor concave, being generally nearly straight or a little arched convex; it is absent in a few late Paleozoic species and in some individuals of

[1] Paleontology of New York, vol. 5, pt. 1, 1885.
[2] De Koninck, L. G., Faune du calcaire carbonifère de la Belgique, vol. 3, pt. 5, pp. 91-98, 1885.
[3] Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, pp. 134-146, 1895.

earlier species. The surface is depressed convex both below the umbones and posterior to the carination; there is no insinuation or flattening comparable with that in the modiomorphoids.

The lunule[1] is occupied by a pronounced lunette. Posteriorly there is a long, deep, but narrow escutcheon, the shape of which almost makes the ligament appear, in isolated valves, to be internal.

Hinge plate very thin, especially in the early species. In the right valve, just under the tip of the beak and at the end of the lunette, there is a small, short, narrow radial fold or tooth, sometimes hardly discernible. This tooth is nearly but not quite vertical, inclining a trifle posteriorly from the beak. Just back of it is a much larger triangular socket for the reception of the large cardinal tooth of the left valve; this triangular socket, the direction of which is nearly horizontal, subtends at the tip an angle not exceeding 45° and generally much less. Above the socket, in the right valve, there is a long, narrow cardinal tooth, which is approximately horizontal or very slightly ascending, and which, though long in proportion to its width, extends but slightly beyond the beak.[2] There are no posterior laterals. In the left valve the most conspicuous feature is the large, triangular, nearly horizontal tooth, fitting into the triangular socket of the right valve. Just in front of it is a small depression for the reception of the minute anterior tooth of the right valve, and just back of it is a slit for the reception of the second or longer narrow tooth of the right valve. The dental structure may be summarized as two narrow radial folds or cardinal teeth in the right valve inclosing a triangular cavity for the reception of the single large triangular cardinal of the left valve, which is preceded and followed by a minute cavity for the reception of the teeth of the right.

The adductor muscular scars are equal or nearly equal in size, shallow, and very feebly impressed; pedal scars nondiscernible. The posterior scar is very near the postcardinal extremity; the anterior scar is at a distance from the beak and begins at the anterior end of the lunule. Pallial line simple, entire. Shell structure unknown.

Surface smooth or with concentric lines of growth commonly bellistriate, but not concentrically plicose or wrinkled, and without radial markings. Size small to medium. The largest species (*C. major* Hall) is 72 millimeters long and 48 millimeters high, but commonly the size does not exceed half these dimensions, and in the Carboniferous forms the shells are much smaller.

The geologic range is from the Upper Ludlow (late Silurian) through the Permian. Most abundant in the Siegen and Lower Coblenzian graywackes in the Rhenish Lower Devonian; in the Meso-Devonian Hamilton and Portage (Ithaca shale number) formations of New York; in the Mississippian Spergen limestone, and in the Viséan. The later forms tend toward Astarte by the strengthening of the tooth and the rounding of the postcardinal extremity and cardinal line, and by the consequent loss of their quadrate outline, with assumption of the trigonal or astartiform outline.

The relation of Cypricardella (Microdon Conrad) Hall, 1856–1858, to Anodontopsis McCoy, 1851, is difficult to determine because illustrations of the hinge structure of Anodontopsis are lacking. The most striking feature in Anodontopsis is the supposed occurrence of a posterior long, slender lateral tooth just below the hinge, apparently double in the right valve, whereas in Microdon no laterals exist. McCoy stated definitely that these supposed posterior laterals might be only an external ligament groove or cartilage plate (escutcheon), and, as some figures of the Microdons[3] show similar appearances, it seems probable that, as McCoy believed, the supposed posterior laterals are indications of a deep, long escutcheon, as in Microdon. Of the five species of Anodontopsis McCoy, all except *Anodontopsis angustifrons* McCoy, the genotype, may be eliminated from consideration. In this shell, as has been stated, the cardinal line

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[1] The terms "lunule" and "lunette," though often used indiscriminately, indicate distinct features. The lunule is the general concavity of the dorsal margin immediately in front of the beaks in most lamellibranchs; the term "lunette" is applied to an excavation in the lunule for the reception of the forward ligament.

[2] Wheelton Hind (British Carboniferous Lamellibranchiata, vol. 1, p. 347, London Paleontogr. Soc., 1899) regards this hindmost tooth as a posterior lateral, and hence describes Cypricardella as having posterior laterals.

[3] See especially Krantz, A., Ueber ein neues bei Menzenberg aufgeschlossenes Petrefakten-Lager in den Devonischen Schichten: Naturh. Verein preuss. Rheinlände Verh., vol. 14, p. 162, pl. 11, fig. 1 (*Tellina bicostula* Krantz), 1857. This is a Microdon (Cypricardella), as was recognized by Beushausen (op. cit., pp. 137–138); see also Beushausen's figures of *Cypricardella elongata* Beushausen and *C. unioniformis* (Sandberger) (idem, pl. 11, figs. 14b, 19b). These figures illustrate very well a feature that might, though occurring in typical Microdon, be easily mistaken for the appearance of two posterior laterals in the right valve.

ascends posteriorly and thus gives the shell the superficial aspect of a compressed Cyrtodonta or Cypricardites, or of a modiolopsoid; but the species is readily distinguished from the modiolopsoids by its convexly rounded, noninsinuated basal margin and by its distinct rounded narrow anterior end, separated by a lunule from the beak; it also has an umbonal undefined ridge. In these three respects *A. angustifrons* very closely resembles Cypricardella (Microdon), differing apparently only in having the cardinal line somewhat more strongly ascending. Among the typical Cypricardellas, however, some forms have a markedly ascending cardinal line; among these are *Microdon* (*Cypricardella*) *major* Hall,[1] from limestones of the age of the "Corniferous" at Delaware, Ohio, and *M.* (*C.*) *complanata* Hall,[2] from the higher arenaceous beds of the Hamilton of eastern New York. Moreover, the great variability in the direction of the cardinal line in the same species of Microdon (Cypricardella)—for instance, in *M.* (*C.*) *bellistriata* Conrad, in which the cardinal line is descending in some species[3] and slightly ascending in others[4]—suggests that McCoy's *Anodontopsis angustifrons* as represented in his plate 1, K, figure 14, is a cypricardelloid shell. If by its internal features this species can be shown to be congeneric with the coterie of shells associated about *Microdon bellistriata* Conrad, then the name Anodontopsis McCoy will have precedence over Cypricardella Hall or any of the other known names used in substitution for the preoccupied Microdon Conrad. From present knowledge (or rather lack of knowledge of McCoy's type species, however, I can not definitely consider it congeneric with the Microdons; indeed, McCoy's description of Anodontopsis and *A. angustifrons* indicates that the posterior muscular impression is longer and stronger than the anterior, whereas in Cypricardella (Microdon) the muscular scars are approximately equal in size and the posterior scar is weaker than the anterior. McCoy's statement may be taken with some reservation, for in dimyarian shells, such as the Anodontopsis forms seem to be, to have the posterior scar stronger than the anterior would indeed be anomalous. Again, McCoy states that in Anodontopsis there is "occasionally one small cardinal tooth beneath the beak." In Microdon (Cypricardella)[5] there are two cardinal teeth in the right valve and one in the left.

I feel justified, therefore, in stating that knowledge of the structure of Anodontopsis McCoy and the genotype *A. angustifrons* McCoy is insufficient to warrant uniting these forms with Microdon Conrad and substituting McCoy's name for the preoccupied Microdon, and that, so far as I am acquainted with McCoy's fossils through his published descriptions, his shell is not congeneric with Microdon Conrad (Cypricardella). The name Cypricardella will, therefore, be retained.

CYPRICARDELLA BELLATULA sp. nov.

Plate XXI, figure 1.

An interesting quadrate, complanate, minute Cypricardella is represented by several specimens from Presque Isle Stream (locality 1099 A), where it appears to be fairly common.

Form subrhomboidal; length about one and three-eighths times the height, the ratio of length and height varying from 4:3 to 3:2; greatest length near the midheight; greatest height between the anterior and posterior third. The umbones are depressed, reaching the cardinal line but not extending beyond, incurved, directed strongly forward. The beaks are generally situated at the anterior fourth (varying between the anterior fifth and two-sevenths in different specimens). The cardinal line is horizontal, perceptibly arched, length about seven-eighths the height of the shell. The cardinal extremity is obtusely subangular, distinct, rarely broadly rounded, and is situated at or near the posterior tenth of the length of the shell. The posterior margin forms an evenly rounded convex curve, slightly retrorse above and curving forward in the lower part, so that the most posterior point is near the midheight. The ventral margin is convex throughout; the postventral angle is obtusely rounded; the ventral margin for the posterior two-thirds of its length is gently arcuate, almost horizontal, but curves strongly

[1] Paleontology of New York, vol. 5, pt. 1, p. 307, pl. 42, fig. 21, 1885.

[2] Idem, p. 311, pl. 42, fig. 22; pl. 74, fig. 16.

[3] Idem, pl. 73, figs. 10, 13; pl. 74, fig. 8.

[4] Idem, pl. 73, figs. 15, 19. Compare the variability of this feature in *M.* (*C.*) *gregaria* and *M.* (*C.*) *tenuistriata* as figured by Hall.

[5] The figures of the dentition of Microdon given by Hall are imperfect and do not indicate the conditions normally found in these shells; in this respect Beushausen's figures and descriptions are much more satisfactory.

forward and upward into the anterior end. The extreme lowest point is apparently just in front of the midlength. The anterior end is prominent and rounded; it extends three-fourths the height of the shell and one-fourth the length, and is separated from the umbo by a short, well-marked lunule. The most anterior point is near or slightly above the midheight. The shells are compressed convex throughout and are marked by a conspicuous though undefined umbonal ridge, which is pronounced for two-thirds of the length from the umbo to the post-ventral angle and is less developed below; it is directed in a very slightly convex arch extending in a general direction of approximately 45° from the vertical. The surface is depressed convex, almost flat, from the ridge forward to below the beaks, and is more convex anteriorly. The greatest depth of the valve is a short distance below and back of the beak, on the umbonal ridge, at one-third the height below the cardinal line and just back of the midlength; the line from this point to the beak makes an angle of 40° or less with the length of the shell. The depth is about one-fifth or one-sixth the height. Shell structure unknown. Internal and external molds are generally rather glossy. A short distance below the cardinal line and parallel to it is a long, faintly impressed line, usually found in Microdon (Cypricardella), indicating and resembling the inner edge of the escutcheon. Teeth unknown. An oval anterior adductor scar of medium size is very faintly impressed. It is separated by its length from the beak. No pedal or posterior muscular scars are discernible, except that there is a faint indication of an oval posterior scar, hardly distinguishable, at the cardinal extremity; it is apparently only very slightly if at all larger than the anterior scar. The mark is too obscure to consider it as definitely indicating a muscular scar.

Internal and external molds are nearly smooth but are marked by obsolescent, very fine lines of growth. In the single external mold observed, there are about three somewhat stronger lines of growth or varices in the older half of the shell.

The average-sized specimens are about 1.5 millimeters thick (in single valves). The smallest specimen was 7.5 millimeters high and about 10 millimeters long; the largest 8.66 millimeters high and 13 millimeters long.

This is the oldest known typical Microdon, with the possible exception of *Pullastra lævis* Sowerby, from the Tilestone fauna, which has been regarded as a Microdon (Cypricardella) on account of its outline, depressed convexity, umbonal ridge, and general expression. Sowerby's form may, however, be a shell with slightly concave or insinuated ventral margin; if so it may prove to be Modiomorpha rather than Cypricardella. The small size of the Chapman shell is interesting in connection with its age. Besides being the smallest Cypricardella known below the Carboniferous, this species is characterized by its quadrate outline, with length $1\frac{3}{8}$ times the height; short, horizontal, arched hinge line equal in length to only seven-eighths the height of the shell; strongly arched posterior margin with posterior extremity at the midheight; ventral margin nearly horizontal for the posterior two-thirds of its length and arching upward and forward into the anterior end; well-developed anterior end extending three-fourths the height of the shell and one-fourth the length; depressed convexity; well-marked umbonal ridge, directed at approximately 45° to the length and height; nearly smooth surface with very faint lines of growth and a few stronger varix-like lines in the earlier portion of the shell.

Locality: Chapman sandstone, Presque Isle stream, at end of Tweedy road (locality 1099A), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59825.

Comparisons.—*Cypricardella bellatula* belongs to the group of quadrate smooth, compressed Cypricardellas including, in the Devonian faunas, *Cypricardella gregaria* Hall,[1] *Cypricardella tenuistriata* Kayser[2] (not Hall), *Cypricardella curta* Beushausen,[3] and *C. subovata* Beushausen.[4] *Cypricardella bellatula* is, however, smaller than any of the species indicated.

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 309, pl. 73, figs. 1-6; pl. 74, figs. 1-4, 1885; Middle and Upper Devonian.

[2] Kayser, Emanuel, Sur une faune du sommet de la série rhénane à Pepinster, Goë et Tilff [Belgium]: Soc. géol. Belgique Annales, vol. 23, p. 199, pl. 1, figs. 10, 11, 1896; Lower Devonian.

[3] Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 144, pl. 12, figs. 7-11, 1895; Lower Eo-Devonian.

[4] Idem, p. 145, pl. 12, figs. 16, 17; Lower Eo-Devonian.

From the Belgian upper Eo-Devonian *Cypricardella tenuistriata* of Kayser (not Hall) the Chapman shell is distinguished by its slightly smaller size and by having the posterior margin more strongly rounded, with the most posterior point at the midheight, whereas in Kayser's form the most posterior point is at the base.

Compared with *C. curta* Beushausen (the undistorted form),[1] *Cypricardella bellatula* has the ventral margin more nearly horizontal in the posterior two-thirds of its length, and not bellied down in so strong an arch as in *C. curta*. In Beushausen's species also the height is a trifle more nearly equal to the length than in *C. bellatula*.

Compared with *C. subovata* Beushausen, *C. bellatula* has the posterior margin less truncated and more arched. In *C. subovata* the most posterior point is near the base instead of the middle, the ventral margin is more strongly bellied down, and the ornamentation is more pronouncedly bellistriate.

C. bellatula is easily distinguished from *Cypricardella gregaria* Hall by its proportionately higher anterior end. In *C. gregaria*, also, the posterior extremity is usually nearer the base than in *C. bellatula*, the ventral margin is commonly more strongly bellied down, and the shell is larger than *C. bellatula* and generally proportionately longer. Hall[2] represents a little *C. gregaria* from the Ithaca shale member of the Portage formation at Cortland, N. Y., which is remarkably similar to the Chapman fossils, but is slightly larger and has the anterior end not so high.

CYPRICARDELLA ROTUNDATA sp. nov.

Plate XXI, figures 14, 15; Plate XIX, figure 25.

?1884. cf. young (?) of *Schizodus orbicularia*. Walcott, U. S. Geol. Survey Mon. 8, p. 181, pl. 5, fig. 8a (not fig. 8). Lower Devonian: Atrypa Peak, Eureka district, Nev.

An interesting cypricardelloid shell found at Edmunds Hill (locality 1099 M) is characterized by evenly though gently inflated, nondepressed convexity over the body of the shell, absence of any conspicuous umbonal ridge, and subcircular outline.

Length 24 millimeters, between one and one-fourth and one and one-fifth times the height (19.5 millimeters); greatest height at the midlength; greatest length below the middle and one-third or more of the height above the base. Umbones small, not extending above the cardinal line; prosogyrate; beaks at the anterior fourth. Cardinal line slightly convex, nearly horizontal or declining slightly; equal in length to two-thirds the height of the shell. Highest point of the shell opposite the midlength. Cardinal extremity distinct, obtusely subangular. Posterior margin retrorse, extending nearly straight for a distance equal in length to the length of the cardinal line and passing into the postventral angle. Most posterior point of the shell at this angle, one-fourth the height above the base. The ventral margin is strongly bellied down in a rather deep, evenly convex arch, so that the lowest point at the midlength is about one-fourth the height of the shell below the respiratory (postventral) angle. The ventral margin arches gradually but strongly upward into the evenly rounded anterior end, which includes one-fourth the length of the shell and two-thirds or more of the height and which is separated from the umbo by a small, shallow lunule.

There is no conspicuous or discernible umbonal ridge, but from the position where it ought to be the surface inclines posteriorly in a depressed-convex though rather steep slope to the cardinal line and posterior margin. Anteriorly the surface is evenly though gently inflated convex, nowhere flattened, nor does the degree of convexity change appreciably up to the anterior and ventral margins. The point of maximum depth of the single left valve known is a trifle above and in advance of the middle. The depth (3.5 millimeters) is equal to 0.18 the height and about one-seventh the length. Hinge and muscular features unknown.

The internal mold is smooth, devoid of any ornamentation, and very dull, not glossy.

Size: Length 24 millimeters, height 19.5 millimeters, depth of left valve (internal mold) 3.5 millimeters.

[1] Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 144, pl. 12, figs. 7, 8.

[2] Hall, James, op. cit., 74, fig. 1.

The distinguishing features of the species are its fairly large size (it is much larger than the similarly inflated Carboniferous species); inflated, noncomplanate convexity; indefinability of any umbonal ridge; very strongly bellied-down ventral margin, giving the shell a subcircular outline; length between 1¼ and 1⅓ times the height; cardinal line horizontal or very slightly declining, and equal in length to two-thirds the height of the shell; and retrorse, nearly straight posterior margin with most posterior point at the respiratory angle.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59827.

Comparisons.—In the inconspicuousness of the umbonal ridge and in the rounded surface with strongly arched ventral margin, the Chapman fossil resembles the figures of *Cypricardella hartii* Clarke,[1] a species from the Lower Coblenzian fauna of Rio Maecuru, Para, Brazil. The Brazilian fossil is transversely more elongated, not subcircular; the cardinal line is therefore proportionately much longer, and the shell is larger. *C. rotundata* may be easily distinguished from the Maecuru fossil by its more circular outline.

The outline recalls the group of small Cypricardellas, including *C. curta* Beushausen, *C. gregaria* Hall, *C. subovata* Beushausen, and *C. bellatula* sp. nov., but these shells are complanate and have a conspicuous umbonal ridge, whereas *C. rotundata* is evenly convex and has no discernible umbonal ridge.

In the Lower Devonian of Atrypa Peak, in the Eureka district, Nev., occurs a small shell which is regarded by Walcott as possibly the young of his species *Schizodus orbicularis*, from the Lower Devonian of Lone Mountain. From the figure alone this small shell can not readily be distinguished from the Chapman fossil, though Walcott's shell seems to have the umbonal ridge slightly more pronounced and the anterior end slightly shorter than in *C. rotundata*.

In the Belgian Carboniferous occur many Cypricardellas—particularly *Cypricardella cantraineana* (De Ryckholt)[2] and *C. parallela* (Phillips),[3] both from the Viséan—which partake of the evenly convex or inflated character of the body of the shell, the inconspicuousness of the umbonal ridge, and nearly subcircular outline of *C. rotundata*. The Belgian fossils referred to, if they really belong to Cypricardella, which is uncertain, are all much smaller shells, with umbones situated farther forward and more tumid, and with a less directly demarcated postumbonal slope.

C. rotundata occurs in a hard, coarse-grained sandstone, and its convexity might perhaps be attributed to its noncompression in the rock; but the shell called in this paper Cypricardella cf. *C. bicostula* (Krantz) is a complanate species and occurs in the same locality, in a very similar kind of rock—possibly in the same stratum, though this is not known; so that the complanation of the one and the convexity of the other seem to represent anatomic and not accidental differences.

CYPRICARDELLA TRANSVERSA sp. nov.

Plate XXI, figure 8.

This name is proposed for a cypricardelloid shell which resembles *C. rotundata* in the evenly inflated, noncomplanate body, but which is distinguished from that species by the transversely more elongated outline.

Length (33 millimeters) equal to one and one-half times the height (21.75 millimeters); greatest height at the midlength; greatest length one-third or two-fifths the height above the base. Umbones small, depressed, not extending above the cardinal line, prosogyrate; beaks at the anterior fifth. Cardinal line not preserved in the type and only specimen but apparently declining slightly, somewhat arched, length about three-fourths the height of the shell. Cardinal extremity obtusely rounded. Posterior margin retrorse, slightly arched, nearly straight as

[1] Clarke, J. M., The Paleozoic faunas of Para, Brazil, pt. 2, Devonian Mollusca: Mus. Nac. Rio de Janeiro Arch., vol. 10, pl. 7, figs. 1–3, 1899 (author's English ed., p. 63, 1900).

[2] De Koninck, L. G., Faune du calcaire carbonifère de la Belgique, vol. 3, pt. 5, p. 93, pl. 17, figs. 31–35, 1885.

[3] Idem, p. 96, pl. 13, figs. 50–51.

far as the respiratory angle for a distance about equal to the length of the cardinal line. The most posterior point is at the respiratory angle, which, on account of the strong arching of the ventral margin, is one-fourth the height above the base. Ventral margin bellied down, its posterior third making with the retrorse posterior margin a somewhat rounded right angle. The lowest point of the shell is at the midlength. The ventral margin sweeps with a broad curve into the rounded anterior end, which includes one-fifth the length of the shell and about two-thirds the height. The forward extremity is at the midheight. The upper anterior margin immediately in front of the beak makes an angle of about 125° with the cardinal line back of the beak. The umbonal ridge is broadly rounded, scarcely discernible. The posterior slope is very steep, rounded, depressed convex. Anterior to the region of the umbonal ridge the surface to the anterior and ventral margins is rounded convex, evenly inflated, noncomplanate. The point of greatest depth is at the midlength of the shell, slightly above the midheight. The depth is 5.2 millimeters, or about one-fourth the height and about a sixth the length. The line from the point of maximum depth to the beak makes an angle of 45° with the height and length of the shell. Hinge features unknown. Muscular markings not impressed.

The specimen, an internal mold, or possibly sculpture cast, preserves traces of concentric, obsolescent lines or low, narrow undulations of growth, apparently very nearly as well developed on the posterior slope as on the body of the shell.

Length 33 millimeters, height 21.75 millimeters, depth 5.2 millimeters (single right valve).

The distinguishing features of the species are the arched (slightly declining?) cardinal line, equal in length to about three-fourths the height of the shell; the transverse outline with the length of the shell equal to one and one-half times the height; posterior margin retrorse; posterior extremity at the respiratory angle one-fourth the height above the base; basal margin bellied down in a strongly convex arch; anterior end including one-fifth the length of the shell; inflated, noncomplanate convexity, with rounded umbonal ridge; depth (each valve) equal to one-fourth the height and situated at the midlength a trifle above the midheight; concentric striation obsolescent.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59828.

Comparisons.—The fossil, especially in the lower half, bears a very strong resemblance to *C. rotundata*, from which the most important and almost the only distinction is the decidedly more transverse outline. The species is also very closely related to *Anodontopsis ventricosa* Billings,[1] from the Gaspe limestone No. 8 of Indian Cove, Gaspe, Quebec; the two species correspond closely in size, outline, curvature, and ornamentation, but in Billings's species the "height at the umbones [is] twelve lines; depth of both valves, ten lines," which would make the depth of both valves five-sixths the height; whereas in *Cypricardella transversa* the depth of both valves is hardly half the height. *Anodontopsis ventricosa* Billings is therefore a much more gibbous shell. The umbones as figured by Billings are also more gibbous and inflated than in *C. transversa.*

CYPRICARDELLA cf. C. BICOSTULA (Krantz).

Plate XXI, figure 9.

cf. 1857. *Tellina bicostula.* Krantz, Naturh. Verein. preuss. Rheinland Verh., vol. 14, p. 162, pl. 11, fig. 1.
Siegen graywacke: Menzendorf, near Bonn, Germany.

1885. *Curtonotus grebei.* Kayser, K. preuss. geol. Landesanstalt Jahrb., 1884, p. 16, pl. 2, figs. 2, 2a.
Taunus quartzite: Katzenloch, near Idar.

1886. *Curtonotus torosus.* Maurer, Fauna des rechtsrheinischen Unterdevon (Darmstadt), p. 16 (not seen).

1895. *Cypricardella bicostula.* Beushausen, K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 137, pl. 11, figs. 5–9.
Taunus quartzite: Katzenloch, near Idar; Stromberger Neuhütte.
Siegen graywacke: Seifen, near Dierdorf; Menzenberg, near Bonn.

1904. *Cypricardella bicostula.* Drevermann, Palaeontographica, vol. 50, p. 243.
Formations and localities same as cited by Beushausen, 1895.

[1] Billings, Elkanah, Paleozoic fossils of Canada, vol. 2, pt. 1, p. 55, figs. 24–25, 1874. Not the *Schizodus ventricosus* (Billings) of Clarke (New York State Mus. Mem. 9, p. 162, pl. 23, fig. 10, 1908).

A transverse, complanate Cypricardella with strong concentric markings is represented by a large fragmentary external mold of a left valve from the west side of Edmunds Hill. The specimen is 16 millimeters or more high, and was probably 26 millimeters or more long. The ventral margin is bellied down at the posterior extremity but only slightly arched in the middle. The posterior margin is slightly convex and strongly retrorse, and has the posterior extremity at the respiratory angle, less than one-fourth the height above the base. The cardinal line is only slightly, if at all, greater than the height of the shell. The umbonal ridge is broadly rounded and inconspicuous. The body of the shell is depressed convex, the posterior slope flattened. The surface markings consist of concentric, almost bellistriate lines of growth, with distant, slightly stronger varices beginning at about the midheight of the specimen.

Locality: Chapman sandstone, west side of Edmunds Hill (locality 1099 M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59829.

Comparisons.—In its large size, outline, and ornamentation the specimen is closely affiliated with Krantz's species *C. bicostula;* but the incompleteness of the single Chapman specimen makes identification with the German species doubtful. It is safe, however, to consider the fossil as a member of the group of large transverse, complanate, semibellistriate forms, including *C. unioniformis* (Sandberger),[1] from the lowest Coblenzian of Singhofen; *C. bicostula* (Krantz),[2] a widespread species in the German lowest Devonian, the Taunus quartzite and Siegen graywacke; *C. elongata* Beushausen,[3] from the Siegen graywacke and Lower Coblenzian; and some forms of *C. tenuistriata* Hall,[4] from the Middle and Upper Devonian of New York.

Superfamily SOLENACEA Lamarck.

Family SOLENIDÆ Leach.

Genus PALEOSOLEN Hall.

The name Palæosolen was proposed by Hall[5] in 1885 for the species *Orthonota siliquoidea* Hall, 1870, which he recognized as differing from typical species of Orthonota "in the regularly convex, cylindrical form of the entire shell, and the gaping posterior extremity." [6]

Although in the description Hall gave Paleosolen subgeneric value, it was not as a subgenus of Orthonota but of Solen. No cardinal teeth have been observed in the original species, a negative character which would seem to throw it into closer relationship with the Solenopsidæ, of the Paleozoic, than with the Solenidæ, of Cretaceous to Recent time; another species of Paleosolen, however, seems to show teeth as in Solen. In general external form, also, Paleosolen much resembles the Recent representatives of Solen, which gape at both ends; McCoy's Solenopsis gapes at the posterior end. Whatever may prove to be the true relationship between the Paleozoic and the Recent shells of this general form, it is evident that Paleosolen is not strictly a subsection of either Orthonota or Solen, but properly a separate genus of the Solenidæ, a family of ancient geologic age; it is therefore ancestrally related to the true Solens.

In separating Paleosolen from Orthonota, Hall called attention to the doubt regarding the type of Conrad's genus Orthonota, stating that the first species mentioned by Conrad (*O. pholadis*) "is evidently not congeneric with *O. undulata,* which Mr. Conrad always regarded as the typical species of the genus." [7] In his redefinition of the genus Orthonota, Hall adopted *O. undulata* as the type of the genus and cited *O. carinata* as another example. *Orthonota carinata* and *O. ensiformis* have sharply defined and angular posterior radial ribs or costæ; in *O. undulata,* although it lacks the rigid ribs or costæ, they are usually represented by faint radial

[1] Sandberger, Guido and Fridolin, Versteinerungen des rheinischen Schichtensystems in Nassau, p. 253, pl. 27, fig. 3, 1850. See also Beushausen, Louis, op. cit., p. 139, pl. 11, figs. 17-19.

[2] Krantz, A., op. cit., p. 162, pl. 11, fig. 1. See also Beushausen, Louis, op. cit., p. 137, pl. 11, figs. 5-9.

[3] Beushausen, Louis, K. preuss. geol. Landesanstalt Jahrb., 1888, p. 226, pl. 4, figs. 3, 4, 1889; K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, p. 138, pl. 11, figs. 10-14, 1895.

[4] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 310, pls. 42, 73, 74, 1885.

[5] Idem, fasc. 2, p. 46.

[6] Idem, p. 483.

[7] Idem, p. 14.

furrows which are variable in number and strength. These furrows may, however, be lacking; indeed, suites of specimens of *Orthonota undulata* from the Hamilton formation at Sherburne and along Cayuga Lake, N. Y., contain mature shells that show no radial furrows. The absence of these characters alone, therefore, might not be regarded as generically separating *O. siliquoidea* and Paleosolen from the typical Orthonotas.

In Paleosolen, however, there is, in addition to the posterior gape, a pronounced anterior gape, effected by the reflexion or flaring back of the forward portion of the shell. This reflexion of the anterior margin will serve to distinguish Paleosolen from Orthonota. The character is developed in *Paleosolen siliquoidea*, as was indicated by Hall, and also occurs in *P. costatus* (Sandberger), from the Rhenish Eo-Devonian. Examination of extensive suites of *Orthonota undulata* and *O. carinata* has failed to furnish any positive evidence of gape at either end; moreover, these species, representing typical Orthonota, lack the reflected anterior margin of Paleosolen. On the whole, I am inclined to consider Paleosolen as representing the primitive Solenidæ, whereas Orthonota and similar soleniform shells occurring in the older Paleozoic are, as suggested by Ulrich, of orthodesmoid-modiolopsoid affiliations.

In *Orthonota undulata* and *O. carinata* the two valves are, when conjoined, commonly spread out flat; the valves are not closed. On the other hand, in the Chapman shells, although the ligament appears to have been very strong, the shells are usually fossilized, with the valves joined and closed. *Paleosolen costatus* (Sandberger) is also found generally with both valves joined together and not spread open. In this habit of the species the Paleozoic Paleosolen, unlike Orthonota, conforms to the habit of the Recent Solens. Whether or not Paleosolen possesses the deeply insinuated pallial line of Solen is unknown.

Paleosolen chapmani, described below, is the earliest solenoid known. The genus includes, in addition to this shell, the following species:

Solen costatus. Sandberger, Die Versteinerungen des rheinischen Schichtensystems in Nassau, p. 252, pl. 27, figs. 1-1d, 1850–1856. Lowest Coblenzian, or Singhofen porphyroid, in Nassau; Würben Valley quartzite of Durrberg, in the Altvater Mountains, Austrian Silesia.

Paleosolen simplex. Maurer, Die Fauna des rechtsrheinischen Unterdevon, p. 18, 1886. Lower Coblenzian near Ehrenbreitenstein and Winnigen. Also recorded from the fauna of the Moose River sandstone of Moosehead Lake, Somerset County, Maine (Clarke, New York State Mus. Bull. 107, p. 235, figs., 1907).

Solenopsis belgica. Kayser, Sur une faune du sommet de la série rhénane à Pepinster, Goë et Tilff: Soc. géol. Belgique Mém., vol. 22, p. 202, pl. 2, figs. 8–9, 1896. Upper Eo-Devonian of Pepinster, Belgium.

Paleosolen eifeliensis. Beushausen, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesantalt Abh., new ser., vol. 17, p. 225, pl. 18, figs. 11, 12, 1895. Upper Coblenzian of Prüm, in the Eifel.

Sanguinolites? gracilis. Walcott, Paleontology of the Eureka district [Nevada]: U. S. Geol. Survey Mon. 8, p. 175, 1884. Eo-Devonian limestone of the Eureka district, Nev., with *S.? combensis*.

Sanguinolites? combensis. Walcott, idem.

Paleosolen siliquoidea. Hall, Paleontology of New York, vol. 5, pt. 1, Lamellibranchiata II, p. 483, 1885. Hamilton (Meso-Devonian) of eastern New York.

Paleosolen occidentalis. Miller and Gurley, New species of Paleozoic invertebrates from Illinois and other States: Illinois State Mus. Nat. Hist. Bull. 11, p. 16, pl. 2, figs. 13, 14, 1896. Chouteau limestone (Mississippian) near Sedalia, Mo. In the long escutcheon and deep lunette, as well as in the deeply impressed muscular scars, this shell seems to differ from the other Paleosolens.

The genus Paleosolen has frequently been confused with Solenopsis McCoy [1] (=Solenomorpha [2]), but McCoy's genus includes Paleozoic solenoid shells in which the dorsal and ventral margins, instead of being parallel, as in the Solens, converge or taper posteriorly, the anterior end is nearly or quite closed, and the posterior end gapes only slightly.

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[1] McCoy, Frederick, Synopsis of the characters of the Carboniferous limestone fossils of Ireland, p. 47, 1844.

[2] It was first pointed out by T. D. A. Cockerell in 1903 (Nature, vol. 67, p. 559, Apr. 16, 1903) that the generic name Solenopsis McCoy, 1844, was preoccupied, having been applied by Westwood in 1841 (Annals and Mag. Nat. Hist., vol. 6, p. 86) to a well-known genus of ants. Cockerell suggested the substitution of Solenomorpha for Solenopsis McCoy. The generic name Solenella had been applied to one of the species of Solenopsis by De Ryckholt in 1847 (Melanges paléontologiques, pt. 1, pl. 11, fig. 17) and would take precedence over Solenomorpha in supplanting Solenopsis were it not that Solenella was itself preoccupied for a different genus of lamellibranchs. Solenomorpha will therefore stand as the substituted name for McCoy's Solenopsis. Solenomorpha has been used by Wheelton Hind (Geol. Soc. London Quart. Jour., vol. 59, p. 334, 1903; Monograph of the British Carboniferous Lamellibranchiata, vol. 2, pt. 3, p. 159, 1904).

PALEOSOLEN CHAPMANI sp. nov.

Plate XXIV, figures 1, 3, 5, and 7.

cf. 1896. *Solenopsis belgica.* Kayser, Soc. géol. Belgique Mém., vol. 22, p. 202, pl. 2, figs. 8–9.
Eo-Devonian (zone of *Spirifer daleidensis* and *S. subcuspidatus*): Pepinster, Belgium.
1907. *Palæosolen simplex* (not Maurer). Clarke, New York State Mus. Bull. 107, p. 235 (pars).
[Lower Devonic]: Presque Isle Stream, Chapman Township, Aroostook County, Maine (not Moosehead Lake).

Shells narrow, solenoid, with dorsal and ventral margins subparallel. Length in complete mature specimens (55 to 56 millimeters) about 6½ times the height (8.5 to 10.25 millimeters); in younger, apparently complete specimens the length (16.5 millimeters) is less than 3½ times the height (5 millimeters). The umbones are between the anterior eighth and ninth, very broad and inconspicuous, hardly extending to the cardinal line. The cardinal line is uninterrupted in front of and behind the beaks; it is horizontal, generally slightly convex, occasionally straight; the portion posterior to the beaks is equal in length to five or more times the height of the shell. The cardinal extremity is obtusely angular. The posterior margin is truncate, appreciably retrorse; it is generally slightly convex, occasionally nearly straight; the hindmost extremity is at the inferior third or fourth. In the lower portion the posterior margin is convex and vertical, forming a rounded right angle into the ventral margin. The ventral margin is horizontal and straight near the posterior end, also near the anterior end, but it is commonly broadly insinuated, producing an obscure concavity in the ventral outline. Young shells frequently lack the ventral concavity in the outline. Toward the front end the ventral margin ascends into the anterior extremity, which is well developed and equal in length to the height of the shell.

The anterior end is conspicuously gaping and the extreme anterior edge is reflexed. In front of the beaks the dorsal margin extends forward, descending only slightly for a distance equal to four-fifths the height of the shell and including the major part of the length of the anterior end. Through this distance the dorsal margin is tightly shut, but, beginning at the forward end of this line, the anterior margin is abruptly deflected out of its plane, producing a wide gape which is increased toward the midheight of the anterior margin and below by the reflexed anterior surface of the shell. The amount of gape is greatest at the midheight and continues below and into the ventral margin, where the gape is continued to a point well behind the beaks. The ventral margins close gradually and over the concave portion seem to be shut. Posteriorly the specimens examined were not well preserved, but seem to indicate that the ventral margins again gradually separate and that the ventral gape gradually widens toward the rear; the posterior margin appears to be truncate and widely gaping, somewhat like the anterior margin, though no reflexion is apparent in the posterior margin. The dorsal margin is closed throughout. The thickness of both valves in conjunction is less than the height of the shell, the proportion varying from 59:100 to 2:3. In some specimens the greatest thickness or depth is at the midheight, just behind the beaks; in others it appears to be on the rounded umbonal ridge much farther back and higher up, just in front of the midlength and in the upper third or fourth. Between these two points of greatest convexity the surface is depressed, almost flattened, and frequently slightly concave. The umbonal ridge is broadly convex and indistinct. Between it and the cardinal line, nearer the latter, there is a radial furrow or sinus, which does not quite reach the umbones. This sinus is variable in appearance and development, but is rarely entirely absent. Commonly it is distinct but shallow. Between the shallow posterior sinus and the ligamental platform there is a very low rounded ridge. An abruptly flattened external (?) ligamental strip extends along the cardinal line to the hinge extremities.

Just behind the umbones there is a depression in the cardinal line which extends for a very short distance, not more than the height of the shell and apparently less. This depression seems to be bounded below by a ridge or rounded septum. The structure probably corresponds to that of the ligamental escutcheon and internal ridge in the typical species of Recent Solen and Ensis. Beyond this excavated escutcheon the cardinal line is elevated, and both valves meet dorsally in a sharp edge. Below this cardinal edge there is a well-developed flattened strip which extends to the hinge extremities and which corresponds to a similar external strip in the Recent Solen and Ensis.

Dentition unknown. Not the slightest indication of muscular scars or pallial line is discovered in well-preserved fossils, and probably neither was impressed upon the shell.

The surface ornamentation consists of very fine lines of growth parallel to the margin. Along the ventral margin these lines are fine, but in curving upward parallel to the dorsal margin some of them gradually become lamellose; in some shells the surface becomes concentrically wrinkled posteriorly, but this wrinkling is never so persistent nor so well developed as in *Orthonota undulata* Hall. The postumbonal slope is variable in appearance, being marked generally by the fine distant lamellæ, less commonly by the very fine lines of growth, an occasional one of which may be slightly strengthened into a sort of varex; very rarely the lines of growth may be accumulated into the low, rounded obsolescent wrinkles. The fine lamellæ are somewhat similar to those of *Solen* (*Paleosolen*) *costatus* Sandberger [1] but are never so even, so close, or nearly so well developed. The ornamentation is not interrupted nor constricted by the posterior sinus below the hinge line. On the extreme anterior end the fine lines of growth are again generally strengthened, and this part of the shell, the extreme anterior margin, is either finely imbricose-lamellate, finely undulate, or, rarely, simply marked by fine concentric lines.

The largest specimen is a fragment 10.25 millimeters high and 47 millimeters long. It is incomplete posteriorly, but originally it was probably more than 60 millimeters long. Specimens 8 or 9 millimeters high are common. The only complete specimen is 8.5 millimeters high and 56 millimeters long.

Locality: Chapman sandstone, along Presque Isle Stream at end of Tweedy road (locality 1099 A), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59830.

Comparisons.—In general outline and ornamentation *Paleosolen chapmani* resembles the German Eo-Devonian shell *P. costatus* (Sandberger), but the German shell differs from *P. chapmani* in having a shorter anterior end, a less retrorse and less convex posterior margin, and a more regular, even imbricate posterior ornamentation, which changes abruptly from the surface ornamentation of the body of the shell. *P. costatus* also lacks the posterior radial sinus below the hinge and is a larger shell than *P. chapmani.*

Some few specimens of the Maine shell which are undulose or semi-imbricostate undulose posteriorly slightly resemble *Orthonota undulata*, but that species is much more evenly undulose; it also lacks the ventral sinus, and the change in its ornamentation posteriorly is much more abrupt. Finally, *Orthonota undulata* does not gape, like Paleosolen.

Some young specimens of *P. chapmani* resemble the English Silurian shell *Orthonota rigida* (Sowerby),[2] but *O. rigida* is much shorter, has a convex ventral margin and a double posterior sinus, and is more strongly marked anteriorly and in the middle and less strongly marked posteriorly; the character of the gape, if any gape is present, is unknown.

The species most closely approaching *P. chapmani* is the Paleosolen from Pepinster, Belgium, described by Kayser [3] as *Solenopsis belgica.* It is indeed difficult to define any really satisfactory characters by which to separate the two, owing to the incompleteness of the fragments described and figured by Kayser. The ornamentation is almost precisely similar and similarly variable; Kayser's figure 9 (the right valve) shows the radial posterior sinus as in *P. chapmani*, and in both species this seems to be sometimes a little stronger in the right valve than in the left. One important distinction lies in the fact that the posterior margin is much more retrorse in *Paleosolen belgica* (Kayser) than in *P. chapmani;* moreover, in the latter the posterior margin is convex, whereas in the Belgian fossil it seems to be slightly concave. In the Maine shell the ventral margin is generally obscurely concave; in *P. belgica* it appears to be straight.

[1] See Beushausen, Louis, op. cit.

[2] Salter, J. W., Paleontological appendix to John Phillips's memoir on the Malvern Hills: Geol. Survey Great Britain Mem., vol. 2, pt. L, p. 362, pl. 19, figs. 1, 2, 1848. The name *Orthonota rigida* Hall, 1885 (Paleontology of New York, vol. 5, pt. 1, p. 481, pl. 80, fig. 6, 1885), is therefore preoccupied, but the English Silurian and American Devonian shells may not be congeneric.

[3] Kayser, Emanuel, Sur une faune du sommet de la série rhénane à Pepinster, Goë et Tilff: Soc. géol. Belgique Annales, vol. 22, p. 202, pl. 2, figs. 8, 9, 1896. This shell occurs in an Eo-Devonian fauna associated with *Spirifer subcuspidatus* var. *alatus* Kayser, *S. daleidensis* Steininger, and *Productella subaculeata* Murchison and is apparently high Eo-Devonian.

As has been indicated, *P. chapmani* has certain features in common with Recent shells. In *Solen siliqua* Linnæus (Europe), *Ensis americana* Beck, *Ensis ensis* Linnæus (Europe), and *Ensis gracilis* Gray (Cape St. Lucas), in which the escutcheon and especially the external posterior flattened strip below the cardinal line are well developed, the escutcheon is a little longer than in *Paleosolen chapmani*. In the Recent shells the escutcheon is perceptibly greater in length than the height of the shell; in the Chapman fossil it is hardly equal to the height. The external flattened strip extends all along the cardinal line to the hinge extremity in the Chapman fossil; in the Recent Solens and Enses named the strip expands in width toward the midlength, contracts posteriorly, and does not quite reach the hinge extremity. In the short escutcheon and long, well-developed posterior infracardinal strip, and also in the ventral constriction or insinuation and consipcuous anterior end, *P. chapmani* conforms with the Recent Machæra, but of course the outline is different, being typically solenoid in the Maine fossil. Among the Recent Solens an anterior end is developed in only a few species, as *S. ambiguus* Lamarck (Guadeloupe, West Indies) and *Solen gladiolus* Gray (Panama); in these two species the ventral margin is insinuated and the anterior margin reflected as in *Paleosolen chapmani*, producing a very close resemblance generically to the Maine shell, which is, however, distinguished by its different manner of gape. In *Paleosolen chapmani* the dorsal margins of the two valves meet in front of the umbo in a closed dorsal edge which includes most of the upper half of the anterior end. In the two Recent species just named the gape begins immediately at the beak. In all the Recent Solens the gape continues and includes most of the ventral edge of the valves, and the two valves do not meet ventrally except near the posterior end. In *P. chapmani* the two valves seem to meet ventrally only a short distance behind the umbones and to diverge again posteriorly. Most of the ventral margin, including all the middle portion, is apparently closed. In *S. ambiguus* and *S. gladiolus* the flattened strip below the posterior dorsal edge is not perceptibly developed.

Genus CIMITARIA Hall.

The following is Hall's description [1] of the genus Cimitaria, which was originally promulgated in 1869: [2]

Shell equivalve, extremely inequilateral, transversely elongate; form solenoid, falcate, or elongate-trapezoid. Anterior end short and rounded. Posterior end elongate, the extremity truncate. Beaks strongly incurved; umbones prominent. Cardinal line straight or concave. Umbonal slope angular and often strongly defined. Surface marked by strong concentric lines of growth, which are simple or lamellose, and by fine radiating striæ, which may be more or less strongly marked or altogether obsolete; a more or less distinct depression or cincture extends from the umbones in a slightly posterior direction to the basal margin. The hinge is marked by a narrow, elongate ligamental groove, and anterior to the beaks is a strongly defined lunule. Ligament external. Teeth unknown. Muscular impressions and pallial line undetermined. The species placed under this genus are remarkable for their transversely elongate forms, the greater portion of which is posterior to the beaks. Some of the forms bear a resemblance to Orthonota, but the hinge line shows a distinct ligamental groove and the anterior margin is rounded, with a well-defined lunule. The species are closely allied to Pholadella, and when more forms become known it may prove convenient to unite the genera. In some important points the genus approaches Grammysia by the way of Allorisma. The marked external ligamental area and strong lunule are common to the three genera, while the surface markings have many points in common. In the absence of critical knowledge of the hinge structure, we are unprepared to make any more positive assertion regarding this genus and its allied forms.

Examples: *Cimitaria recurva* (Conrad), pl. 77, figs. 9–14, p. 467; Hamilton group. *Cimitaria elongata* (Conrad), pl. 77, figs. 5–8, p. 466; Hamilton group. *Cimitaria corrugata* (Conrad), pl. 77, figs. 1–4, p. 465; Hamilton group.

A character of prime importance which was overlooked by Hall is the fact that the posterior extremity is strongly gaping, as may be observed in his figure 11 of *Cimitaria recurva*.

The typical forms of Cimitaria constitute a well-known group of shells of the Middle and Upper Devonian of New York recognizable by their rather large size and characteristic transversely extended scimitar-like outline, length about three or more times the width; well-developed umbonal ridge and concave posterior slope; umbones inflated, arching over the cardinal line, directed upward or nearly so, incurved, and nearly terminal. The broad ventral sinus,

[1] Hall, James, Paleontology of New York, vol. 5, pt. 1, fasc. 2, p. xlii, 1885.

[2] Hall, James, Preliminary notice of the lamellibranchiate shells of the upper Helderberg, Hamilton, and Chemung groups, pt. 2, p. 66, December, 1869.

nearly vertical, but slightly oblique posteriorly, is a constant feature in these typical forms. Among the more diagnostic features are the strong anterior lunule and lunette and long external posterior ligamental groove or escutcheon; the nonpreservation of muscular scars (internal molds are usually glossy except in very coarse sediments); and the gaping posterior extremity.

An apparently typical recurved Cimitaria, which, however, is a little smaller than the New York Devonian shells, is the *Leptodomus borealis* of Tschernyschew and Jakowlew,[1] from the middle or late Silurian faunas of Cape Grebeni, on the island of Waigatsch, off the northeast coast of Russia. In its small size this Silurian species conforms with the supposed Eo-Devonian members of the genus Cimitaria.

The typical Cimitarias, in their large size, scimitar-like outline, convexity, concentric, and granulose ornamentation (though the granules are very rarely observable), lunette and long escutcheon, and posterior gaping, resemble the genus Chænomya Meek and Hayden,[2] 1864, of which the type is *C. leavenworthanus* Meek and Hayden. Half a dozen or more species are known in the upper Mississippian to Permian strata of the Mississippi Valley. Meek and Hayden also refer to Chænomya a couple of Jurassic fossils from Europe. This genus differs from Cimitaria in having the posterior extremity reflected so as to produce a wider and more flaring gaping, whereas in Cimitaria the gaping is not produced by any conspicuous reflexion of the posterior margin and is much less pronounced. The sinus present on the surface below the umbones in all the typical Cimitarias is absent in Chænomya, where the body of the shell is evenly convex; the umbonal ridge is somewhat more strongly pronounced in Cimitaria. Finally, Chænomya has a distinct pallial sinus (in the typical Pennsylvanian-Permian forms), and the hinge is edentulous. In Cimitaria the pallial line and hinge features are unknown.

From the typical Cimitarias may be dissociated the apparently grammysioid, nongaping genus Pholadella Hall, which is marked by prominent raised, persistent radial lines or riblets. The allied genus Cercomyopsis Sandberger (= ?Physetomya Ulrich) resembles Cimitaria but is distinguished by having a comparatively large body and a smaller, acutely tapering posterior portion, the beaks not quite terminal, the surface marked by concentric undulations or ridges on the body crossed by tenuous radial or vertical striations, and the posterior slope smooth. Both Pholadella and Physetomya have already been referred to in the discussion of the genus Grammysia, to which they seem to be more closely related than to Cimitaria, to judge from existing incomplete evidence. A subgroup that may be separated from typical Cimitaria might be designated the group of *Cimitaria? chapmani* sp. nov. It includes besides that species, which occurs in the Chapman sandstone of Maine, the following species:

Sanguinolites decipiens. McCoy, British Paleozoic rocks and fossils, p. 277, pl. 1, L, fig. 24, 1852. Upper Ludlow of Benson Knot, near Kendal, Westmoreland.

Cimitaria karsteni. Clarke, The Devonian Mollusca of the State of Para, Brazil: Mus. nac. Rio de Janeiro Arch., vol. 10, p. 60, pl. 8, figs. 18, 19, 1899 (author's English ed., 1900). Lower Coblenzian formation, Rio Maecuru, Para, Brazil.

Pholadella parallela. Hall, Paleontology of New York, vol. 5, pt. 1, p. 470, pl. 78, figs. 22–24, 1885. Hamilton formation throughout New York State.

The Arctic Silurian *C. borealis* (Tschernyschew and Jakowlew) may also be included in this subgroup, and possibly *Sphenotus ellsi* Clarke[3] (pars), from the late Silurian (?) of Dalhousie, New Brunswick, and *Cimitaria elongata* (Conrad),[4] from the Hamilton of New York. *C. elongata* lacks the recurvature of typical Cimitaria and has prosogyrate beaks; it is also smaller than any of the typical Cimitarias though larger than any of the other members of the group of *C. chapmani.*

The shells of this subgroup are easily distinguishable from the typical Cimitarias by their much smaller size. Their length does not exceed twice the width, and the umbones are prosogyrate (directed forward). The lunette and long escutcheon are developed in *Cimitaria?*

[1] Tschernyschew, T., and Jakowlew, N., Die Kalksteinfauna des Cap Grebeni auf der Waigatsch-Insel und des Flusses Nechwatowa auf Nowaja Semlja: Russ.-k. min. Gesell. St. Petersburg Verh., vol. 36, p. 66, pl. 6, figs. 17–19, 1899.

[2] Meek, F. B., and Hayden, F. V., Paleontology of the upper Missouri: Smithsonian Contr. No. 172, p. 42, 1864.

[3] Clarke, J. M., New York State Mus. Bull. 107, p. 226, lower figures only, 1907.

[4] Hall, James, Paleontology of New York, vol. 5, pt. 1, p. 466, pl. 77, figs. 5–8, 1885.

chapmani and *Sanguinolites decipiens* McCoy, and the former shows obscure indications of having been gaping posteriorly; these features have not been noted in the descriptions of the other species of this little group. As in Cimitaria, the muscular scars, pallial line, and dentition are unknown. There is a well-developed umbonal carina in all the species, and a wide, concave, almost smooth posterior slope. The body of the shell is inflated, with overarching umbones, and a sinus extends below the beaks in all the species except *Cimitaria karsteni* Clarke, which is without sinus. The surface is marked by concentric striæ of growth, sometimes aggregated anteriorly into undulations and apparently granulose; these are usually less pronounced posteriorly.

Although this little group ranges from the uppermost Silurian through the Lower Devonian to the Middle Devonian, typical large Cimitaria is probably confined to the Middle and Upper Devonian.

The group of *Cimitaria? chapmani* recalls in many of its features the genus Cuneamya Hall but is distinguished from Cuneamya by the gaping posterior and superficially by the more distinctly carinate umbonal ridge.

CIMITARIA ? CHAPMANI sp. nov.

Plate XXIV, figure 16.

cf. 1852. *Sanguinolites decipiens*. McCoy, British Paleozoic rocks and fossils, p. 277, pl. 1, L, fig. 24.
Upper Ludlow: Benson Knot, near Kendal, Westmoreland.

Length (22 millimeters) barely exceeding twice the height (10.5 millimeters); greatest height on the umbones at the anterior three-tenths; greatest length indefinitely below the middle and probably nearer the basal margin, the most posterior point being near the base, the most anterior point at the midheight. Umbones inflated, incurved, arching a little over the hinge line, slightly prosogyrate; beaks between the anterior fourth and fifth. The cardinal line is rigid, straight, horizontal, or slightly declining, in length (from beak to postcardinal extremity) about one and one-eighth times the height of the shell. The cardinal extremity is angular, obtuse (140°), situated at the posterior sixth. The posterior margin is truncate, retrorse, almost straight, slightly convex, especially at the base, where it curves into the rounded respiratory "angle." The most posterior point of the posterior margin is at or very near the base. The ventral margin is conspicuously insinuated; the posterior half is horizontal and parallel with the cardinal line anterior to the insinuation, which extends at an angle of 40° to 45° posteriorly downward from the beaks; the ventral margin is convex, a little lower than the posterior half and curving into the anterior end. The lowest point of the ventral margin is below the beak, at the anterior fourth, where the height is equal to about one and one-third times the height of the posterior half of the shell. The anterior end is rounded and very short; the forward extremity is at the midheight, above which the margin recedes upward in a shallow lunule to the beak. The depth of the single left valve known (4 millimeters) is three-eighths the height, or nearly a fifth the length. The point of maximum depth is on the umbonal carina, just back of the middle and at three-fifths the height above the base. One of the most conspicuous features is the high sigmoidal carina, the curvature of which is convex over the postumbonal portion and straight or concave below; the carina is sharp throughout, especially toward the umbones. Posteriorly the surface descends into a smooth concave slope to the top of the escutcheon. Anterior to the carina the body of the shell is inflated and marked by a conspicuous though shallow, undefined broad sinus extending from the carina forward to a point below the beaks. The anterior half of the body of the shell is strongly convex. The sinus extends posteriorly downward from the umbones to the basal margin at an angle of approximately 40° to 45°. Anterior to the beak there is a fairly well developed lunette occupying a shallow lunule. Posteriorly there is a strongly excavated escutcheon, or external ligamental groove, about 1 millimeter thick (in the left valve) at the umbo, tapering toward the posterior extremity and extending nearly, if not quite, the entire length of the cardinal line. Dentition unknown. Shell structure unknown. The "sculpture cast" is peculiarly glossy and dark in color. Obscure and doubtful indications of granulation cross the concentric markings. Muscular and pallial line unknown. The difficulty of observing such features as the gaping in a single internal mold or "sculpture cast" of an isolated left valve embedded in the rock, especially when parts of the margin have been clipped away, is apparent, and the features of the gaping described below should be considered as far from conclusively proved. The anterior end appears to have been perceptibly gaping, as may be observed by holding the cardinal line and antero-ventral margin on a plane with the eye. This appearance of gaping may, however, be due to the breaking away of a piece of the shell from the anterior end. The posterior and post-ventral margins also appear to be gaping, with the maximum gape at the respiratory angle.

Posterior to the carina the surface appears to be quite smooth, but exceedingly tenuous lines of growth may be observed parallel to the posterior margin. The body of the shell is crossed by coarse lines of growth aggregated into obsolescent, narrow, concentric, irregular undulations, which are most conspicuous on the convex portion below the beaks in front of the sinus and immediately in front of the carina.

Length, 22 millimeters; height, 10.5 millimeters; depth of left valve a trifle over 4 millimeters.

Locality: Chapman sandstone, Presque Isle Stream at end of Tweedy road (locality 1099A), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59831.

Comparisons.—This species may prove to be identical with McCoy's *Sanguinolites decipiens.* The Chapman fossil differs in only a few doubtful minor respects from McCoy's description of his species, which is as follows:

Elongate, oblong, dorsal, and ventral margins subparallel; beaks incurved, small, depressed, about one-fifth the length from the anterior end; hinge line long, not elevated (the inflected edges forming a nearly horizontal posterior lunette extending its entire length); cardinal angle about 115°; anterior end rounded, narrowed by a large elongate, elliptic lunette; a strong, sigmoidally contorted diagonal ridge extends from the beak to the respiratory angle; posterior slope steeply inclined; posterior end slightly oblique, subtruncate, rounded; ventral margin with a wide, rather deep sinus in the middle, from which a wide concavity extends nearly to the beak, and from the diagonal ridge to the anterior end, which is convex anterior to the beaks; surface marked with sharp concentric wrinkles from the anterior lunette to the diagonal ridge. Length, 8 lines; in proportion to the length greatest width (from beak to opposite margin) $\frac{48}{100}$, length of anterior end $\frac{20}{100}$, from beak to end of hinge line $\frac{65}{100}$, greatest depth of one valve (about middle of diagonal ridge) $\frac{25}{100}$.

I have seen numerous specimens of this species from the Upper Ludlow rocks, usually confounded with the so-called *Cypricardia cymbiformis* (Sowerby), which it strongly resembles at first sight, although the anterior end is considerably longer. That fossil, however, has simple erect dorsal margins and belongs to the genus Orthonotus as restricted in this work, while the distinctly inflected dorsal edges forming the elongate, concave, posterior lunette show the present species to belong to the genus Sanguinolites.[1]

The anterior end is a little larger in *C.? chapmani* than it appears to be in McCoy's figure, and the forward extremity is at the midheight, with a shallow concave lunule above to the beaks. In McCoy's figure the anterior extremity is near the base, and there is no concave lunule below the beaks; but the figure seems to be incomplete in the anterior end, and McCoy, in his description, mentions specifically the presence of a lunule. The ventral insinuation seems to be a little more pronounced in *C.? chapmani,* and the ventral margin anterior thereto is more deeply bellied down, but the posterior margin, though destroyed in the Chapman fossil, appears from the faint lines of growth to have been slightly less arched than in McCoy's species. Finally, in McCoy's species the depth of the single valve is one-fourth the length, whereas in the Maine fossil (which is a little crushed) it is only one-fifth the length. The differences indicated may prove to be accidental or individual characters, but for the present the Chapman shell may be listed as specifically distinct from the Upper Ludlow English species.

Of the other species of the group of *Cimitaria? chapmani, C. karsteni* may at once be distinguished by the absence of the ventral insinuation.

The *Sphenotus ellsi* of Clarke's lower figure resembles *C.? chapmani,* but the Maine species has a slightly more convex posterior margin and the ventral margin is more bellied down anteriorly, causing the greatest height of the shell to be under the umbone, whereas in

[1] McCoy, F., British Paleozoic rocks and fossils, p. 277, 1855.

Sphenotus ellsi the greatest height is posteriorly, as in McCoy's species. Clarke's shell may possibly belong to the group of *Cimitaria? chapmani*. *Sphenotus ellsi*, as represented by Clarke's upper figure, is a more transversely elongate shell having the postumbonal radial ridge and groove of Sphenotus.

Superfamily LUCINACEA.

Family LUCINIDÆ Fleming.

Genus PARACYCLAS Hall, 1869.

The genus Paracyclas Hall is easily recognized among Paleozoic lamellibranchs by the circular or subcircular outline; beaks minute, and central or nearly so; surface evenly rounded; ligament internal, more or less supported by septa, one on each side of the beak with commonly an abruptly flattened strip over the posterior ligamental region. The genotype is *P. occidentale* Hall and Whitfield (=*P. elliptica* Hall, 1843, not (Phillips), 1841).

Lucina (*Paracyclas*) *elliptica* var. *occidentalis* is commonly accepted as a synonym of *P. elliptica* Hall. Hall's name, however, is preoccupied by *Pullastra elliptica* Phillips, 1841, which is regarded by De Koninck (1898) as a Paracyclas. The name *Paracyclas occidentale* may therefore be applied to the American *P. elliptica*.

The typical species *Paracyclas elliptica* Hall (not (Phillips) De Koninck) and *P. lirata* Conrad are very common in the American Corniferous, *P. lirata* continuing into the Hamilton, and extending upward in eastern New York into the lower part of the Portage formation. A couple of species are known in America in the higher Chemung of Pennsylvania and the Ouray limestone of Colorado. In Europe the genus occurs in the Carboniferous, according to Beushausen and De Koninck,[1] and ranges nearly throughout the German Devonian, from the upper Neo-Devonian down to the Lower Coblenzian, near the base of the Devonian of the Rhine [2] and the Harz. One species (*Paracyclas lebescontei* Barrois [3]) has been found in the Lower Devonian of France, and the genus also occurs in the Devonian of England, Spain, and Australasia.[4] It is, in fact, of world-wide range in the Devonian rocks.

Paracyclas is also found in the Silurian. In England typical forms of the genus include several small species like *Mytilus quadratus* Salter,[5] from the Upper Ludlow of Llangadoc; *Mytilus perovalis* Salter,[6] from the Ludlowian of Usk; and *Anodontopsis bulla* McCoy,[7] from the Upper Ludlow of Kendal, Westmoreland, and Galway, Ireland (?).

Barrande [8] has described a gigantic form, *Paracyclas bohemica*, from étage E^2 of Bohemia (equivalent of the Aymestry of England). If this form belongs to the genus, which is somewhat doubtful, it is the largest as well as the earliest species of Paracyclas known.

Paracyclas may therefore be regarded as probably first appearing in Aymestry or approximately Guelph time, becoming widespread in the late middle Silurian or upper Silurian, attaining its maximum in the Devonian, and continuing into the Carboniferous.

Paracyclas is easily distinguished from the other Paleozoic lucinoids. Ilionia Billings has a large anterior end toward which the small beaks are directed, and the small posterior end is sinuated or broadly emarginate postventrally. The shell is compressed and is concentrically striated. Prolucina Dall, 1896, which appears to be a synonym of Ilionia, is a widespread genus in the Aymestry zone of Europe and in the Guelph dolomite of America and continues into the Manlius and "Corniferous" of America. It was founded on *Lucina prisca* (Hisinger), from the Aymestrian fauna of Gotland. This species is considered by Lindström, Dames,

[1] De Koninck, L. G., Descriptions of the Paleozoic fossils of New South Wales, Australia: Geol. Survey New South Wales Mem., Paleontology, No. 6, p. 85, 1898.

[2] Beushausen, Louis, Die Lamellibranchiaten des rheinischen Devon: K. preuss. geol. Landesanstalt Abh., new ser., vol. 17, pp. 65 et seq., 1895.

[3] Barrois, Charles, Faune du calcaire d'Erbray, Loire-Inférieure, p. 179, pl. 11, fig. 13, 1889.

[4] De Koninck, L. G., op. cit., p. 85.

[5] Phillips, John, and Salter, J. W., The Malvern Hills compared with the Paleozoic districts of Abberley: Geol. Survey Great Britain Mem. vol. 2, pt. 1, p. 363, pl. 20, fig. 1, 1848.

[6] Idem, p. 363, pl. 20, fig. 2.

[7] Sedgwick, Adam, and McCoy, Frederick, British Paleozoic rocks and fossils, p. 271, pl. 1, K, figs. 11-13, 1852.

[8] Barrande, Joachim, Système silurien du centre de la Bohême, pt. 1, vol. 6, pl. 67, box III, pl. 129, 1881.

and other European authors to be congeneric with Ilionia. If *L. prisca* does not belong to Ilionia, the name Platymermis, applied by Nötling in 1883 to the same species, has priority over Prolucina.

A shell which might be confused superficially with the circular Paracyclas is the genus Ontaria Clarke, including the world-wide *Cardiola concentrica* Von Buch of the Upper Devonian Intumescens zone. This well-known fossil differs from Paracyclas in being hingeless, as well as in its peculiar development of postdorsal radial striæ.

PARACYCLAS BULLOIDES sp. nov.

Plate XXV, figures 23, 23a, 24.

Shells small, circular to quadrate-circular, the length equal to or slightly greater than the height. Greatest height and length in the middle. Umbones inconspicuous, depressed, situated in the middle or slightly in advance of the middle. The upper margin of the anterior end extends forward, slightly descending from the beaks; it is flatly arched, nearly straight, and devoid of lunule, and it curves into the long, nearly vertical, rounded anterior margin, which curves similarly into the rounded ventral margin, and the latter into the posterior margin. The posterior margin is convexly rounded throughout and is not indented. The hinge extremity is rounded but approaches angularity more nearly than any other "corner" of the shell. The hinge line is nearly horizontal, descending slightly to the rear. It is gently convex, nearly straight. Shell moderately convex. The surface is subspherical, slightly more inflated umbonally than ventrally. There is discernible on internal molds, along the dorsal margin, a more or less well-developed flattened strip. Occasionally, also on internal molds, there is a flattened or subconcave rim around the lateral and ventral margins of the shell outside and below the muscular scars and pallial line. The depth of the single valve is about one-fourth the height. The point of greatest depth is below the umbones, at the upper two-fifths or three-sevenths the height.

Ligament internal. It is supported near the umbones by an internal septum, which continues backward, diverging slightly from the hinge line, and around to the upper hind part of the posterior muscular scar, where it dies out. This septum in Paracyclas may serve as a muscular support, as suggested by Beushausen, rather than as the lower part of the ligamental groove, or it may possibly be the base of a broad hinge plate. Structure of anterior end not observed. Dentition unknown. Muscular scars faintly impressed, apparently both of them elongate in outline and extending below the midheight of the shell. Pallial line simple, faintly impressed; parallel to the ventral and lateral margins, and continuous into the distal margins of the muscular scars. One of the best-preserved specimens shows delicate radial or vertical striations above the pallial line in the middle and posterior portions of the interior of the shell.

Internal molds are smooth, devoid of ornamentation. This is the usual mode of preservation. The surface ornamentation has been observed only on a small fragment, dorsally, where the shell is marked by concentric broad striæ or grooves depressed below the surface, giving the appearance of concentric lirations, somewhat as in *P. lirata* but less conspicuous.

The type specimen has a length of 10 millimeters and a height of 9.1 millimeters. Another specimen is 9 millimeters high and 9.66 millimeters broad; a third has a height of 10 millimeters and a length of 10 millimeters.

The species is easily recognized by its small size and circular to quadrate-circular outline.

Locality: Chapman sandstone, 2 miles west of Presque Isle Stream (locality 1099 J), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59832.

Comparisons.—*P. bulloides* resembles some English late Silurian species, among them *Mytilus perovalis* Salter,[1] from which it is distinguished by having the umbones more nearly central and the height more nearly or quite equal to the length. The Chapman shell is also more convex. The two fossils appear, however, to be closely related specifically.

[1] Salter, J. W., Great Britain Geol. Survey Mem., vol. 2, pt. 1, p, 363, 1848.

The Maine form bears a still closer resemblance to the Upper Ludlow *Mytilus quadratus* Salter[1] in the subquadrate outline and convexity, but *P. bulloides* is not quite so tall, and the posterior septum is a little farther below the dorsal edge.

The British *Anodontopsis bulla* McCoy,[2] from the Upper Ludlow-Downtonian of Kendal, Westmoreland, may possibly prove identical with the Chapman species, but its characters are imperfectly known. The Irish types of McCoy's species from Galway appear to be more gibbous than the Maine shells, with the pallial line more distant from the margin, and are described as having two rounded muscular scars; in the Chapman species the muscular scars are elongated.

Class GASTROPODA.

Family CAPULIDÆ Cuvier.

Genus PLATYCERAS Conrad.

In the collections from the Chapman sandstone are fourteen specimens which I refer to the genus Platyceras, including a few uncoiled conic shells referable to Hall's genus Orthonychia. The last named, however, are regarded as of only subgeneric rank, under Platyceras.

Aside from the imperfect state of preservation and posthumous distortion of the Chapman specimens, the great irregularity in mode of growth characteristic of most platycerids makes specific determination very unsatisfactory. As is well known, the most frequent cause of irregularity in the platycerids results from attachment to or fixation upon other objects, and the consequent accommodation or yielding of the peristome of the gastropod to the inequalities of the surface of attachment.

In all the Chapman specimens here under consideration the shell aperture is irregular in form, although the attachment must have been to some other object than a crinoid, for crinoids are rare or unknown in the Chapman fauna.

To the more characteristic forms of Platyceras are given separate specific names, in accordance with the practice of paleontologists, because of the practical value of this mode of designating fossil forms, although it is strongly probable that the differences noted are in large degree the results of individual or racial deformation in growth rather than specific characters associated with heredity.

PLATYCERAS CHAPMANI sp. nov.

Plate XIII, figures 12, 16.

cf. 1907. *Platyceras kahlebergensis* (not Beushausen's sp.). Clarke, New York State Mus. Bull. 107, p. 185, figs.
Lower Devonic [Chapman sandstone]: Edmunds Hill, Chapman Township, Aroostook County, Maine.

Nine specimens from the Chapman sandstone of Edmunds Hill present several points in common and may be regarded as representing a single species. This form has been already noted by Clarke under the name *Platyceras kahlebergensis* Beushausen.

The following characters appear to be distinctive of the Chapman form: Shell with a sharp, slender, apical portion close coiled for the first volution, then rapidly expanding to form a loose-coiled spiral with two volutions. The first volution is nearly regular, and is elevated above the lower whorls; after the completion of one full volution a deep sulcus develops on the outer or lower half of the whorl, the upper part remaining gently convex, producing a sinuate peristome. The surface is marked by fine transverse striæ and by faint transverse undulations visible near the opening.

The greatest diameter of the largest specimen is 25 millimeters; at right angles to this diameter the distance across the coils is 16.5 millimeters; the diameter of the peristome is about 15 millimeters.

Locality: Chapman sandstone, Edmunds Hill (localities 1099 C′ and 1099 M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59833, 59834.

[1] Salter, J. W., Great Britain Geol. Survey Mem., vol. 2, pt. 1, p, 363, 1848. [2] McCoy, F., British Paleozoic rocks and fossils, p. 271, 1855.

Comparisons.—Clarke regarded this fossil as identical with the Hercynian *Capulus kahlebergensis* Beushausen,[1] but the German fossil is distinguished by having the apical whorl or spire much larger and broader proportionately than in the Chapman fossils. The two species are, however, closely related. *Capulus crassus* Trenkner, also from the Kahleberg, as figured by Beushausen,[2] resembles in some features *Platyceras chapmani*. The body whorl, however, does not become detached or sulcate. *C. crassus* may be regarded as the regular form of growth of a race the irregular form of which is *C. kahlebergensis*.

The Maine species *P. edmundi* and *P. chapmani* exhibit a similar relationship to each other, and both have the apical whorl more slenderly developed than in the German types.

Platyceras edmundi sp. nov.

Plate XIII, figure 19.

A second species of Platyceras has about the same dimensions and begins growth at the apex in the same way, but the sulcus begins to develop near the end of the first volution on the upper side of the body of the shell. The sulcus, however, is not deep and toward the front it broadens out into two low grooves. The prominent extension of the body of the second volution is along the lower outer side. The resultant form produced is a plane coiled shell in which, viewed in such a position that the axis of the spiral stands vertical, the apex is on the same horizontal plane with or below the upper rim of the aperture. In *P. chapmani* the apex is elevated 7 millimeters above the upper rim of the aperture.

The greatest diameter of this shell is 20 millimeters; the peristome is 15 millimeters broad.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59836.

Platyceras (Orthonychia) hebes Clarke.

Plate XIII, figure 20.

1907. *Platyceras hebes.* Clarke, New York State Mus. Bull. 107, p. 185, figs.
Lower Devonic: Edmunds Hill, Chapman Plantation, Aroostook County, Maine.

A third form of Platyceras has been called *Platyceras hebes* by Clarke, whose description of this shell is as follows:

> Shell conical, slightly oblique, apex blunt or minute, surface expanding rapidly with a vertical slope on the posterior and a more broadly curved slope on the anterior side; lower part of the cone obscurely plicated, aperture nearly round.

The figures usually seem to indicate a simple cone, but in realty one side (the anterior ?) is longer than the other. The posterior (?) side (right side of fig. 20) of the body of the shell is nearly straight and vertical from beak to aperture, but the anterior side is longer and its outer surface is broadly curved in an arc measuring about a quarter of a circle from beak to peristome, producing a twisted or humpbacked form. On the anterior side of the body the longitudinal plications are twisted The margin of the peristome is sinuous, conforming to the irregular sulcations of the surface.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59837.

Comparisons are given below, under var. β.

Platyceras (Orthonychia) hebes var. α.

Plate XIII, figure 26.

Another specimen referred to this species has a blunt conical form with the broadly rounded apex and the flaring body of the type, but shows no plications on the anterior side. The posterior

[1] Beushausen, Louis, Beiträge zur Kenntniss des oberharzer Spiriferensandsteins und seiner Fauna: Abh. geol. Specialkarte Preussen, vol. 6, pt. 1, p. 53, pl. 1, fig. 14, 1884.
[2] Idem, pl. 1, fig. 13.

side from tip of beak to margin of lip is 14.5 millimeters long, the peristome is circular and 16 millimeters in diameter. The surface of the shell is smooth, without either concentric or longitudinal folds or striations.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59838.

Comparisons are given below under var. *β*.

Platyceras (Orthonychia) hebes var. *β*.

Plate XIII, figure 14.

Another short Orthonychia, figured from the lateral aspect, appears like a young stage of the typical form of *Orthonychia hebes;* the apex has the humpbacked appearance on the posterior side, but the tip is sharper and is arched backward. Below the apex the posterior margin is not vertical but is inclined backward at an angle of about 45°.

Locality: Chapman sandstone, west side of Edmunds Hill (locality 1099 M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59839.

Allies of Orthonychia hebes and varieties.—Clarke noticed the resemblance of his *Platyceras hebes* to Acroculia sp. Oehlert,[1] from the French Lower Devonian of Angers. In its blunt conical shape and obscurely plicated lower half the typical form also resembles two species from the Eo-Devonian of Pasterkriffer, near Vellach, in the eastern Alps, mentioned by Frech[2]—*Platyceras protei* (Oehlert) and Platyceras sp. *Acroculia protei* Oehlert, which the typical form of *Platyceras* (*Orthonychia*) *hebes* resembles very closely in the body of the shell, is a much larger species and has a coiled apex; the body of the shell expands a little less rapidly than in *P.* (*O.*) *hebes*. Oehlert's species, which is widely reported in the European Eo-Devonian, was originally described in 1883.[3] The species is from Mayenne.

The variety *α*, with low, smooth, regular cone, devoid of plications, but with bluntly rounded erect apex, is similar to Acroculia sp. Oehlert, already mentioned, but Oehlert's species is much larger. The variety *β* is a symmetrical pileopsoid shell with apex arched to the rear and with the posterior part of the shell broadly expanded and larger than the anterior part. It is similar to some of the forms of the Konieprussian *Acroculia subcarinata* Barrande,[4] of the Bohemian Eo-Devonian, but in the Chapman shell the apex is farther forward.

Platyceras (Orthonychia) aroostooki sp. nov.

Plate XIII, figures 22, 23.

cf. 1859. *Platyceras elongatum*. Hall, Paleontology of New York, vol. 3, p. 335, pl. 64, figs. 6, 10; pl. 65, fig. 5.
Lower Helderberg shaly limestone: Schoharie County, N. Y.

Shell conical, elongate, nearly straight, with blunt apex, the inner (anterior ?) side short (13 millimeters) and the outer side greatly produced (37 millimeters), forming an oval elongate aperture 28 by 18 millimeters in diameter. The body of the shell is crossed by a few obsolescent transverse undulations and is longitudinally subcarinate along the posterior (?) surface. The apex is blunt, with a minute, obscurely arched tip. The specimen may have been crushed slightly in a way to affect the carination of the body.

Locality: Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59841.

Comparisons.—This species is in general aspect similar to Hall's species *Platyceras elongatum* and may possibly prove identical with it, but the Chapman shell is much smaller. Hall's spe-

[1] Oehlert, D. P., Sur le dévonien des environs d'Angers: Soc. géol. France Bull., vol. 17, pl. 19, fig. 4, 1889.
[2] Frech, Fritz, and Loeschmann, E., Ueber das Devon der Ostalpen; III, Die Fauna des unterdevonischen Riffkalkes, pt. 1: Deutsche geol. Gesell. Zeitschr., vol. 46, pp. 471, 472, pl. 37; figs. 2, 7, 1894.
[3] Soc. géol. France Bull., 3d ser., vol. 11, p. 68, pl. 16, fig. 1, 1883.
[4] Barrande, Joachim, Système silurien du centre de la Bohême, vol. 4, Gastéropodes, pl. 32, figs. 30, 31, 1903.

cies has been reported from Devonian (?Eo-Devonian) rocks in the east slope of the Urals,[1] but the Russian shell is a different species, being arched and having stronger radial ribs.

PLATYCERAS (ORTHONYCHIA) COMPRESSA sp. nov.

Plate XIII, figure 24.

An Orthonychia occurring with the species just described forms a narrow, bilaterally compressed cone, with nearly straight sides and narrow ovoid aperture. Its length from tip of beak to inner margin of lip is 11.5 millimeters and to the outer margin of the lip is over 17 millimeters, but the apertural rim is imperfect. The aperture is over 14 millimeters long (incomplete) and 8.5 millimeters wide.

Locality: Chapman sandstone, Edmunds Hill (localities 1099 M and 1099 C[2]), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59840.

Comparisons.—In the high, narrow, conoid form this species resembles the European Middle Devonian *Platyceras conoideum* (Goldfuss) reported by Frech[2] from the eastern Alps, but differs in having a nearly straight instead of arched profile.

Genus PLATYOSTOMA Conrad, 1842.

The generic name Diaphorostoma was proposed by Fischer[3] in 1885 to supplant Platyostoma Conrad on the ground that Conrad's generic name had been preoccupied by Klein (1753) for a terrestrial gastropod, by Meigen (1803) for a genus among the Diptera, and by Agassiz (1829) for a genus of fish. The name Diaphorostoma has crept into frequent usage; but as the generic name used by Klein, Meigen, and Agassiz was Platystoma, and as Conrad's genus of fossil snails is Platyostoma, the name Platyostoma is not strictly preoccupied. Platyostoma has indeed been used by Megerle for a molluscan genus now regarded as a synonym of Buccinum; but as Megerle's genus was proposed without definition in a manuscript catalogue of shells its publication was deficient.

The shells of Platyostoma have suffered little deformation, though they were fixed on a host organism, like the typical Platycerida. From the latter Platyostoma differs in possessing a coiled spire; the coils are usually contiguous, and the lip more or less expanded, always so on the inner side. Platyostoma differs from Strophostylus in lacking the twisted columella.

PLATYOSTOMA VENTRICOSUM Conrad.

Plate XIII, figures ?15, 18.

1842. *Platyostoma ventricosa.* Conrad, Acad. Nat. Sci. Philadelphia Jour., vol. 8, p. 275, pl. 17, fig. 5.
Oriskany sandstone: Schoharie, N. Y.

1842. *Platyostoma arenosa.* Conrad, idem, p. 276, pl. 17, fig. 6.
Helderberg: Catskill, N. Y.

1859. *Platyostoma ventricosa.* Hall, Paleontology of New York, vol. 3, p. 300, pl. 55, figs. 9a–d; p. 469, pl. 112, figs. 1–10; pl. 113, figs. 7–8; pl. 115, fig. 8.
Helderberg shaly limestone: Catskill and Becraft Mountain, N. Y.
Oriskany sandstone: Albany, Schoharie, Greene, and Ulster counties and elsewhere in New York; rocks of similar age in Maryland and Virginia.

1859. *Platyostoma arenosa* Hall, idem, p. 302, pl. 57, figs. 3a, 3b.
Helderberg shaly limestone: Near Catskill, N. Y.

1861. Platystoma sp. Billings and Hitchcock, Maine Board Agr. Sixth Ann. Rept., pp. 244–245.
Oriskany sandstone: Parlin Pond, Moosehead Lake, Telos Lake, Webster Lake, Seboois River, etc., northern Maine.

1866. *Platyostoma ventricosa* (?). Billings, Portland Soc. Nat. Hist. Proc., vol. 1, p. 2, p. 106.
Oriskany sandstone: Telos Lake, Maine.

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[1] Tschernyschew, T., Die Fauna des unteren Devon am Ostabhange des Urals: Com. geol. [St. Petersburg] Mém., vol. 4, No. 3, p. 24, pl. 1, fig. 28, 1893.

[2] Frech, Fritz, Ueber das Devon der Ostalpen, II: Deutsche geol. Gesell. Zeitschr., vol. 43, p. 678, pl. 44, figs. 6–60, 1891.

[3] Fischer, Paul, Manuel de conchyliologie et de paléontologie conchyliologique, fasc. 8, p. 756, January, 1885.

1900. *Platyostoma ventricosa ?* and sp. Williams, U. S. Geol. Survey Bull. 165, pp. 30, 33.
Moose River sandstone: Localities cited by Billings, 1861 and 1866.
1905. *Platyostoma ventricosum.* Williams and Kindle, U. S. Geol. Survey Bull. 244, pp. 32, 39.
Giles sandstone: 1½ miles above Hicksville, Bland County, Va.
Top of Lewistown limestone: Jackson River, one-half mile below the iron furnace, Covington, Alleghany County, Va.
1908. *Diaphorostoma ventricosum.* Clarke, New York State Mus. Mem. 9, p. 149.
Oriskany: Union Springs, Oriskany Falls, Glenerie, Becraft Mountain, N. Y.
(?)Grande Greve limestone (Oriskanian): Grande Greve, Gaspe Bay, Quebec.

A large specimen from Detroit, Maine (Pl. XIII, fig. 18), presents some of the characters of this species as described and figured by Hall. The shell is globose, obliquely ovoid; spire consisting of three regular contiguous revolutions, the last of which is ventricose and comprises the bulk of the shell. Volutions broad-shouldered on the upper side and with excavated sutures. The aperture is circular or broadly subovate, 28.5 millimeters wide. The total width of the body whorl is 30 millimeters. The diameter of the shell at the penultimate whorl is about 13.5 millimeters. The surface ornamentation comprises striæ of growth which in the body whorl are aggregated into broad transverse undulations. The undulations are more pronounced than in New York shells and are developed only on the body whorl; this constitutes about the only difference between the Maine shell and the typical forms from the New York Oriskany. A small specimen, showing the first whorl (Pl. XIII, fig. 15), is referred with doubt to the same species.

Locality: Moose River sandstone between Parlin Pond and Detroit (locality 1100A), Somerset County, Maine, associated with *Spirifer arenosus* (Conrad), *S. antarcticus* Morris and Sharpe (*S. gaspensis* Billings or *S. hercyniæ* Giebel), *S. murchisoni* Castelnau, *Leptocœlia flabellites* (Conrad), *Antispirifer harroldi* sp. nov., and other species of the Moose River sandstone fauna. Platyostoma seems not to occur in the Chapman sandstone fauna.

U. S. National Museum, catalogue No. 59842.

Genus STROPHOSTYLUS Hall, 1859.

STROPHOSTYLUS cf. S. GLOBOSUS Hall.

Plate XIII, figure 13.

cf. 1859. *Strophostylus globosus* Hall. Paleontology of New York, vol. 3, p. 305, pl. 55, fig. 8.
Helderberg shaly limestone: Catskill and Becraft Mountains, N. Y.

A naticoid platycerid found in the Chapman sandstone of Edmunds Hill shows the shallow canaliculate sutures and overhanging upper lip of the aperture prevalent in the species of Strophostylus. It also has obscure indications of the twisted columella characteristic of Strophostylus, so that the shell is with hardly any question referable to Hall's genus.

The specimen is globular, with height and breadth of the spire about equal. There are three or four regular, contiguous whorls, of which the body whorl comprises the bulk of the shell, including seven-eighths the height of the spire. The surface is smooth; even the striæ of growth are discernible only with difficulty, but this faintness of striation may be due to maceration.

In size and proportions the shell resembles Hall's *Strophostylus globosus*, from the New York Helderberg, but the Chapman specimens show fainter striæ of growth, the sutures are less deeply impressed, and the upper spire is somewhat smaller. There are also minor differences.

Locality: Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

Family BELLEROPHONTIDÆ.

Representatives of three or four distinct types of the Bellerophons have been discovered in both the Chapman sandstone and the Moose River sandstone of Maine. No attempt is made here to settle the taxonomic value of the names applied to these types, which will be here adopted as of generic rank, and the species will be distributed in the genera Patellostium Waagen, Plectonotus Clarke, and Tropidodiscus Meek.

Genus PATELLOSTIUM Waagen, 1880.

The name Phragmostoma Hall has been variously applied by authors to different forms of Paleozoic bellerophontoids until its real status has been somewhat obscured by the multitude of interpretations given to it. Waagen, De Koninck, Koken, Ulrich and Scofield, Perner, Hall himself, and Clarke have used the name in conflicting senses. As an instance of such conflicting usage, in 1899 Clarke[1] referred to the supposedly erroneous views of Waagen, De Koninck, etc., on Phragmostoma as "quite excusable, but somewhat out of its proper signification, De Koninck even specifying *Bellerophon natator* Hall as its type," but in a later work[2] Clarke himself adopts *B. natator* as the type of the genus. In this second work he gives excellent descriptions and illustrations of the forms, which enable us to differentiate to better advantage the terms Phragmostoma Hall, Ptomatis Clarke, and Patellostium Waagen.

As shown by Clarke, the name Phragmostoma was introduced by Hall[3] in 1861, chiefly for *P. cunulæ* and *P. cymbula*, from the Ordovician of the Mississippi Valley, but these two species were found to be congeneric with Carinaropsis Hall, 1847. In 1862 Phragmostoma was used in a different sense by Hall[4] for the Neo-Devonian *P. natator*, from the Cashaqua shale or Intumescens zone of New York, and as this is the only one of the original species of Phragmostoma which is generically distinctive the name Phragmostoma should be, as is generally admitted, applied to this type. The structure of *Phragmostoma natator* Hall and the allied *P. incisum* Clarke, as elucidated by Clarke,[2] resembles that of Carinaropsis in the general form of the shell, differing chiefly in that the septal plate or diaphragm, which in the carinaropsoids extends from the inner lip into the body cavity, does not exist in Phragmostoma, where it is represented only by a blunt thickening or callousing of the inner lip, which may become wedge shaped. In Phragmostoma also a distinct slit band, best developed near the mouth, is a conspicuous feature. In the carinaropsoids the slit band is represented, when present, by a dorsal carination which decreases in intensity on approaching the aperture, and frequently in Carinaropsis the dorsal carination is lacking altogether.

The generic name Patellostium was conferred by Waagen[5] on the Devonian *Bellerophon macrostomus* Roemer, from the Coblenzian graywacke at Unkel, as type. This agrees with Phragmostoma in lacking the apertural diaphragm of Carinaropsis, but it resembles Carinaropsis in lacking the slit band of Phragmostoma. It was originally figured by Roemer[6] as having a nonemarginate, circular mouth, but as the lines of growth are broadly insinuated it appears quite probable, as intimated by Drevermann, that the mouth really has a broad sinus anteriorly. Posteriorly the mouth has an entire noncalloused peristome; the inner lip is reflected back like a trumpet mouth below and is not in contact with the inner whorl. The umbilicus is broad and open, exposing the inner whorls, as in Bucania and Trematonotus.

The genus Ptomatis Clarke was founded on the species *Bellerophon patulus* Hall, of the New York Middle Devonian, which agrees with Patellostium in having the expanded mouth broadly emarginate anteriorly and which, like Patellostium, differs from Phragmostoma in lacking a slit band on the body whorl. Ptomatis does not, however, possess an entire peristome; the inner lip is formed by the preceding whorl, which typically becomes calloused and pappilose. I doubt whether this distinction of the interrupted inner lip in Ptomatis is of more than subgeneric value, especially as Roemer's genotype of Patellostium Waagen is but imperfectly understood. In Ptomatis, however, the umbilicus is decidedly less open than in Patellostium. It is quite possible that the development of an entire peristome, as suggested by Ulrich and Scofield, may be a fugitive character in the group of shells described under the names Phragmostoma, Patellostium, and Ptomatis, giving place to variations displaying the inner whorl as bulging or projecting

[1] Clarke, J. M., The Devonian Mollusca of the State of Para: Mus. nac. Rio de Janeiro Arch., vol. 10, p. 42, 1899 (author's English ed., 1900).
[2] Clarke, J. M., Naples fauna in western New York: New York State Mus. Mem. 6, p. 322, 1903.
[3] Hall, James, New York State Cab. Nat. Hist. Fourteenth Ann. Rept., p. 93, 1861.
[4] Hall, James, idem, Fifteenth Ann. Rept., p. 60, 1862 (not pl. 6, figs. 12–14, which show *Carinaropsis cymbula*).
[5] The Salt Range fossils; I, The Productus limestone fossils: Paleontologia Indica, 13th ser., p. 131, 1880.
[6] Roemer, C. F., Das rheinische Uebergangsgebirge, p. 80, pl. 2, fig. 6, 1844.

through the inner lip of the peristome or causing the inner lip to become more or less calloused. There is a great deal of variability in the form of the inner lip in many closely allied species and in different stages of the same species.

BELLEROPHON (PATELLOSTIUM) REVOLVENS sp. nov.

Plate XIV, figures 14, 15, 20, 27.

A Bellerophon of moderate size, globular or elongate ovoid, with broadly expanded mouth. Whorls expanding rapidly, especially the last or body whorl; involute, but not very deeply so. Umbilicus exposed only in internal molds, where it is small. In all four specimens showing the umbilicus in the internal molds the inner whorls are completely lacking, so that it is impossible to state their number. This absence of the inner whorls in internal molds may be accidental, or it may represent calcification of the apical or inner whorls and hence their total removal, with the removal of the other calcareous shelly matter. Clean external molds show a smaller, very minute umbilicus, and the inner whorls are covered by the shell of the outer whorl and the expanded lip. In cross section the whorl is broadly reniform, concave in the middle of the under side and convexly rounded on the sides and back. The width of cross section of the whorl varies from one and three-fourths times the height in the earlier or smaller volutions to two or two and one-fourth times the height in the later or larger whorls. Aperture laterally and posteriorly broadly expanded like a trumpet mouth, but not expanded anteriorly. Outline of aperture broadly suboval; width one and one-half times the length of the mouth, and at the inner lip three times the width of the preceding whorl. Greatest width of the aperture at or very near the midlength. The anterior margin is broadly and shallowly insinuated. Posteriorly the mouth is also expanded and appears to have been spread over the preceding whorl, producing an apparently entire peristome. The inner whorl, however, causes this portion of the aperture to bulge more or less. Two good external molds show no trace whatever of a slit band, a peripheral keel, seam, or other band on the surface, the back being broadly rounded on the body whorl. One internal mold, however, shows a very faint flattening or very obscure narrow ridge on the dorsum. The surface is ornamented by very fine revolving raised lines separated by much broader interspaces. There are three interspaces in the width of 1 millimeter on the back. Toward the sides and umbilicus the revolving lines become a little more crowded. Commonly in the back a very much fainter raised line is developed on the interspace between each pair of lines. The revolving lines seem to die out on approaching the broadly expanded apertural portion. No concentric striæ of growth have been observed, except an obscure partial wrinkle of growth near the edge of the aperture. Internal molds are smooth. Shell apparently rather thin. The largest specimen has an apertural width of about 25 millimeters and a total length of shell of about 20 millimeters.

Locality: Common in the Moose River sandstone between Parlin Pond and Detroit (locality 1100 A), Somerset County, Maine; associated with the normal marine fauna of the Moose River sandstone.

U. S. National Museum, catalogue No. 59843.

Comparisons.—The species is similar to *Bucania freitasi* Clarke,[1] from the Lower Coblenzian fauna of Rio Maecuru, Brazil, but has a relatively smaller spire and the sides of the mouth are more nearly symmetrically elliptical. *Bellerophon rhenanus* Drevermann [2] has, like *B. freitasi* Clarke, a larger spire, and the ornamentation is coarser than in the Maine shell.

Genus PLECTONOTUS Clarke, 1899.

The trilobed Bellerophons, represented by the well-known *Bellerophon trilobatus* Sowerby, which have commonly passed in revised classifications under the generic name Bucaniella or

[1] Clarke, J. M., The Devonian Mollusca of the State of Para: Mus. nac. Rio de Janeiro Arch., vol. 10, p. 35, pl. 3, fig. 22, 1899 (author's English ed., 1900).

[2] Drevermann, F., Die Fauna der Untercoblenzischichten von Oberstadtfeld bei Daun in der Eifel: Palaeontographica, vol. 49, p. 76, pl. 9, figs. 6, 7, 1903.

Bucanella Meek, have recently been divided by Clarke [1] into two generic groups. The earlier group includes some minute Ordovician shells, with *Bucaniella nana* Meek,[2] from Crater Falls, Colo., as the genotype. Meek described the specimens of this genotype as not exhibiting any slit band; and in the minute Neo-Ordovician *Bucaniella bohemica* Perner,[3] from the Bohemian étages D^2 and D^5, the slit band is also recorded as being absent, but the specimens are poorly preserved. It has also been inferred [4] that the slit band is absent in the likewise minute and poorly preserved *Bucaniella trilobata* (Conrad), from the Medina group.

Ulrich,[5] however, states that through the kindness of E. W. Claypole and A. F. Foerste he has been enabled to see specimens of *B. trilobata* (Conrad), which retained some of the shell. This he found to be comparatively thick and marked externally with very fine revolving lines. The lines of growth are very faint, and they form a broad sinus on the central lobes of the beak about as in Protowarthia. There is no slit band. Neither the locality nor the geologic formation of specimens examined by Ulrich is indicated, nor is there any intimation whether the absence of the slit band in the specimens may be original or is due to poor preservation. To judge from the descriptions, the specimens were casts preserving some of the shell substance rather than clean external molds. The newly discovered presence of revolving lines is interesting, especially in connection with their occurrence in similar Ordovician species from the Baltic region.

The following is a translation of a statement made by Koken:[6]

> It is still promulgated that for Bucania a deep parallel-margined slit and a narrower band, and that for Bucaniella a broader, more angular sinus and lack of a real band, are characteristic. However, the middle of the dorsum in Bucaniella is elevated, often quite bandlike, but the striæ of growth continue across without deflection.

A true slit band is developed near the mouth, however, in the Ordovician *B. inflata* Koken,[7] and a bandlike elevation is recorded in *B. divergens* Linnarsson,[8] but in Koken's descriptions of the remaining fourteen Baltic Ordovician species of Bucaniella no slit band or trace of slit band is recorded, and in some of the species it is definitely known to be absent. It is therefore quite probable that in the minute Ordovician *Bucaniella nana* Meek a slit band is really absent, as is commonly supposed; but at the same time it must be emphasized that in *Plectonotus trilobatus* the slit band is faint at best, discernible only on clean, well-preserved external molds, frequently not discernible on external molds, and only rarely indicated on sculpture casts or internal molds. It is possible, too, that there may be some variability in the persistence or nonpersistence of development of the band. At any rate, the term Plectonotus Clarke may be used for those forms in which a slit band is developed. Clarke's criterion for distinguishing the genus [9] is given in his discussion of the genus Bucaniella Meek, 1870, as follows:

> Bucaniella must be restricted to the seamless, broad-backed *trilobatus* (Conrad) group. For the broad trilobed species having a seam I am compelled to introduce a new name, Plectonotus, as the presence or absence of this feature is certainly a matter of considerable taxonomic importance.

BELLEROPHON (PLECTONOTUS) TRILOBATUS Sowerby.

Plate XIV, figures 1, 1a, 1b, 12, 13, 17, 18, 19, 28.

It is not certain whether or not all the specimens cited as *Bellerophon trilobatus* Sowerby are to be regarded as synonymous with the species described by Sowerby. Doubt was expressed by Sowerby [10] in the original description of the species as to the identity of the typical form from Felindre with the older Silurian form. He said: "Loc. Felindre. Is the same species in the Caradoc [May Hill?] sandstone at Eastnor Park; northeast of Gaerfawr, Prescoed Common; and Michaelwood Chace, Tortworth?"

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1 Clarke, J. M., The Devonian Mollusca of the State of Para: Mus. nac. Rio de Janeiro Arch., vol. 10, pp. 36-39, pl. 3, 1899 (author's English ed., 1900).
2 Meek, F. B., A preliminary list of fossils collected by Dr. Hayden in Colorado, New Mexico, and California, with a brief description of a few of the new species: Am. Philos. Soc. Proc., vol. 11, p. 426, 1870.
3 Perner, Jaroslav, Système silurien du centre de la Bohême, pt. 1, vol. 4, Gastéropodes, tome 1, p. 66, pl. 86, figs. 40-42, 1903.
4 Clarke, J. M., op. cit., p. 36.
5 Ulrich, E. O., and Scofield, W. H., The Lower Silurian Gastropoda of Minnesota: Geology of Minnesota, vol. 3, Paleontology, pt. 2, p. 848, 1897.
6 Koken, Ernst, Leitfossilien, p. 392, 1896.
7 Koken, Ernst, Die Gastropoden des baltischen Untersilurs: Acad. imp. sci. St.-Pétersbourg Bull., 5th ser., vol. 7, No. 2, p. 127, September, 1897.
8 Idem, p. 128.
9 Clarke, J. M., op. cit., p. 37.
10 Sowerby, J. C., in Murchison, R. I., The Silurian system, pt. 2, p. 604, 1839.

Phillips indicated three varieties of the species—*a*, from Baggy Point; *b*, from Meadsfoot Sands; and *c*, from South Petherwin—pointing out slight differences in form; at the same time he associated with var. *a* the specimens from Felindre, Baggy Point, and Eastnor Park, the last being in Caradoc [May Hill?] sandstone. It is highly improbable that the May Hill and Devonian species are identical; nevertheless the characters described make it difficult to separate them. The species from Felindre is supposed to be the typical form, but the following references to the species should be made as indicating what have been regarded by authors as synonymous:

?1838. *Planorbis trilobatus*. Conrad, New York Geol. Survey Second Ann. Rept., p. 113; name only [possibly a Bucaniella].
Fourth group of "Saliferous sandrock" of Eaton: Medina, N. Y.

?1839. *Planorbis trilobatus*. Conrad, New York Geol. Survey Third Ann. Rept., p. 65.
No formation or locality given.

1839. *Bellerophon trilobatus*. Sowerby, in Murchison's Silurian system, pt. 2, p. 604, pl. 3, fig. 16 (type).
Old Red sandstone (lowest beds): Felindre.
?Not Caradoc sandstone: Eastnor Park, etc. (p. 643, pl. 21, fig. 21 (pars), =Bucaniella?).

1840. *Bellerophon trilobatus*. D'Orbigny, Histoire naturelle des Cephalopoda, p. 209, pl. 7, figs. 24–27; pl. 8, fig. 13.
No formation or locality cited.

1841. *Bellerophon trilobatus*. Phillips, Paleozoic fossils of Cornwall, p. 107, pl. 40, fig. 200.
Var. *a* is reported to occur in North Devon, at Baggy Point, in limestone and in other districts; at Felindre, in the lower part of the Old Red sandstone, and at Eastnor Park, in Caradoc sandstone, etc. Var. *b* has been found only at Meadsfoot Sands, near Torquay. Var. *c* at South Petherwin, in Cornwall.

?1843. *Bellerophon trilobatus*. Hall, New York Geol. Survey Rept. Fourth Dist., p. 48, figs. 6, 7 [?Bucaniella].
Gray sandstone: Medina and Lockport, N. Y.

1843. *Bellerophon bisulcatus*. Roemer, Versteinerungen des Harzgebirges, p. 32, pl. 12, fig. 30.
Hercynian: Kahleberg, in the Harz.

1850. *Bellerophon trilobatus*. D'Orbigny, Prodrome de paléontologie, vol. 1, p. 31.
No formation or locality cited.

?1852. *Bucania trilobatus*. Hall, Paleontology of New York, vol. 2, p. 13, pl. 4, figs. 5a, b; 3d [?Bucaniella].
Medina sandstone: Medina, N. Y.

?1852. *Bucania trilobata*. Hall, idem, p. 93, pl. 28, fig. 10.
Clinton: Near Blackstone's and Wadsworth's quarries, New Hartford, Oneida County, N. Y.

1855. *Bellerophon trilobatus*. Sedgwick and McCoy, British Paleozoic rocks and fossils, p. 311.
Tilestones: Storm Hill, Llandeilo, Caermarthenshire.

1856. *Bellerophon trilobatus* var. *tumidus*. Sandberger, Die Versteinerungen des rheinischen Schichtensystems, in Nassau, p. 177, pl. 22, fig. 1.
Spirifer sandstone: Niederlahnstein, Fachingen near Diez, Attenhausen near Holzappel, Nassau; Kahleberg in the Harz; Laubach and Winningen near Coblenz; Meadsfoot Sands and Baggy Point, Devonshire; South Petherwin, Cornwall.
Pterinea shales: Singhofen, Nassau.

1856. *Bellerophon (Euphemus) quadrilobatus*. Salter, Geol. Soc. London Mem., 2d ser., vol. 7, p. 214, figs. 1, 2.
Devonian (?): Warm Bokkeveld, South Africa.

?1858. *Bucania trilobatus*. Rogers, Geology of Pennsylvania, vol. 2, pt. 2, p. 822, fig. 624.
Levant uppermost sandstones: "Long Narrows," below Lewistown, Pa.

1868. *Bellerophon trilobatus*. Bigsby, Thesaurus siluricus, p. 145.
?Not Ordovician: Portugal (Bronn).
?Middle Silurian: Southwest Scotland, Malvern, Shropshire; Marlees Bay, Llanrwst, Wales; Galway, Tonlegee, Ireland.
Upper Silurian: Lammermiur, southwest Scotland; Storm Hill, Plas Madoc, Llamgadock, Felindre, etc., Wales, and Shelve, Shropshire.

1868. *Bucania trilobita*. Dawson, Acadian geology, pp. 498, 569, 605.
Upper Arisaig or newest Silurian: East River, Pictou, Nova Scotia.
Upper Silurian [Arisaig beds]: Arisaig, Nova Scotia.
Nictau coarse limestone (loose), below the Oriskany ferriferous beds: Nictau, Nova Scotia.

1873. *Bellerophon trilobatus*. Salter, Catalogue of Cambridge Museum, pp. 97, 192.

1879. *Bucania trilobatus*. Derby, Mus. nac. Rio de Janeiro Arch., vol. 2, p. 92.

1879. *Bucania trilobata*. Derby, Am. Philos. Soc. Proc., vol. 28, p. 168.

1884. *Bellerophon trilobatus*. Lindström, Silurian Gastropoda and Pteropoda of Gotland, pp. 18, 19, 80, pl. 4, figs. 13–15.
Wenlock shales: Wisby and Hablingbo, Gotland.
Neo-Silurian oolite and sandstone: Bursvick, Gotland.

1884. *Bellerophon tumidus.* Beushausen, Abh. geol. Specialkarte Preussen, vol. 6, pt. 1, p. 44.
Haupt-Spirifer sandstone: Kahleberg, Schalk, Bocksberg, etc., in the Harz Mountains.
1889. *Bellerophon tumidus.* Fr. Sandberger, Nassauischer Verein Naturkunde Jahrb., Jahrg. 42, pp. 13, 25.
cf. 1890. Bellerophon sp. Derby, Mus. nac. Rio de Janeiro Arch., vol. 9, p. 77.
Devonian: Chapada, 30 miles northeast of Cuyaba, Matto Grosso, Brazil.
1892. Bellerophon sp. indet. Ulrich, Neues Jahrb., Beilage Band 8, p. 41.
Eo-Devonian, Conularia beds: Between Oconi and Pulquina, Bolivia.
1895. *Bellerophon tumidus.* Kayser, Soc. geol. Belgique Annales, vol. 22, p. 182, pl. 4, figs. 7, 8 (not 5, 6).
Upper Coblenzian: Pepinster, Belgium.
1899. *Bellerophon trilobatus.* Peach and Horne, The Silurian rocks of Britain, vol. 1, Scotland, pp. 681, 714.
Not Ordovician: South Scotland (pp. 681, 696).
Wenlock-Ludlow beds: Kirkcudbright, Riccarton, etc., South Scotland.
?1899–1900. *Bucaniella trilobata* var. *viramundo.* Clarke, Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 2, figs. 20–22, 1899 (author's English ed., p. 18, 1900).[1]
Silurian: Rio Trombetas, Para, Brazil.
1899–1900. *Bucaniella reissi.* Clarke, idem, p. 37, pl. 3, figs. 7, 8, 9.
Eo-Devonian: Rio Maecuru, Para, Brazil.
1899–1900. *Plectonotus? salteri.* Clarke, idem, p. 39, pl. 3, figs. 12, 13.[2]
Eo-Devonian: Rio Maecuru, Para, Brazil.
1899–1900. *Plectonotus derbyi.* Clarke, idem, p. 38, pl. 3, figs. 14–18.[3]
Eo-Devonian: Rio Maecuru, Para, Brazil.
1902. *Bellerophon? (Bucanella?) tumidus.* Drevermann, Palaeontographica, vol. 49, p. 77.
Lower Coblenzian: Oberstadtfeld, near Daun, in the Eifel.
1903. *Bucaniella reissi.* Katzer, Geologie des Unteren Amazonasgebietes, p. 198, pl. 12, fig. 11.
1903. *Plectonotus? salteri.* Katzer, idem, p. 198, pl. 12, fig. 10.
Eo-Devonian: Rio Maecuru, Para, Brazil.
1904. *Bellerophon quadrilobatus* Salter. Reed, South African Mus. Annals, vol. 4, pt. 6, p. 242.
[Eo-Devonian]: Warm Bokkeveld, South Africa.
1904. Bellerophon (Bucaniella) aff. *B. trilobatus* (Sowerby). Reed, idem, p. 242, pl. 30, fig. 5.
[Eo-Devonian]: Gydo Pass, South Africa.
1904. Bellerophon (Bucaniella) cf. *B. reissi.* Reed, idem, p. 243, pl. 30, fig. 6.
[Eo-Devonian]: Road cut, north of Whupperthal, South Africa.
1904. Bellerophon (Plectonotus) aff. *B. salteri* Clarke. Reed, idem, p. 243, pl. 30, fig. 7.
[Eo-Devonian]: Road cut north of Whupperthal, South Africa.
1906. *Bellerophon reissi* Schwartz, Albany Museum Rec., vol. 1, pt. 6, p. 402, pl. 8, fig. 1.
Bokkeveld beds: Warm Bokkeveld, Ceres, Cape Colony.
1906. *Bellerophon trilobatus.* Schwartz, idem, p. 403, pl. 8, fig. 2.[4]
Bokkeveld beds: Warm Bokkeveld, Ceres, Cape Colony.
1907. *Bellerophon (Plectonotus?) gaspensis.* Clarke, New York State Mus. Bull. 107, p. 194, figs.
Lower Devonic: Grande Greve, Quebec.

Shell globular, symmetrically plane coiled, whorls between 2½ and 3¼, rapidly and regularly expanding, the body whorl composing the visible bulk of the shell. The apical whorls are minute inclosed and hidden within the body whorl. The back is trilobed; there is a broad median convex saddle with a shallow but distinct furrow on each side serving to demarcate a lateral wing on the outer side. These two furrows are always distinctly and sometimes strongly developed, though they are variable in different individuals. They increase in width and usually in depth with age and are visible in the youngest specimens. The median lobe is particularly variable in convexity. Occasionally the median lobe is strongly convex or inflated, but in most specimens it is depressed-convex along the center. On the median lobe of some specimens, for a portion of the whole of the body whorl there are developed two faint parallel minor grooves which divide the median lobe into three obscure, nearly equal strips. The central strip apparently bears the slit band or represents it and is more conspicuous on the internal molds than on the exterior. The lateral lobes of the shell expand in width gradually from the earlier whorls and rapidly on the last half of the body whorl. In dorsal aspect they are usually about half the width of the median lobe. Sculpture casts and internal molds show a large,

[1] In this species the medium lobe is a little smaller, relatively, than usual.
[2] As is shown by Clarke's fig. 12, the apertural sinus in this form is much shallower than in the Maine forms.
[3] As illustrated in Clarke's fig. 17, the inner end of the apertural sinus is more pointed and angular than in the Maine forms, where the margins are nearly parallel some distance below the end.
[4] This form differs from the preceding in exposing more of the inner whorls. There is variability in this respect among the Maine fossils, which is increased by differences in preservation.

well-defined, deep umbilicus, but this is nearly filled by the thickness of the shell and the lateral expansions of the mouth, so that the umbilicus is really narrower, though fairly deep and broad. The aperture is slightly expanded, and the peristome, in well-preserved specimens, shows a deep triangular sinus, which cuts into the margin of the aperture for a distance equal to the width of the median lobe. The edge of the lip is turned slightly outward at the extreme apex of the sinus, though the peristome in general does not flare at the edge. Two faint grooves are occasionally seen on the median lobe arising from the sides of the inner end of the sinus, inclosing a narrow flattened medial band which may represent the slit band, but this band is very indistinct and in specimens that show it best affects only the outer third of the last whorl. Outside and inside molds are generally quite smooth; but exceptionally clean molds of the exterior show very faint regular lines of growth, closely crowded, about six or seven to the millimeter. The dimensions of one of the largest and best preserved specimens are, width of aperture from side to side, 16.5 millimeters; diameter of last whorl from center of lip to opposite side of whorl, 17 millimeters; width of body of whorl one-half revolution back from lip, 7.5 millimeters; depth of sulcus from outer edge of lip, 8.5 millimeters; width of central lobe at edge of lip, 10 millimeters. The smallest individual has a length of 7 millimeters. The average length of the specimens is 12 to 14 millimeters.

Locality: This is one of the very few species common to both the Chapman and the Moose River sandstones, in both of which it is fairly abundant. In the Chapman the species is common in the sandstones west of Presque Isle Stream (locality 1099 J) and also occurs in loose bowlders in Edmunds Hill (localities 1099 C, 1099 K). In the Moose River sandstone at Detroit, Somerset County, the species is also fairly abundant. In size, outline, convexity, relative development of lobes, apertural sinus, slit band, and ornamentation I have not been able to distinguish the forms from the two horizons.

U. S. National Museum, catalogue Nos. 59843 to 59847.

Comparisons.—In the synonymy of *P. trilobatus* are included forms which are called by different names but which in size, outline, convexity, relative development of lobes, etc., do not depart from the specific type. As for the more precise details of the apertural sinus and the presence and strength of the revolving lines, which have been shown by Koken to be important specific characters in the species of Bucanella, too little is known of the forms cited above to warrant separating them at present. The species, or at least this specific type, has a long range in time and is widespread in areal extent.

Genus TROPIDODISCUS Meek, 1866.

In the Ordovician, Silurian, Devonian, and Carboniferous, and particularly in certain horizons of the upper part of the Silurian and the Lower Devonian appear some laterally compressed, lenticular, keeled, deeply involute Bellerophons without slit band, in which the aperture is not expanded and which are marked on the surface by concentric lines of growth. For such shells the generic name Tropidiscus (type *Bellerophon curvilineatus* Conrad,[1] Eo-Devonian) was proposed by Meek [2] in 1866, but as the name Tropidiscus was preoccupied, Meek shortly afterward changed it to Tropidodiscus [3] and included in the genus a second species, the Mississippian (Kinderhook) from *B. cyrtolites* Hall.

In 1882 and 1883 De Koninck,[4] recognizing the preoccupancy of Tropidiscus but apparently neglecting the corrected name Tropidodiscus Meek, proposed the new term Tropidocyclus (type *B. curvilineatus* Conrad), including in the genus two or three new species from the lower Mississippian (Tournaisian) and higher Carboniferous limestone (assises VI) of Belgium. In discussing these forms in 1899 Clarke [5] proposed that the name Tropidocyclus De Koninck be

[1] See Hall, James, Paleontology of New York, vol. 5, pt. 2, p. 94, pl. 22, figs. 1-6, 1879.
[2] Meek, F. B., Chicago Acad. Sci. Proc., vol. 1, p. 9, 1866.
[3] Meek, F. B., Illinois Geol. Survey, Paleontology, vol. 1, p. 160, 1866.
[4] De Koninck, L. G., Notice sur la famille des Bellerophontidæ suivie de la description d'un nouveau genre de cette famille (Waagenia): Soc. géol. Belgique Mém., vol. 9, p. 83, 1882; Faune du calcaire carbonifère de la Belgique, pt. 4, Gastéropodes: Mus. roy. hist. nat. Belgique Annales, vol. 8, pp. 123, 160, pls. 42 bis, 43 (pars), 1883.
[5] Clarke, J. M., The Paleozoic faunas of Para, Brazil; Devonian Mollusca: Mus. nac. Rio de Janeiro Arch., vol. 10, pl. 3, figs. 10, 11, 1899 (author's English ed., pp. 39-40, 1900).

restricted to the Carboniferous forms characterized by "their lateral appression, narrow dorsum, small umbilicus, and conspicuously, the character of their ornamentation," such as *T. rotula* and *T. gratiosus*, and including *B. cyrtolites* Hall, and that the name Tropidodiscus Conrad be restricted to cover such forms as *B. curvilineatus* Conrad, in which the shell is "lentiform, sharply keeled, and deeply involute, without expanded aperture or peripheral seam, and with rather coarse concentric growth wrinkles." Koken's name Oxydiscus [1] (type *O. imitator* Koken; Meso-Devonian) has been applied by European authors [2] to similarly compressed keeled shells, identical with the Tropidodiscus of Meek as amended by Clarke. In the Ordovician species included by Koken [3] in Oxydiscus the whorls are not involute, and the shells hence differ from typical Oxydiscus.

For shells of similar form which display revolving lines or ornamentation, Perner [4] proposed the name Cyrtodiscus; but it is questionable whether on this ground alone Perner's genus is valid.

Koken's genus Temnodiscus superficially resembles the group of Tropidocyclus De Koninck, as amended by Clarke, but it is described in Koken's "Leitfossilien" as having a distinct slit band. In 1897, however, Koken [5] stated that no slit band occurs in Temnodiscus, and he was followed in his assertion by Perner,[6] who made the distinction between Temnodiscus and Oxydiscus [Tropidodiscus] lie in the more rapid expansion of the body whorl in Temnodiscus.

I have adopted the term Tropidodiscus in the sense evidently intended by Meek in 1866, in using the species *Bellerophon curvilineatus* Hall as type, and regard the name Oxydiscus Koken, 1896, as a synonym; Temnodiscus Koken, 1897, and Cyrtodiscus Perner, 1903, are held to be either synonymous with or subordinate to Tropidodiscus Meek.

TROPIDODISCUS OBEX Clarke.[7]

Plate XIV, figures 3–10, 16, 21.

?1839. *Bellerophon carinatus*. Sowerby, in Murchison's Silurian system, p. 604, pl. 3, figs. 1d., 4.
Lowest "Old Red sandstone" or "Passage beds": Horeb Chapel, Caermarthenshire.
1900. *Bellerophon carinatus*. Williams, U. S. Geol. Survey Bull. 165, pp. 85, 86.
Chapman sandstone: Edmunds Hill, Chapman, Maine.
1907. *Tropidodiscus obex*. Clarke, New York State Mus. Bull. 107, p. 193, figs.
Lower Devonic: Edmunds Hill, Chapman Township, Maine.

Shell a lenticular disk, whorls 3 to 3½, expanding with moderate rapidity; deeply involute, embracing more than half the inner whorl. Umbilicus of moderate width, depth, two-thirds the width or slightly more, bounded by a rounded ridge. An external mold of the umbilicus of the right side resembles a little turbinate gastropod, while that of the left side might be easily mistaken for a little sinistral gastropod like Cliospira. The internal whorls are exposed to good advantage only in very clean internal molds. The distance from the inner lip across the apex to the opposite, inner suture of the body whorl is equal to about two-thirds the distance from the inner suture continued to the dorsal edge opposite the mouth. There appears to be no callosity on the inner lip. In cross section the whorl is compressed, approximately an equilateral triangle; dorsum subangular, with lateral profiles mostly convex to the umbilical ridge. In this distance is included an angle of about 60°, or very slightly over 60°. On the clean inter-

[1] Koken, Ernst, Entwickelung der Gastropoden von Cambrium bis zur Trias: Neues Jahrb., Beilage Band, vol. 6, p. 390, 1885; Die Leitfossilien, p. 100 (not p. 393), 1896.

[2] Frech, Fritz, and Loeschmann, E., Ueber das Devon der Ostalpen; III, Die Fauna des unterdevonischen Riffkalkes, 1: Deutsch. geol. Gesell. Zeitschr., vol. 46, p. 463, pl. 34, figs. 2a–2c, 1894 (*O. geyeri* Frech; *O. delanovi* Oehlert). Tschernyschew, T., Die Fauna des unteren Devon am Ostabhange des Urals: Com. géol. Mém., vol. 4, No. 3, pp. 29, 160, pl. 3, fig. 2, 1893 (*O. minimus* Tschernyschew; not the other species here cited under Oxydiscus).

[3] Koken, Ernst, Die Gastropoden des baltischen Untersilurs: Acad. imp. sci. St.-Pétersbourg Bull., 5th ser., vol. 7, No. 2, pp. 130–131, September, 1897.

[4] Perner, Jaroslav, Système silurien du centre de la Bohême, pt. 1, vol. 4, Gastéropodes, tome 1, p. 74, 1903.

[5] Koken, Ernst, Die Gastropoden des baltischen Untersilurs: Acad. imp. sci. St.-Petérsbourg Bull., 5th ser., vol. 7, No. 2, p. 129, 1897.

[6] Perner, Jaroslav, op. cit., p. 75.

[7] In the preparation of this report the specimens here listed were referred to Sowerby's species *Bellerophon carinatus*. As, however, before the report was ready for publication Clarke proposed the name *obex* for specimens derived from the same locality, undoubtedly the same forms, I have adopted his name as applicable, although there appear to be no constant differences by which the Maine shells can be distinguished from the specimens to which Sowerby's name is applied in Great Britain.

nal mold there is a slight concavity in the profile just below the dorsum. In the imperfect casts which represent the usual aspect of the species in the Chapman sandstone the profile is commonly convex from dorsum to umbilical ridge; in a few specimens, however, an exceedingly faint constriction of semiconcavity is developed either midway down the side or shortly above the umbilical ridge, causing the ridge to bulge more pronouncedly.

From the rounded umbilical ridge the profile in transverse section slopes inward and downward on the ventral side of the whorl in a concave or sigmoidal line to the suture. Between the sutures the ventral side of the whorl is arched up by the dorsum of the preceding whorl into a deep groove, semicircular in section and equal in width to one-fourth the width of the whorl. No revolving lines have been observed in this groove. The height of the whorl in cross section is $1\frac{1}{3}$ times the width (in clean internal mold). The mouth is only slightly, if at all, longer than wide and is not expanded. A slight apertural sinus is developed. There is no slit band on the dorsum. In one specimen a narrow impressed striation revolves part way along one side of the dorsum, but this may be due to crushing.

In two well-preserved fragments the surface is covered with fine raised lines of growth, barely visible to the naked eye, separated by interspaces of equal width; there are about five of these lines in the space of 1 millimeter. The lines of growth sweep back in a broad curve approaching the dorsum; ventrally they die out just within the umbilical ridge. There is no ornamentation in the umbilicus. In a small fragment showing an exceptionally well preserved mold of the external surface (Pl. XIV, fig. 3) very fine revolving lines, finer than the lines of growth and cancellating them, are observable with a magnifying glass. Internal molds and the common sculpture casts are smooth.

A large individual has a length of 26.5 millimeters, a height of 15 millimeters, and a width of 10.5 millimeters. Some other specimens have the following dimensions:

Dimensions of specimens of Tropidodiscus obex.

Length (millimeters).	Height (millimeters).	Width (millimeters).
20.5	17.5	8.75
20.75	16	10
13.66	10	5

Some of this variability appears to be due to distortion by pressure in the rock.

Locality: Abundant in the Chapman sandstone, Edmunds Hill (localities 1099 M, 1099 C), Chapman Township, Aroostook County, Maine. The same form seems to occur also in the Moose River sandstone at Detroit and Parlin Pond, Somerset County, Maine, accompanying the species *T. somerseti*, described below.

U. S. National Museum, catalogue Nos. 59848 to 59851.

Specific relations.—This shell is very similar to *Bellerophon* (*Cyrtodiscus*) *compressus* Sandberger,[1] from the basal Meso-Devonian Wissenbach shales, but *T. obex* is more deeply involute and its ventral profile within the umbilical ridge is sigmoidally concave, instead of convex. The ventral groove in the base of the whorl is deeper in the Chapman fossil and lacks the four furrows developed in the German form.

TROPIDODISCUS (TEMNODISCUS) SOMERSETI sp. nov.

Plate XIV, figure 22.

In the Moose River sandstone at Detroit, Somerset County, Maine, occur a few specimens of a Tropidodiscus which at first glance appears to be identical with the Chapman *T. obex*. Close examination, however, shows the Detroit specimens to be slightly narrower; the body whorl expands a trifle more rapidly than in the Chapman species, and the umbilicus appears to

[1] Sandberger, Guido and Fridolin, Die Versteinerungen des rheinischen Schichtensystems in Nassau, p. 180, pl. 22, figs. 6–6f, 1856.

be somewhat broader. These characters will serve to distinguish the species. Only faint growth lines have been observed. Specimens showing the revolving lines, if indeed these exist, have not yet been found.

Locality: Moose River sandstone, Detroit, Somerset County, Maine.

U. S. National Museum, catalogue No. 59852.

Comparisons.—Shells of the type of *T. somerseti* are widespread in the Eo-Devonian and Meso-Devonian of Bolivia, Argentina, Brazil, and South Africa, where they are usually identified with *Bellerophon* [*Temnodiscus*] *gillettianus* Hartt and Rathbun. The originals of *T. gillettianus* from the Meso-Devonian fauna of Erere, Para, Brazil, differ from *Tropidodiscus somerseti* in having a broader dorsum, three-quarters of a whorl less, and the whorls less deeply involute.[1] *Tropidodiscus* (*Temnodiscus*) *somerseti* bears a close resemblance also to figures of the Bohemian Ordovician *Sinuitopsis neglecta* (Barrande) var. *transgrediens* Perner,[2] but the Maine shell has a narrower dorsum and half a whorl more, and the whorls are more deeply involute than in the Bohemian Ordovician shell.

TROPIDODISCUS MINIMUS var. AMERICANUS var. nov.

Plate XIV, figures 2, 11.

?1893. *Oxydiscus minimus*. Tschernyschew, Com. géol. Mém., vol. 4, No. 3, p. 160, pl. 3, fig. 4.
Eo-Devonian: Smelting pool, 4 versts northeast of the Bogosslowsk mines, eastern Ural Mountains.

A single specimen from the Chapman sandstone agrees in its extreme compression, general outline, convexity, number and depth of whorls, umbilicus, and ornamentation with Tschernyschew's description and figure of *Oxydiscus minimus*, from the Eo-Devonian of the eastern Ural Mountains. It is, however, about twice as large as that species. Tschernyschew compared his *Oxydiscus minimus* with *Oxydiscus orbiculus* (Lindström), distinguishing the two by the lesser involution of the whorls in *O. orbiculus*. Lindström's species has two whorls more than the Chapman species, and if *O. minimus* has the same large number of whorls as Lindström's species, it is quite distinct from the Chapman fossil. The figures do not indicate this, however, and the Maine specimen is referred to a variety of the Russian species with the following characters:

Shell small, very much compressed, discoid, symmetrically plane coiled, whorls between $2\frac{3}{4}$ and $3\frac{1}{4}$, expanding with moderate rapidity; deeply involute, inclosing about half or more of the preceding whorl when the shell is preserved, but apparently much less involute when the shell substance is removed. Umbilicus broad, open, deep, bounded by a rounded ridge. In cross section the whorl is very much compressed, with sharply carinated narrow keel, on each side of which the profile is concave for a short distance, then becoming convex as far as the rounded umbilicus ridge. In this distance is included an angle of less than 60°. The profile then bends inward, and on the ventral side the whorl is deeply excavated by the preceding revolution. The height of the whorl is equal to about one and eight-tenths times the width. The mouth is longer than wide, is not appreciably expanded (note cross section of the whorl), and is characterized by a very deep Λ-shaped sinus. This sinus extends nearly one-fifth of the revolution, and the close subparallel edges at the upper end give it the appearance of a typical Bellerophon or Emarginula slit. No true slit band is demarkable on the dorsum. The whorl on the inner side of the mouth, appears to have been covered with a membranous expansion of the peristome, though this conclusion may be erroneous.

The surface is covered with exceedingly fine concentric lines of growth, which arch slightly backward over the sides of the whorl and very far backward on the dorsal keel, where they become nearly parallel to the dorsal edge of the shell. These lines are very faint, being barely visible under a hand lens.

Length, 10.7 millimeters; height, 10 millimeters; width, 4 millimeters.

Locality: Chapman sandstone, west of Presque Isle Stream (locality 1099 J), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59853.

[1] See Clarke, J. M., The Devonian Mollusca of the State of Para: Mus. nac. Rio de Janeiro Arch., vol. 10, p. 40, pl. 3, figs. 10–11, 1899 (author's English ed., 1900).

[2] Perner, Jaroslav, op. cit., p. 71, text figs. 45–47, pl. 88, figs. 33, 35, and 37.

Family PLEUROTOMARIIDÆ D'Orbigny.

No representatives of the genus Pleurotomaria De France or of its multitudinous subgenera, which are so widespread in Paleozoic faunas, have been recognized up to the present time in the Chapman fauna. The form listed as Pleurotomaria sp. in the preliminary catalogue of the Chapman species [1] belongs to Perner's genus Pseudotectus; Clarke also mistook the same shell for a Pleurotomaria, referring it to the genus or subgenus Eotomaria.

Several species present in the Chapman fauna, however, are referable to several of the groups of the old genus Murchisonia of authors.

Genus "MURCHISONIA" of authors.

Genus MESOCŒLIA Perner, 1907.

Mesocœlia was proposed by Perner [2] as a subgenus of Murchisonia and includes an easily recognized, characteristic type of shell distinguished by the exceedingly terrete spire, with a minimum number of 13 to 20 or more whorls. Owing to the slenderness of the spire, the entire spire is only rarely preserved; hence the total number of whorls is rarely apparent. Mesocœlia differs from Cœlocaulus Oehlert (=Cœlidium Clarke and Ruedemann), Ptychocaulus Perner, Turritoma Ulrich and Scofield, Catozone Perner, and similar exceedingly terrete murchisonoid shells by having the whorls cylindrically rounded and widest near the middle, with more deeply excavated sutures; moreover, the slit band is very faint, frequently not discernible, and is situated on the middle of the whorls, instead of near the suture. A few whorls, especially in senile shells of Mesocœlia, commonly show an obscure angulation on the periphery, less pronounced than in Goniostropha and not at all persistent. From the somewhat similar round-whorled Hormotoma Salter Mesocœlia is easily distinguished by its slender, terrete spire and more numerous and narrower whorls.

Perner includes in Mesocœlia seven or eight species from the Lower Ludlow and Aymestry faunas in the limestones of the Bohemian étage E^2. To the genus are also referable *Murchisonia compressa* Lindström,[3] from the Östergarn lower limestone, of similar age, in Gotland; *Cœlidium strebloceras* Clarke,[4] from the Devonian limestones at Dalhousie, New Brunswick; the present Chapman species described below; and perhaps also the British species *Turritella* or *Holopella obsoleta* Sowerby,[5] from the Tilestones of Horeb Chapel and Felindre, and the Eo-Devonian *Murchisonia hebe* Billings,[6] which is widespread in the Grande Greve limestone at Grande Greve, Indian Cove, etc., Gaspe Bay.

MESOCŒLIA TENUELLA sp. nov.

Plate XIII, figures 6–11.

1907. *Cœlidium tenue* (pars). Clarke, New York State Mus. Bull. 107, p. 190 (?), left-hand figure only; not descriptive text.

Lower Devonic: Presque Isle Stream, Chapman Plantation, Maine.

(?) Limestones: Dalhousie, New Brunswick.

Numerous incomplete spires of a very high spired, many-coiled Loxonema-like Murchisonia occur in the Chapman sandstone. The whorls are deeply rounded, with prominently excavated oblique sutures; the width of each whorl at right angles to the suture is three-fifths the "length" exposed between sutures. The umbilicus is minute or absent, and no reflection of the aperture is apparent. An obscure angulation, evidently indicating the position of the slit band, is evident

[1] Williams, H. S., and Gregory, H. E., Contributions to the geology of Maine: U. S. Geol. Survey Bull. 165, p. 86, 1900.

[2] Perner, Jaroslav, Système silurien du centre de la Bohême, pt. 1, vol. 4, Gastéropodes, tome 2, p. 113, 1907.

[3] Lindström, Gustaf, On the Silurian Gastropoda and Pteropoda of Gotland: Roy. Swedish Acad. Sci. Trans., vol. 19, No. 6, p. 129, pl. 12, figs. 15–19, 1884.

[4] Clarke, J. M., New York State Mus. Bull. 107, p. 189, fig., 1907.

[5] Sowerby, J. C., in Murchison, R. I., The Silurian system, p. 603, pl. 3, figs. 7a, 12f, 1839.

[6] Clarke, J. M., Early Devonic history of New York and eastern North America: New York State Mus. Mem. 9, p. 153, pl. 17, figs. 31–32, 1908; as *Cœlidium hebe* (Billings, 1874).

in many molds, especially on the latest whorls. When present it is at the midheight of the whorl rather than nearer the suture. The shell is nacreous on the interior. The surface ornamentation must have been very faint, for it is not preserved.

Locality: Common in the Chapman sandstone 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine. What is apparently the same form occurs at the end of the Tweedy road on Presque Isle Stream (locality 1099 L). This seems to be the shell referred to by Clarke as identical with his *Cœlidium tenue*. A similar shell is rare on Edmunds Hill (locality 1099 C).

U. S. National Museum, catalogue Nos. 59854–59856.

Comparisons.—The text describing Clarke's *Cœlidium tenue*, like his right-hand figure, refers to an angulated Murchisonia comparable with Oehlert's genus Goniostrophia. Clarke also compares *Cœlidium tenue* with such angularly keeled murchisonids (? Goniostrophia) as *M. losseni* Kayser, from the German Eo-Devonian, and *M. angulata* Phillips and varieties, from the Stringocephalus zone of the Meso-Devonian. Clarke's description of "sharply keeled whorls margined by a simple slit band to which the surface slopes in an almost direct plane without either convex or concave curvature" does not apply to any of our shells, nor does it apply to the form shown in Clarke's left-hand figure, which resembles the shells here under discussion, but shows a slightly greater apical angle and a more conspicuous slit band.

Mesocœlia tenuella sp. nov. seems most nearly allied to the imperfectly known British Tilestone *Mesocœlia? obsoleta* (Sowerby), from which it can with difficulty be distinguished. The Chapman shell, however, seems to have decidedly more than the nine whorls mentioned by Sowerby for *M.*(?) *obsoleta* and the whorls appear to be perhaps a trifle more inflated.

MESOCŒLIA ? sp. cf. M. COMPACTA (Hall).

The Chapman fauna includes representatives of a group of Murchisoniæ related to Mesocœlia Perner which may, however, prove distinct from the extremely tall spired, typical forms of Mesocœlia. The shells referred to conform with Mesocœlia in the large number of whorls and, like Perner's genus, differ from Cœlocaulus Oehlert in having the whorls more cylindrically rounded and the slit band less conspicuous and situated on the middle of the whorls rather than near the suture. The shells differ markedly from typical Mesocœlia in having the whorls more compressed or compact, with less width between sutures, thus producing a shorter spire. The group includes the middle Silurian *Mesocœlia compressa* (Lindström),[1] from the lower limestones of Östergarn; *Murchisonia longispira* Hall [2] and *Murchisonia logani* Hall,[3] both from the Guelph dolomite at Galt, Ontario; the basal Helderbergian *Loxonema? compacta* Hall,[4] from the lower part of the Coeymans ("Pentamerus") limestone of the Helderberg group, Schoharie County, N. Y.; and the present species, from the late Helderbergian fauna of the Chapman sandstone. Lindström's species has the perforate axis and reflected lip of Cœlocaulus Oehlert, but the whorls are deeply rounded and the slit band is at the midheight, as in the Mesocœlia of Perner.

The Chapman specimens are fragmentary spires which are characterized by narrow whorls; in external molds the width of the whorl between sutures is only two-fifths the length, and in internal molds the whorls appear narrower still. The whorls are deeply rounded. There does not appear to have been any umbilicus or perforation in the narrow axis. The slit band when best preserved is only indistinct; it appears to be at the midheight in the upper whorls, where the faint striæ of growth that mark the surface make a broad reentrant angle.

The fragments resemble *Mesocœlia compacta* (Hall) in the narrowness of the whorls and in the apparently somewhat fusiform shape of the spire, but the whorls in the Chapman shell are more cylindrical and have deeper sutures, in these respects approaching those of Lindström's Gotlandian species *Mesocœlia compressa.*

[1] Lindström, Gustaf, The Silurian Gastropoda and Pteropoda of Gotland, p. 129, pl. 12, figs. 15–19, 1884.
[2] Hall, James, Paleontology of New York, vol. 2, p. 345, pl. 83, figs. 1, 2, 1852.
[3] Idem, p. 346, pl. 83, figs. 4a, b.
[4] Idem, vol. 3, p. 297, pl. 54, fig. 12, 1859.

Locality: Several fragmentary spires, too incomplete for full specific description, occur in the softer beds of the Chapman sandstone along Presque Isle Stream, near the Tweedy road (locality 1099 A), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59857.

Genus CŒLIDIUM Clarke and Ruedemann, 1903 (=CŒLOCAULUS Oehlert, 1888).

The genus Cœlocaulus was proposed by Oehlert[1] in 1888 for highly turriculate murchisonoid shells which differ from Hormotoma Salter in possessing a narrow umbilicus that extends as a straight hollow canal up the vertical columella and which have also a reflection of the lip. Other and perhaps more conspicuous characters which distinguish Cœlocaulus are the flattening of the whorls above the slit band, the shallow sutures, the position of the slit band near the suture in the upper whorls, and the usually greater number of whorls. The generic name Cœlidium was proposed by Clarke and Ruedemann [2] to supplant Oehlert's generic name Cœlocaulus on the ground that the latter was preoccupied by Hall and Simpson, 1887, for a subgenus of Bryozoa under Callopora.

From Cœlocaulus there have been more recently dissociated the genera Ptychocaulus Perner, 1907; Catozone Perner, 1907; and Turritoma Ulrich and Scofield, 1897. Ptychocaulus, of which *Murchisonia bivittata* Hall, from the Guelph dolomite of Ontario and contemporaneous beds in Indiana is a characteristic American species, has a secondary plication on the columellar lip; the genus Catazone has the whorls rounded as in Hormotoma and Mesocœlia; and Turritoma has the whorls flattened or even concave in the middle and also lacks the umbilicus or perforated columella of Cœlocaulus, Ptychocaulus, and Catazone. All four groups agree, however, in having the slit band only slightly removed above the suture.

CŒLIDIUM cf. C. PLANOGYRATUM (Hall).

Plate XIII, figure 1a.

?1859. *Loxonema planogyrata.* Hall, Paleontology of New York, vol. 3, p. 298, pl. 54, fig. 13. [Coeymans] "Pentamerus" limestone of the Helderberg: Schoharie County, N. Y.

A third type of Murchisonia in the Chapman sandstone has the whorls flatter and the sutures less deeply excavated than in the types already described; in the upper whorls the slit band is below the midheight and only a little above the suture. In these features the shell conforms with the superficial characteristics of Cœlidium (= *Cœlocaulus*), but the columellar and apertural characters have not been observed.

The width of the whorl between sutures is three-fifths of the length. The broad and, in external molds, fairly conspicuous slit band produces a blunt vertical subangulation in the lower part of the whorl. The slit band is separated by hardly more than its width from the suture; above the band the surface of the whorls is nearly plane—hardly at all inflated.

Locality: Chapman sandstone, along Presque Isle Stream, near the end of the Tweedy road (locality 1099 L), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59858.

Comparisons.—The shell resembles *Cœlocaulus davidsoni* Oehlert[3] from the French (Mayenne) Eo-Devonian; *Murchisonia* [*Cœlocaulus*] *cingulata* (Hisinger)[4] and *M.* [*C.*] *obtusangulata* Lindström,[5] from the highest Silurian limestones of Gotland; and *M.* [*C.*] *egregia* Billings,[6] from the Oriskany fauna of Gaspe; but in the Chapman shell the whorls are a trifle wider ("taller") in proportion to their length. Still closer resemblance to the Helderbergian *Loxonema planogyrata* Hall, from which, indeed, the Chapman shell seems indistinguishable; but it must be emphasized that both the Chapman and Helderberg fossils are very poorly preserved.

1 Oehlert, D. P., Descriptions de quelques espèces dévoniennes du département de la Mayenne: Soc. études sci. Angers Bull. for 1887, p. 20, 1888.
2 Clarke, J. M., and Ruedemann, Rudolf, Guelph fauna in the State of New York: New York State Mus. Mem. 5, p. 65, 1903.
3 Oehlert, D. P., op. cit., p. 21, pl. 7, fig. 4.
4 See Lindström, Gustaf, op cit., p. 127, pl. 12, figs. 9, 10.
5 Idem, p. 128, pl. 12, fig. 12 (not fig. 7, which is a Goniostropha).
6 Clarke, J. M., New York State Mus. Mem. 9, p. 152, pl. 17, figs. 29-30, 1908.

Genus GONIOSTROPHA Oehlert, 1888.

The genus Goniostropha Oehlert was defined to include some French Eo-Devonian elongated Murchisoniæ having the slit band situated on a prominent and persistent angulation of the whorls which occupies the midheight between the sutures. The position of the slit band is similar to that in Hormotoma Salter, from which Oehlert's genus is easily distinguishable by the angulation and by the typically flat, sloping profile of the whorls from the keeled band to the sutures. From Cœlidium (Cœlocaulus) Goniostropha is distinguished by its more pronounced angulation and by the position of the angulation and slit band near the midheight of the whorls rather than near the suture. Goniostropha was also defined by Oehlert as being nonumbilicate, and this character would add another distinction from Cœlidium (Cœlocaulus), in which the vertical columella has a wide canal ascending upward through it. Perner, however, places little reliance on the supposed absence of an umbilicus in Goniostropha; and Clarke and Ruedemann's figures of *Murchisonia* [*Goniostropha*] *macrospira* Hall indicate that the columella in the same individual may in some whorls be perforate, in others imperforate.[1]

Murchisonia macrospira Hall, from the Guelph, is a typical Goniostropha, as are also *M. extenuata* Hall and *M. minuta* Hall, from the Manlius limestone; *Cœlidium tenue* (pars) Clarke,[2] from the late Silurian or Devonian limestones at Dalhousie, New Brunswick; *Murchisonia hercynica* Roemer, from the German Eo-Devonian; *Murchisonia angulata* D'Archiac and De Verneuil, from the European Meso-Devonian; and *Murchisonia micula* Hall, from the American Meso-Devonian. Several other species are known from the Silurian and Devonian of Europe, and in both Europe and America the genus appears to continue into the Carboniferous.

GONIOSTROPHA CHAPMANI sp. nov.

Plate XII, figure 28.

A small shell with tapering conoid spire in the Chapman fauna belongs to the genus Goniostropha and seems to require specific appellation. The fragmentary spire is 8 millimeters long, 2 millimeters wide at the upper end, and 6 millimeters wide at the base, and in this portion shows four whorls; the apex is broken away. The whorls are half as wide ("tall") as long, with oblique sutures, and show a pronounced sharp angulation at the midheight. The surface slope from the median carination to the sutures is but slightly convex, nearly plane.

The species seems readily distinguishable from the described species of Goniostropha by its small size, tapering conic spire, sharp simple median carination, and whorls twice as long as wide, with oblique sutures.

Locality: Chapman sandstone, 2 miles west of Presque Isle Stream (locality 1099 J), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59859.

Family TROCHIDÆ Adams.

Genus PSEUDOTECTUS Perner, 1907 (PALÆONUSTUS Perner, 1903).

The genus Paleonustus was founded by Perner[3] for fossils resembling the well-known Silurian *Euomphalopterus alatus* in having a peripheral keel but no slit band, and easily distinguished from the Pleurotomarias, with which the shells might otherwise be confused, in lacking the retral swing of the striæ of growth near the region of the keel or supposed slit band. From Euomphalopterus Roemer Paleonustus differs chiefly in having a higher and more nearly straight-sided conic spire and a less open umbilicus or no umbilicus at all; moreover, the keel is immediately above or at the suture in Paleonustus, instead of higher, as in Euomphalopterus. In Euomphalopterus also the aperture is circular and holostomate; in Paleonustus the aperture is more or less pentagonal, there is a narrow columella, and the inner lip is interrupted by the body whorl. Euomphalopterus is usually more highly ornate than Paleonustus.

[1] See Clarke, J. M., and Ruedemann, Rudolf, The Guelph fauna in the State of New York: New York State Mus. Mem. 5, p. 65, pl. 7, figs. 6, 7, 8, etc., 1903.

[2] Clarke, J. M., Some new Devonic fossils: New York State Mus. Bull. 107, p. 190, text and right-hand figure, 1907.

[3] Perner, Jaroslav, Système silurien du centre de la Bohême, pt. 1, vol. 4, Gastéropodes, tome 1, pl. 57, figs. 36-40, 1903.

A Silurian group intermediate between Euomphalopterus Roemer and Paleonustus Perner includes the *Pleurotomaria? pretexta, P. togata,* and *Trochus astraliformis* of Lindström,[1] and some other species from Gotland, as well as *Euomphalopterus alata* var. *limatoidea* Kindle and Breger,[2] from beds in Indiana contemporaneous with the Guelph of Ontario. In this group the flange is located at the suture, and the spire is sometimes conic, as in Paleonustus, but the mouth is circular, with holostomate lip; the deep umbilicus is continued upward through the center of the spire, and finally the shells are more strongly ornate, as in Euomphalopterus.

In 1907 Perner[3] abandoned the name Paleonustus on the ground that it had been based on a false conception of supposed relationship with the Recent genus Onustus; Pseudotectus was substituted instead, the new name being suggested by the resemblance to the Triassic-Recent genus Tectus. As Paleonustus had not been generically described nor adopted prior to 1907, Perner's abandonment of his own generic name Paleonustus may be excused and Pseudotectus accepted.

Along with Pseudotectus Perner described, in 1907, the new genus Streptotrochus,[4] which included some Silurian gastropods that agree with Pseudotectus in general external appearance, especially in the conic spire and in the peripheral keel, situated at or just above the suture. In Streptotrochus, however, the keel, though conspicuously developed, is never extended into the pronounced sheetlike or flangelike expansion which characterizes Pseudotectus Perner and Euomphalopterus Roemer. However, when this flange is broken away, as it is in many specimens, Pseudotectus and Streptotrochus are distinguishable only by the deeper umbilicus of Streptotrochus.

In the Chapman sandstone occurs a shell, well figured by Clarke, who called it *Eotomaria hitchcocki*, having a pronounced keel, which, by its simulation of a slit band, causes the shell to be easily confused with Pleurotomaria or its various allies. That the shell is not a Pleurotomaria and that the outer lip has neither the slit nor the >-shaped sinus of that genus is readily evinced, even in fragmentary shells, by the lines of growth. These, though they curve backward down to the keel, do not curve forward below the keel. Hence the latter has only the suggestion, not the function, of a slit band. The Chapman shells conform with the Pseudotectus and Streptotrochus of Perner. The extended flange of Pseudotectus has not yet been observed by us, and the lack of it would seem to ally the shell with Streptotrochus. The lack of the flange may be more apparent than real, however, and is possibly due to fracture or imperfect material. Clarke, indeed, describes the whorl as "sharply carinate or even extended into a keel or flange." On the basis of his statement the shell is here referred to Pseudotectus, a reference which seems the more proper, because the shell lacks the deep umbilicus of Streptotrochus, the columella being closed and having only a small umbilicus developed, as in *Pseudotectus comes* Barrande. Perner[5] describes Pseudotectus as without umbilicus, but a minute deep umbilicus is distinctly indicated in his text figures. This minute umbilicus and the apertural characters are identical with similar features in *Pseudotectus hitchcocki* (Clarke).

In the American faunas the genus Pseudotectus seems to be represented by the *Pleurotomaria eloroidea* Kindle and Breger,[6] from the dolomitic limestones with Guelph fauna at Huntington, in northern Indiana. In Europe Pseudotectus includes *Trochus lundgreni* Lindström,[7] from the late Silurian (Upper Ludlow) limestones at Samsugn, in Othem, and at Lutterhorn, in Faro, Gotland; *Pseudotectus comes* Perner,[8] from the Bohemian Eo-Devonian of Konieprus; and the shell called *Euomphalopterus conoidea* Oehlert,[9] from the French Eo-Devonian. The range of the genus is therefore from the middle part of the Silurian to the Lower Devonian, inclusive.

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[1] Lindström, Gustaf, On the Silurian Gastropoda and Pteropoda of Gotland, pls. 11, 14, 1884.
[2] Kindle, E. M., and Breger, C. L., Paleontology of the Niagara of northern Indiana: Indiana Dept. Geology and Nat. Res. Twenty-eighth Ann. Rept., pl. 14, figs. 3, 4, 1904.
[3] Perner, Jaroslav, op. cit., tome 2, p. 241, footnote, 1907.
[4] Idem, p. 238.
[5] Idem, p. 240.
[6] Kindle, E. M., and Breger, C. L., op. cit., p. 457, pl. 13, figs. 1, 2.
[7] Lindström, Gustaf, On the Silurian Gastropoda and Pteropoda of Gotland, p. 149, pl. 14, figs. 47-53, 1884.
[8] Perner, Jaroslav, op. cit., p. 241.
[9] Oehlert, D. P., Sur le dévonien des environs d'Angers: Soc. geol. France Bull., 3d ser., vol. 17, p. 772, pl. 19, fig. 5, 1890.

PSEUDOTECTUS HITCHCOCKI (Clarke).

Plate XII, figure 17.

cf. 1884. *Trochus lundgreni.* Lindström, K. Svenska Vetensk. Akad. Handl., vol. 19, No. 6, p. 149, pl. 14, figs. 46–53. Neo-Silurian limestones: Samsugn in Othem; Lutterhorn, Faro.

1907. *Eotomaria hitchcocki.* Clarke, New York State Mus. Bull. 107, p. 190, figs. Lower Devonic: Presque Isle Stream and in the burnt lands 2 miles west, Chapman Plantation, Maine.

The typical form of this shell from Presque Isle Stream is represented in our collection by one or two crushed specimens which are too poorly preserved to show well the distinctive specific characters. The following description is therefore drawn up mostly from Clarke's work:

Spire rather high, conical; proportion of height to width as 11:10. Angle of spire 70°. Whorls contiguous throughout; six[1] in number; angular, sharply keeled a little below the midheight, overlapping the lower third to a point just below the keel. From the narrow keel which forms the periphery of the whorl the profile toward the suture is nearly straight, gently concave in the lower half, gently convex just below the suture, thus giving the shell a conical profile from the tip of the spire to the keel of the body whorl. Sutures not conspicuous, hardly discernible; located immediately below the peripheral keel, very nearly horizontal. The total height of the body whorl is a little less than half the total height of the spire. The greatest width is along the keel, which is peripheral. The body whorl is slightly concave immediately below the keel, becoming convex over the greater portion to the umbilicus. The base of the shell is broad and flat for nearly the full width. A narrow umbilicus is distinctly developed, although it seems to be closed by the union, in the center of the spire, of the inner sides of the whorls. Mouth subpentagonal, as wide as high or wider, angulated by the peripheral keel, which does not bear a slit band. The base of the mouth is broadly rounded. The lower part of the inner lip is vertical and slightly thickened, with a narrow untwisted columella. Peristome interrupted by the body whorl. The upper part of the inner portion of the mouth is formed by the next upper whorl.

The surface is nearly smooth, but is covered with tenuistriate lines of growth directed backward from the suture to the keel. They do not arch or sweep farther back on approaching the keel, but continue in their direction across the keel and below it.

Height of shell 21 to 22 millimeters; width, 19 to 20 millimeters.

Locality: Chapman sandstone, Presque Isle Stream (locality 1099 A), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59860.

Comparisons.—Pseudotectus hitchcocki, from the Chapman sandstone, seems scarcely to be distinguished from the Gotland species *Trochus* [*Pseudotectus*] *lundgreni* Lindström, in which the keel is somewhat nearer the base of the body whorl and mouth; and the profile from keel to suture is less sigmoidal. These, however, are minor distinctions.

PSEUDOTECTUS? DECIDUUS sp. nov.

Plate XII, figures 18–27.

In the region west of Presque Isle Stream there is an abundant species closely related to *P. hitchcocki*, but preserved as partial casts or internal molds, making it very difficult to learn the real external structure. The form may be distinguished from the typical Presque Isle Stream shell by a tendency of the last whorl to become free or irregular. The internal molds show the peripheral keel, which is fairly well developed on the body whorl, becoming very pronounced and angular just back of the mouth. On the upper whorls, however, the angulation of the keel is usually not discernible on internal molds, the whorls here appearing rounded except that occasionally the whorl next the body whorl may be slightly angulated. The mouth was slightly expanded, to judge from the internal mold. There appears to have been, also, some variation in the height of the spire above the normal. Externally there was a narrow flat shoulder below the suture and a vertical rim above, neither of which is definable on internal molds.

[1] Clarke mentions only four or five whorls, but his figures show six or seven whorls, and that number is also indicated by our less perfect specimens.

Locality: Chapman sandstone, 2 miles west of Presque Isle Stream (locality 1099 J), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59861.

Comparisons.—This species appears to be similar to *Trochus incisus* Lindström,[1] from the highest Silurian of Gotland, in the tendency toward the deciduous character of the body whorl. *Streptotrochus incisum* Lindström has a taller spire. Species may perhaps be referable to Streptotrochus rather than to Pseudotectus.

PSEUDOTECTUS? sp. indet.

Plate XII, figure 16.

Some poorly preserved internal molds of a species of Pseudotectus (?) have been found loose in the Chapman sandstone on Edmunds Hill. These specimens, like many of the internal molds from the locality west of Presque Isle Stream, show angulation only on the body whorl, the upper whorls appearing rounded. The fossil is a small species, of Holopea-like outline, with only three or four whorls, but is too poorly preserved to be recognizable specifically, and is listed simply as representing the genus.

Locality: Chapman sandstone, Edmunds Hill (locality 1099 C), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59862.

Family PSEUDOMELANIIDÆ Fischer.

Genus LOXONEMA Phillips.

LOXONEMA WELLERIANA sp. nov.

Plate XIII, figures 2, 3, 5.

cf. 1903. *Loxonema jerseyense* (pars). Weller, New Jersey Geol. Survey, Paleontology, vol. 3, pp. 95, 335, pl. 43, fig. 10 (not fig. 9).

Trilobite beds (basal Oriskany): Trilobite Ridge, New York and New Jersey.

Shell of moderate size; a high, turriculate, closely coiled spire, showing in the best preserved specimen over 12 whorls, probably about 13 or 14. The apical whorls are minute and usually absent; the last six whorls occupy seven-ninths the total height of the spire. Apical angle 19° to 20°. The whorls are convexly rounded, rather strongly, with sutures sharp and moderately oblique (10°). The width of the whorl exposed between the sutures is about half the length, the proportion of length to width varying from 2:1 to 1.9:1. Each of the last four whorls is 1.7 to 1.8 times as long as the next upper whorl. Aperture unknown.

The ornamentation consists of sigmoidal lines of growth; these vary in strength, continuity, and direction. They are slightly convex at the base, but swing back into a reentrant, shallowly concave arch, which includes most of the width of the whorl. Below the suture the striæ again swing forward, and as a rule continue concave up to the suture, though in many specimens they become convex and nearly direct for less than a millimeter just below the suture. In strength the lines are variable. For short patches they may become even, about eight in the space of 2 millimeters on the middle of the whorl, or they may become very fine and aggregated into fascicules or wrinkles, about three or four of the latter in the space of 2 millimeters. The striæ arch back shallowly, with the greatest depth of arch variable, at or above the mid-height of the whorls. The ornamentation is strongest in the arch of the striæ near the middle portion of the whorls. In some external molds the striæ may appear strongest near the suture, but this appearance is due to erosion of the shell surface on the exposed parts of the whorls.

A specimen with the extreme apex incomplete but still preserving 12 whorls has a height of 27.75 millimeters, a width at the base of 8 millimeters, and the basal six whorls are 21.5 millimeters high and the basal four whorls 16.75 millimeters high. Another fragment preserving four whorls has a height of 17 millimeters and width of 8.25 millimeters. A third and larger fragment with six whorls was 24 millimeters long and 10.5 millimeters wide at the base.

[1] Lindström, Gustaf, op. cit., p. 151, pl. 14, figs. 22-31.

The species may be recognized by the deep convexity of its whorls, the sharp oblique sutures, the width of the whorls (half the length), the narrow spire, gradual increase of the whorls, shallow arch of the striæ of growth, and strong but varying ornamentation.

Locality: Moose River sandstone, Detroit (locality 1100 A), Somerset County, Maine. Common, along with *Leptocœlia flabellites* Conrad, *Spirifer antarcticus* Morris and Sharpe, *Spirifer arenosus* Conrad, *S. murchisoni* Castelnau, *Leptostrophia perplana* Conrad (*L. blainvillei* Billings), etc. These shells are often overspread by an explanate bryozoan.

U. S. National Museum, catalogue No. 59863.

Comparisons.—*L. welleriana* approaches most nearly, among described forms of Loxonema, *L. subtilistriata* Oehlert,[1] from the French (Mayenne) Eo-Devonian; but the ornamentation of the American shell is less uniformly fine and becomes in places much coarser than in the French species. The latter also has the greatest depth of the arch of the striæ uniformly above the middle, whereas in the Chapman form it is variable and most commonly nearer the middle.

Loxonema jerseyense Weller.

Plate XIII, figures 1, 4.

1903. *Loxonema jerseyense*. Weller, New Jersey Geol. Survey, Paleontology, vol. 3, pp. 95, 335, pl. 43, figs. 8, 9 (not fig. 10).

Trilobite beds (basal Oriskany): Trilobite Ridge, New York and New Jersey.

In the basal Oriskany, at Trilobite Ridge, N. Y., in New Jersey, and in the Lower Coblenzian fauna of the Moose River sandstone at Detroit, Maine, occur two associated but distinct forms of Loxonema. One of these is described above as *L. welleriana* sp. nov.; the other is here called by the name *L. jerseyense* Weller, which is restricted to this form. Both forms were included by Weller in the species *L. jerseyense*.

L. jerseyense s. str. conforms with *L. welleriana* in the character and variability of its ornamentation but is easily distinguished by having the whorls much wider in proportion to the length. Indeed, the whorls are nearly as wide as long in *L. jerseyense*, the proportion of length to width ranging from 11:8 to nearly 12:8, compared with 19:10 to 2:1 in *L. welleriana*. The spire is therefore more tapering in *L. jerseyense;* the height of the four basal whorls of the spire is $2\frac{4}{9}$ to $2\frac{6}{9}$ times the width, compared with a ratio slightly greater than 2:1 in *L. welleriana*.

Locality: Moose River sandstone, Detroit, Somerset County, Maine, along with *L. welleriana* sp. nov. *L. welleriana* is more common than *L. jerseyense* in the Maine collections, but in New Jersey the reverse is true.

U. S. National Museum, catalogue No. 59864.

Genus AURIPTYGMA Perner, 1907.

The genus Auriptygma was erected by Perner[2] in 1903, and the genotype, *A. fortior* (Barrande) from the Aymestrian fauna of étage E^2, was figured, but the genus was not described until 1907.[3] A translation from the French of Perner's diagnosis of Auriptygma is as follows:

Shell terbinate; whorls inflated, scalariform; apex pointed; sutures straight and deep; last whorl very much developed. Mouth elliptical, elongated toward the base. Inner lip neither thickened nor tucked in, but simply undulating and merging by simple passage into the columella; the latter is solid and straight. Surface striæ transverse, distinct, faintly inclined, a little arched.

Auriptygma offers the closest resemblance to the early Paleozoic gastropods which have been placed in the genera Holopea Hall and Macrochilina Bayle (=Macrocheilus Phillips, Phillips's name being preoccupied). In Macrochilina, founded on the British Devonian *M. acuta*, there is no umbilicus whatever, and the base of the inner lip is tucked into a short tortuous columella. In *M. arculata* (Goldfuss) and several other species of Macrochilina there is a pronounced twist at the base of the columella, producing a columellar fold; Kittl,[4] indeed, regards

[1] Oehlert, D. P., Descriptions de quelques espèces dévoniennes du département de la Mayenne: Soc. études sci. Angers Bull., 1887, p. 12, pl. 7, fig. 1.

[2] Perner, Jaroslav, Système silurien du centre de la Bohême, pt. 1, vol. 4, Gastéropodes, tome 1, pl. 61, figs. 51-54, 1903.

[3] Idem, tome 2, p. 361, text figures 260, 261, 1907.

[4] Kittl, Ernst, Die Gastropoden der Schichten von St. Cassian der südalpinen Trias, pt. 3: K. k. Naturhist. Hofmuseum Annalen, vol. 9, p. 208, 1894.

this columellar fold as characteristic of the Paleozoic forms of Macrochilina and describes several later species of Macrochilina having one or two additional broadly rounded folds higher up on the columella or inner lip. Auriptygma has a much simpler inner lip than that of even the simplest forms of Macrochilina.

There is some difficulty in distinguishing Auriptygma Perner from Holopea of Hall and authors, for Hall's genus is but little understood. Holopea Hall is founded on the Trenton limestone species *Holopea symmetrica* Hall;[1] the generic details of the species are unknown, the genus having been based more or less on external form. Holopea was supposed to have been recognized subsequently in the New York Devonian and elsewhere, but it is not certain, perhaps not even probable, that the Devonian shells called Holopea[2] correspond generically with the Trenton limestone types of Holopea. The apertural and other generic characters of Holopea can best be elucidated by comparison with the American Ordovician species described and figured by Ulrich and Scofield[3] and with the European late Ordovician shells of similar type described by Koken.[4] However, there must first be removed from the higher or buccinoid-spired shells characteristic of Holopea the large number of so-called Holopea species which have a lower naticoid spire and, usually, a deep umbilicus, a continuous circular peristome, and one or two whorls less than the typical Holopea. Typical Holopea, even more so than Macrochilina, presents superficially a striking similarity to Auriptygma; the umbilicus is minute or absent, the columella and thickening of the inner lip are absent, the inner lip is interrupted by the body whorl and toward the base is elongated and slightly explanate. That the stronger and posteriorly arching striæ of Auriptygma are alone sufficient to distinguish the genus from Holopea Hall is questionable. With Perner, I believe that the name Auriptygma, which defines a concisely demarkable gastropod structure, is preferable to the loosely applied name Holopea, which seems to have served authors as a blanket name for unplaced shells of this general type. In the tenuity of the surface striæ and in the slightly less rounded or more nearly vertical-shouldered whorls, as well as in the distinct though minute umbilicus, the Chapman shells under discussion conform more nearly with Holopea Hall than with the type species of Auriptygma.

HOLOPEA (AURIPTYGMA) BEUSHAUSENI Clarke.

Plate XII, figures 1–15.

1907. *Holopea beushauseni*. Clarke, New York State Mus. Bull. 107, p. 188, figs.
Lower Devonic: Presque Isle Stream, Edmunds Hill (?), Chapman Plantation, Aroostook County, Maine.

Shells rather large in the typical forms. Spire moderately high, buccinoid; proportion of height to width as 3:2. Angle of spire between 58° and 70°. Whorls five or six; contiguous; convex, rather flattened or vertical below the shoulders; overlapping the lower fourth; broadest below the middle. Sutures rather strongly impressed, profoundly so in internal molds; obliquity from the horizontal 5° to 25°, depending largely upon distortion and pressure in the rock; usually about 20°. The height of the body whorl exclusive of the mouth is a trifle less than the height of the rest of the spire. The total height of the body whorl is equal to two-thirds the height of the shell. The greatest width is below the middle. The mouth is elongate, oval in outline; the base is broadly rounded, not tapering, and in good specimens is explanate or slightly recurved. Umbilicus absent or minute. Internal molds show a straight, narrow canal extending up the middle of the spire, apparently a little wider than the thickness of the shell. Whether this canal was hollow or filled is not known.

Internal molds and sculpture casts are quite smooth. One external mold was also quite smooth, and another showed only extremely tenuous lines of growth. The surface may therefore be considered to have been smooth, or very nearly so.

[1] Hall, James, Paleontology of New York, vol. 1, p. 170, pl. 37, fig. 1, 1847.
[2] Idem, vol. 5, pt. 2, pl. 12, 1879.
[3] Ulrich, E. O., and Scofield, W. H., The Lower Silurian Gastropoda of Minnesota: Geology of Minnesota, vol. 3, pt. 2, Paleontology, p. 1065, pl. 79, 1897.
[4] Koken, Ernst, Die Gastropoden des baltischen Untersilurs: Acad. imp. sci. St. Pétersbourg Bull., 5th ser., vol. 7, No. 2, p. 193, 1897.

Locality: Chapman sandstone, on Presque Isle Stream, at the end of the Tweedy road (localities 1099 A and 1099 L), Chapman Township, Aroostook County, Maine. Apparently the same species occurs also on Edmunds Hill (localities 1099 C and 1099 M); and a smaller species of the same genus occurs abundantly in the calcareous Chapman sandstone west of Presque Isle Stream (localities 1099 J, 1099 K, and 1099 L). The specimens are rather poorly preserved, and it is by no means certain that they are all cospecific. Indeed, in the case of the lamellibranchs which are better preserved than these gastropods, the representatives of a genus from the Edmunds Hill locality, however closely allied, are in general specifically distinct from those of the Presque Isle Stream localities. Possibly better material would show the gastropods also to be specifically distinct.

U. S. National Museum, catalogue Nos. 59865 to 59869.

Comparisons.—From *Auriptygma fortior* (Barrande) Perner this species differs chiefly in having the profile of the whorls more nearly vertical. The outer extremity of the mouth is below the midheight in the Chapman species, instead of above; the mouth is a little more explanate than is apparent in the Bohemian figures; and the ornamentation is much more subdued.

The explanate mouth and general buccinoid outline suggest a similarity with Macrocheilus sp. Beushausen,[1] from the Siegen fauna of the Bockberg, in the Harz, but the German fossil has a decidedly higher spire and stronger ornamentation.

Class CEPHALOPODA.

Family ORTHOCERATIDÆ.

Genus ORTHOCERAS Breyn.

ORTHOCERAS sp. (?O. NORUMBEGÆ Clarke).

?1907. *Orthoceras norumbegæ*. Clarke, New York State Mus. Bull. 107, pp. 177–178, figs.
Lower Devonic: Edmunds Hill, Chapman Plantation, Maine.

A few fragments of Orthoceras have been obtained from the Chapman sandstone of Edmunds Hill, sufficient to establish the presence of these marine organisms in the Chapman fauna; but specific characters can not be defined from such imperfect material. The several fragments are of similar size and might belong to a single species. They represent a slender, medium-sized shell, varying in diameter from 13 to 20 millimeters. The chamber of habitation is represented by a fragment 20 millimeters wide and preserving a length of 35 millimeters. The chambers are one-third as long as they are wide. The septa are arched and the siphuncle central and small.

The fragments may possibly represent smaller individuals of the large and bizarrely ornamented *Orthoceras norumbegæ* Clarke, the chamber of habitation of which was described from the same locality.

Locality: Chapman sandstone, Edmunds Hill (localities 1099 C and 1099 M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59870, 59871.

ORTHOCERAS PRINCIANA sp. nov.

Plate XIII, figure 17.

Two species of smooth, typical Orthoceras from the calcareous Moose River sandstone are represented in our collections by incomplete specimens. The larger form, to which is applied the name *O. princiana*, is distinguished by the moderately deep chambers, the deep transverse septa, the subcentral siphuncle, and the rapid tapering of the shell. A fragment shows the cone expanding from 32 to 36 millimeters in a length of 30 millimeters. Three chambers are included in this distance, the average depth of the chambers between sutures being, therefore,

[1] Beushausen, Louis, Beiträge zur Kenntniss des Oberharzer Spiriferensandsteins und seiner Fauna: Abh. geol. Specialkarte Preussen, vol. 6, pt. 1, p. 52, pl. 1. fig. 7, 1884.

three-tenths the width. The septa are deeply convex, extending below the suture approximately two-fifths the height of the chamber above the suture. The siphuncle appears to have been very nearly though probably not quite central; it is 3 millimeters or more in diameter. The surface is devoid of ornamentation.

Locality: Moose River sandstone, Somerset County, Maine. The shells were collected by Mr. Harold W. Prince, after whom the species is named.

U. S. National Museum, catalogue No. 59872.

ORTHOCERAS PARLINENSE sp. nov.

Plate XIII, figures ?21, 25.

A second species of smooth Orthoceras in the Moose River sandstone fauna is a smaller shell, with slender, more tapering cone, very deep septa, and a central proportionately large siphuncle. In shells only 3 millimeters wide the chambers are 2 millimeters deep; they maintain a nearly uniform depth regardless of the size of the shell, and are 2.8 millimeters deep in shells 6 millimeters thick. About 2.5 millimeters represents the average and usual distance between sutures. The septa are transverse and very deeply arched; they extend below the sutures for a distance equal to the depth of the chambers between sutures. The siphuncle is central and is proportionately very broad, 1.5 to 2 millimeters in thickness—equal to one-third to one-fourth the diameter of the shell. The specimen figure 25 is the type of the species and figure 21 is referred provisionally to this species.

Locality: Moose River sandstone, Parlin Pond, Somerset County, Maine.

U. S. National Museum, catalogue No. 59873.

Suborder PTEROPODA.

Family TENTACULITIDÆ Walcott.

Genus TENTACULITES Schlotheim, 1820.

TENTACULITES SCHLOTHEIMI Koken.

Plate V, figure 30; Plate XIV, figures 23, 24.

1820. *Tentaculites annulatus* var. Schlotheim, Petrefaktenkunde, p. 377 (pars).
Lower Devonian: The Schalke, Prussia.

1899. *Tentaculites schlotheimi.* Koken, Deutsch. geol. Gesell. Zeitschr, vol. 41, p. 82.
Lower Devonian: The Schalke, Prussia.

1896. *Tentaculites schlotheimi.* Koken, Die Leitfossilien, p. 540.
Lower and Upper Coblenzian: Rhenish Prussia.

1900. *Tentaculites schlotheimi.* Gürich, Ueber Tentaculiten und Nowakien: Schlesischen Gesell. vaterlandische Kultur Jahresb., Naturw.-Abtheil., vol. 77, p. 34.
Lower Devonian: Prussia.

1907. *Tentaculites scalaris* (not of authors). Clarke, New York State Mus. Bull. 107, p. 174.
Lower Devonic: Edmunds Hill, Chapman Plantation, Maine.

Shell a free tapering cone of 8° apical angle, in mature specimens 12.25 millimeters long, passing from a width of 0.65 to 2.5 millimeters, and increasing 1 millimeter in width in a distance of 6.62 millimeters. Annulations equal, eight or nine in number in a space of 5 millimeters where the shell is 2 millimeters thick, eight to nine in number in a space of 2 millimeters where the cone is only 0.66 to 0.75 millimeter thick. The annulations are crowded, with interspaces usually only slightly broader than the ribs. Very rarely an interspace nearly twice as wide as the ribs may occur; but frequently the interspaces are scarcely as wide as the ribs. As seen in good specimens, the ribs are strongly elevated and the interspaces deeply excavated. The surface is covered with very fine, threadlike, equal transverse or horizontal striæ covering both the ribs and the interspaces. From six to eight of these may be counted in the space of a millimeter where the shell is a little over 2 millimeters wide. In the sandstones the finer ornamentation is rarely preserved; in most external molds both the ribs and interspaces appear to be devoid of fine striæ, and only in the cleanest specimens do these show. The transverse striæ are usually parallel to the ribs and interspaces, but where the ribs are slightly oblique the finer striæ are transverse and cut obliquely across the ribs in a very small angle. There are not more than four striæ on either a rib or on an interspace, and commonly only three. Fragments about 2 centimeters long and 2 to 2.3 millimeters wide occur abundantly.

Locality: Chapman sandstone (Pl. XIV, figs. 23, 24); common with *Chonetes striatissimus* n. sp. in dark soft sandstones and with *Chonetes novascoticus* Hall and *Spirifer cyclopterus* Hall in lighter sandstone, Edmunds Hill (localities 1099 C, 1099 M), Chapman Township, Aroostook County, Maine. Two specimens from the blue siliceo-calcareous grits of the Moose River sandstone can not be distinguished from the specimens obtained in the Chapman sandstone. (See Pl. V, fig. 30.) Isolated fragments of Tentaculites also occur in a rock full of *Leptocœlia flabellites* between Detroit and Parlin Pond, Somerset County, Maine.

U. S. National Museum, catalogue Nos. 59874 to 59876.

TENTACULITES cf. T. ELONGATUS Hall.

Plate XIV, figure 26.

cf. 1859. *Tentaculites elongatus*. Hall, Paleontology of New York, vol. 3, p. 136, pl. 6, figs. 16-21.
Shaly limestone and upper Pentamerus, Lower Helderberg group: Helderberg Mountains and Schoharie, N. Y.

Additional specimens have since been found which indicate that a probably distinct species occurs in the Moose River sandstone fauna. This species is extremely abundant in light-buff calcareous quartzites in Somerset County, along with *Leptocœlia flabellites* Conrad, *Chonetes novascoticus* Hall var. *canadensis* Billings, *Chonetes antiopus* Billings, *Leptostrophia blainvillei* Billings, and crinoid segments. The Tentaculites here attain a gigantic size, fragments over 25 millimeters long and 1.5 millimeters wide at the smaller end being common. These large Tentaculites differ from the Chapman form in being much more attenuate, the cone widening 1 millimeter in a length of more than 10 millimeters. These large forms are even more slender than *Tentaculites elongatus* Hall and may perhaps be regarded as a slender variety of that species.

Locality: Moose River sandstone, Somerset County, Maine.

U. S. National Museum, catalogue No. 59877.

Comparisons.—The name *Tentaculites scalaris* was proposed by Schlotheim for internal molds of a species of Tentaculites found in Prussia, in drift bowlders of the Baltic Silurian Beyrichia-Chonetes limestones. At the same time Schlotheim described *Tentaculites annulatus*, based on complete shells from Gotland. Both the *T. annulatus* and the *T. scalaris* of of Schlotheim are now commonly regarded as representing a single species, a Silurian Tentaculites similar to the Silurian shells which in England are named *T. ornatus* Sowerby and which in America are called *T. niagarensis* Hall, *T. gyracanthus* Eaton, etc. With the Gotlandian *T. annulatus* Schlotheim described a variety of this species in which the rings are more closely crowded, from Devonian rocks in Prussia. The surface, according to Koken, is covered with the usual finer striæ. For this German early Eo-Devonian shell Koken [1] proposed the name *Tentaculites schlotheimi*. Koken stated that *T. schlotheimi* was specifically distinct from similar forms of Tentaculites occurring in the Coblenzian of Altenahr, Kyll, Ems, and elsewhere in the Coblenz district, and also from *Tentaculites grandis* Roemer, from the Silesian Eo-Devonian Wurben Valley quartzite, but he did not point out the distinctive characters of these species. The Tentaculites from the Coblenz district are well figured and described by Quensted [2] and by the Sandbergers.[3] These shells pass under the name *Tentaculites scalaris*, though they are plainly not Schlotheim's species, which is a shell with distant and inequidistant ribs, as was pointed out in 1859 by Boll [4] and later by Krause,[5] by Roemer, and by Koken.

The Chapman shells conform with the brief description of *Tentaculites schlotheimi* given by Koken. Clarke identified the fossils with the Coblenzian forms of Tentaculites referred to

[1] Deutsch. geol. Gesell. Zeitschr., vol. 41, p. 82, 1889.
[2] Quensted, F. A., Handbuch der Petrefaktenkunde, p. 399, pl. 35, figs. 26–29, 1852.
[3] Sandberger, Guido and Fridolin, Die Versteinerungen des rheinischen Schichtensystems in Nassau, p. 248, pl. 21, figs. 9 a–g, 1856.
[4] Boll, Ernst, Ver. Freunde Naturgeschichte Meklenburg Arch., vol. 13, p. 163, 1859.
[5] Krause, A., Deutsch. geol. Gesell. Zeitschr., vol. 29, p. 28, 1877.

by Koken, but the shells here called *Tentaculites schlotheimi* show the fine horizontal striæ to be less profuse than in the German Coblenzian forms as figured by the Sandbergers.

In the American faunas the nearest species is *Tentaculites elongatus* Hall, from the Helderberg [1] and Oriskany.[2] Hall's species agree with the Chapman and Detroit fossil in ornamentation, but is more slender and more tapering, and attains greater size than *T. schlotheimi*.

Tentaculites scalariformis Hall,[3] from the "Corniferous" limestone, is a large, thick, closely annulate shell of the type of *T. schlotheimi*, but is more profusely striate. It comes nearest to the Sandbergers' *T. scalaris* (not Schlotheim), from Coblenz.

ARTHROPODA.

Class CRUSTACEA.

Subclass TRILOBITA.

Genus HOMALONOTUS Koenig, 1820.

HOMALONOTUS LATICAUDATUS sp. nov.

Plate XXII, figures 11, 14, 17, 18, 22.

Cranidium quadrangular, laterally extended at the base into the narrow, ribbon-like fixed cheeks. Total width of cranidium one and four-sevenths times the total length. The width between the palpebral lobes is decidedly greater than the length of that portion of the cranidium between the anterior suture and the occipital furrow, the proportion being 5:4, thus giving the cranidium above the fixed cheeks a rather broad appearance. The glabella is depressed convex, reaching barely above the level of the palpebral lobes. Its demarcation from the rest of the cranidium is exceedingly faint, the anterior and lateral furrows are scarcely definable, and only when oriented in the proper light. No transverse glabellar furrows are evident. The glabella is slightly longer than wide, in the proportion of 20:19. The occipital furrow is narrow and strongly defined, extending entirely across the fixed cheeks. The occipital ring is slightly narrower than the fixed cheeks. The ring is transverse, and slightly but not conspicuously arched forward in the middle; on the sides the occipital ring swings forward somewhat. The free cheek is nearly straight on its outer border, the eye lobe rises high and abruptly from the lateral margin, and the cheek is terminated posteriorly by a strong, short, but acutely pointed genal spine. The free cheeks are detached in all our specimens. They are highly inclined to the general plane of the cranidium, and were trigonal to trapezoidal in outline, with the length (lateral margin of the cephalon) two or more times as great as the width. Thorax deeply arched, forming nearly a semicircle in transverse section, the height being 0.47 of the width. The axis or middle lobe is very broad, though ill defined. The axis is limited laterally on the individual segments by a slight constriction of the segment and by a small notch or pit on the anterior (?) side, similar to the notch or pit on the occipital ring. Between these pits the middle lobe of each segment is arched upward; the height of the arch (when uncrushed) is slightly more than one-quarter the distance between the pits. The lateral divisions of the thoracic segment are about one-quarter as wide as the thorax measured along its arching surface, but when the thorax is viewed from the back the lateral lobes appear much narrower, the middle lobe or axis then appearing to absorb three-fourths the total width of the animal. The inclination of the lateral pleura of the thoracic segment does not exceed 20° from the vertical. The extreme outer portion of the lateral segment is spatulate in form and in the specimens preserved appears to have stood nearly vertical to the horizontal plane of the body.

Pygidium relatively obtuse, triangular-pentate. The lateral margins are very nearly straight lines, forming an angle of 86°, or nearly a right angle. The pygidium is gibbously elevated. In lateral profile the median line of the surface makes an angle of 37° to 40° with

[1] Hall, James, Paleontology of New York, vol. 3, p. 136, pl. 6, figs. 16–21, 1859; vol. 5, pt. 2, supplement, p. 6, pl. 94, fig. 14, 1888.
[2] Clarke, J. M., The Oriskany fauna of Becraft Mountain, Columbia County, N. Y.: New York State Mus. Mem., vol. 3, No. 3, p. 27, pl. 3, figs. 8–12, 1900. Weller, Stuart, The Paleozoic faunas [of New Jersey]: New Jersey Geol. Survey, Paleontology, vol. 3, p. 363, pl. 50, figs. 4–5, 1903.
[3] Hall, James, Paleontology of New York, vol. 5, pt. 2, p. 167, pl. 31, figs. 3–11, 1879.

the base. The terminus is obtusely subangular. The axis is moderately well defined and shows distinctly on the internal molds 11 or 12 annulations, indicating about 13 on the complete surface. The rings are strongly convex and transverse, without any arching forward in the middle, and are wider than the interspaces. Posteriorly the axis merges into the smooth terminus. The lateral segments, though well defined, are less strongly elevated but broader than those of the axis; eight segments can be distinctly counted on the internal mold and on a fragmentary exterior, and if a ninth segment is present it must be exceedingly faint. The first ring of the axis is continued laterally into the first lateral segment; the eighth ring of the axis is continued laterally into the seventh lateral segment. The intervening lateral segments and furrows and axial rings and furrows, respectively, do not abut directly against each other. The lateral segments continue to the margin and both the lateral and the axial segments are devoid of grooving.

Two or three fragments of clean external molds of the pygidium and fragments of thoracic segments indicate that the surface was smooth, devoid of pustules, pores, or corrugations, etc. It is barely possible, however, that more abundant and better material may show the pustulated or pitted ornamentation common in Homalonotus, at least on the cephalon.

A pygidium of a young specimen is 21.66 millimeters wide and is 19 millimeters long (length measured on sloping surface). Another fragmentary pygidium was about 60 millimeters wide and 53 millimeters long. The latter specimen probably represents the usual size, though several specimens of small size correspond nearly to the small pygidium mentioned.

Among the more diagnostic characters of the species are the faint demarcation of the glabella; total absence of furrows on the glabella; anterior suture nearly transverse, only slightly arched; well-marked occipital ring; strong upward arching or gibbosity of the thorax; lateral segments of the thorax nearly vertical; pygidium relatively broad, the sides including an angle of 86° or very nearly a right angle; surface devoid of spines, and apparently smooth.

Locality: The species is represented by detached free cheeks, isolated thoracic segments, and a few fragmentary pygidia and cranidia supposed to belong to a single species. These occur in loose blocks of the Chapman sandstone on Edmunds Hill and 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue Nos. 59878, 59879, 59880.

Comparisons.—The species is nearly allied to *H. delphinocephalus* Green,[1] from the Niagara group. The Chapman fossil can be easily distinguished from the Silurian form by its broader pygidium. Moreover, in the cranidium the anterior suture is nearly transverse and angular at the sides in *H. laticaudatus* sp. nov., whereas it is ovally arched and curves into the lateral or facial suture in *H. delphinocephalus* Green.

The broad pygidium and the great gibbosity of the body distinguish *H. laticaudatus* from other species.

HOMALONOTUS VANUXEMI Hall.

Plate XXII, figures 10, 12, 13, 15, 21.

1859. *Homalonotus vanuxemi.* Hall, Paleontology of New York, vol. 3, p. 352, pl. 73, figs. 9–11 (not fig. 12).
Helderberg shaly limestone: Herkimer County and Helderberg Mountains, Albany County, N. Y.

1888. *Homalonotus vanuxemi.* Hall, idem, vol. 7, p. 11, pl. 5 B, figs. 1, 2.
Helderberg shaly limestone: Albany and Herkimer counties, N. Y.

not 1903. *Homalonotus vanuxemi.* Weller, Paleontology of New Jersey, vol. 3 (Paleozoic faunas), p. 321, pl. 39, figs. 7, 8; p. 338, pl. 44, figs. 4–7.
Northwestern New Jersey.

Besides the *Homalonotus laticaudatus* from Edmunds Hill, the Chapman sandstone fauna contains several well-preserved pygidia and abundant fragmental remains of another species of Homalonotus occurring 2 miles west of Presque Isle Stream. This second form I identify with *Homalonotus vanuxemi* Hall. It does not seem to attain the large size of *H. laticaudatus* and is, moreover, easily distinguished by the narrower and more profusely annulated pygidium.

[1] Hall, James, Description of the species of fossils found in the Niagara group at Waldron, Ind.: Indiana Dept. Geol. and Nat. Res. Eleventh Ann. Rept., p. 332, pl. 34, figs. 17, 18, 1882.

Figures 13 and 14, Plate XXII, represent characteristic pygidia of *H. vanuxemi* Hall and *H. laticaudatus* sp. nov., respectively, and make plain the distinction between the two species. In size, outline, convexity of the pygidia, and occurrence of 14 or 15 annulations on the elongated axis and of 12 lateral pleuræ, the small specimens conform with the New York Helderbergian fossil.

Locality: Chapman sandstone, 2 miles west of Presque Isle Stream (locality 1099 J), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59881.

Genus PHACOPIDELLA Reed.

The generic name Phacopidella was proposed by Reed[1] in 1905 to supplant Acaste Goldfuss, 1843, which was preoccupied. The type chosen was *Phacops glockeri* Barrande, from the Bohemian étage E^2 or middle of the Silurian. The genus Phacopidella, originally placed near Dalmanites, resembles Phacops in having only the hindmost glabellar lobe and furrow well developed, the second and first pairs of lateral lobes of the glabella being obscure, though present. The cephalon and pygidium are semicircular or rounded in a broad semiellipse, as in Phacops, and are not elongate or spinose, as in Dalmanites.

Phacopidella differs from Phacops chiefly in the character of the glabella. In Phacops the glabella is tumid or broadly bulbous in front, and the first and second furrows are merely faint scratches. In Phacopidella the glabella is more elongate, resembling in its gross outline that of typical Dalmanites. The first and second lateral furrows in the glabella of typical Phacopidella are better developed than in Phacops, occurring as faint furrows rather than as mere scratches, but in the group of *Phacopidella anceps* Clarke the anterior furrows are faint, as in Phacops. Finally, the glabella in Phacops is tuberculate; in Phacopidella it is non-tuberculate or rarely tuberculate on the frontal lobe only.

Two well-marked sections are easily demarcated in Phacopidella. Section 1, the group of *Phacopidella glockeri* (Barrande) (typical section), in which the first and second pairs of lateral lobes are discernible, includes *Dalmanites phillipsi* Barrande, from étage D^4 (Neo-Ordovician); *Phacops downingi* Sowerby, from the Wenlock (middle Silurian); *Phacops glockeri* Barrande, from étage E^2 (middle Silurian); and *Phacops pupillus* Lake and *P. africanus* Salter, from the Bokkeveld (Eo-Devonian). Section 2, the group of *Phacopidella anceps* Clarke, in which only the third pair of lateral lobes is developed, the first and second pairs being either entirely obliterated or exceedingly faint, includes *Phacopidella nylanderi* Clarke, and *Phacopidella chapmani* sp. nov., from the Chapman sandstone; *Phacopidella brasiliensis* Clarke, from the Lower Coblenzian of Rio Maecuru; and *Phacopidella anceps* Clarke, from the Oriskany-"Corniferous" transition beds.

PHACOPIDELLA CHAPMANI sp. nov.

Plate XXII, figures 1, 3.

Cephalon elongate-paraboloid, angular in front. Length 4.25 millimeters; width 5.5 millimeters; greatest width opposite the occipital furrow. Genal angles broadly rounded. The glabella is elongate, expanding slightly in width from the occipital ring forward. The frontal lobe of the glabella is much longer than wide; its width is only half the total length of the cephalon. The frontal lobe is most tumid between the eyes. Anteriorly it descends, merging into the general convexity of the shell. The posterior half of the frontal lobe is marked by an angulated ridge, which, with the elongation of the cephalon and the gibbous form, seems at first to be due to bilateral compression in the rock; but the presence of a similar ridge in *Phacopidella anceps* Clarke, a flatter species, and the absence of such a ridge in *P. brasiliensis*, a gibbous species, together with the variability in outline and convexity of the cephalon in the different species, have led to the belief that the characters indicated are to only a slight extent due to compression. This angulated ridge dies out over the third glabellar lobe before reaching the occipital groove. The first and second glabellar furrows and lobes are totally lacking on the clean internal mold. The third pair of furrows are represented as deep transverse pits which do

[1] Reed, F. R. C., The classification of the Phacopidæ: Geol. Mag., new ser., decade 5, vol. 2, pp. 225, 227, 1905.

not quite meet medially, forming an incomplete furrow. The occipital furrow extends across the glabella as a wide groove, the ends of which are developed into transverse pits of the third pair of lateral furrows. Between these two pairs of pits the third glabellar lobes are developed as a narrow ring which is somewhat thinner than the occipital ring. The palpebral lobes are minute; the eyes are large and strongly elevated. They extend to the midlength or slightly in advance of the midlength of the cephalon and occupy a width equal to 0.8 the length of the cephalon. The facial structure is faint and extends very nearly horizontally from behind the eyes, reaching forward but little. The free cheeks are steeply inclined. The border is rather thin.

Size minute. Length 4.25 millimeters; width 5.5 millimeters; a minute pygidium from Edmunds Hill, suggesting in its semicircular outline the pygidia of Phacops, Proëtus, etc., is referred to the present species. The pygidium is 4 millimeters long and 6 millimeters wide and shows six annulations on the elevated axis.

Phacopidella chapmani is easily distinguished from all the described species of Phacopidella by the narrowly elongate glabella, the maximum width of which is scarcely half the length of the cephalon. The elongate outline of the cephalon is also characteristic.

Locality: Chapman sandstone, Edmunds Hill (locality 1099M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59882.

Comparisons.—In the median angulation or ridge on the glabella the species approaches *P. anceps* Clarke,[1] from the base of the "Corniferous," or rather the Oriskany-"Corniferous" transition beds of Ontario, but is distinguished by having the glabella and cephalon more elongate, as well as by having the third glabellar lobes proportionately narrower with reference to the occipital ring. The transverse pits in the occipital groove of *P. anceps* are not so well developed as in *P. chapmani.*

Clarke [2] has described a cephalon of *Phacopidella nylanderi* from Edmunds Hill, the locality where *P. chapmani* was found. *P. nylanderi* Clarke as figured and described is entirely distinct from *P. chapmani;* it is much broader, the glabella is also broader, it lacks the median angulation, and the genal angles are sharper.

Genus SYNPHORIA Clarke.

The genus Synphoria Clarke is now made to include all the trilobites[3] differing from the typical Dalmanites in having the margin of the cephalon bizarrely ornamented with spines. This ornamentation in the various forms previously classed as different genera—Probolium, Odontocephalus, Corycephalus, etc.—but now grouped together in the genus Synphoria, may consist of a single spine projecting in front of the cephalic rim, or the spine may be a two-pronged or three-pronged fork, or the rim of the cephalon (both front and side) may include a row of numerous spines or crenulations. A common feature in all the forms included in Synphoria is the coalescence or tendency to coalesce laterally of the first and second glabellar lobes. These fossils also have the genal angles spinose, and the pygidium usually ends rather sharply or in a spine. Among the several groups of Dalmanites the Synphorias usually possess the maximum number of axial segments in the pygidium.

The Chapman collections include two elongate, acutely ending pygidia representing at least one and probably two species of Synphoria. Unfortunately, the cephalon and the marginal ornamentation are unknown.

DALMANITES (? SYNPHORIA) α sp. nov

Plate XXII, figure 8.

This species is represented by an elongate pygidium unornamented in internal mold. It is characterized by its depressed convexity, the specimen being nearly flat, and by having the axis of the pygidium depressed below the level of the sides. About 12 segments seem to have

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[1] Clarke, J. M., As trilobitos do grez de Erere e Maecuru, Estado do Para, Brazil: Mus. nac. Rio de Janeiro Arch., vol. 9, p. 16, pl. 1, fig. 3, 1892.
[2] Clarke, J. M., Some new Devonian fossils: N. Y. State Mus. Bull. 107, p. 166, 1907.
[3] Clarke, J. M., The Oriskany fauna of Becraft Mountain, Columbia County, N. Y.: New York State Mus. Mem., vol. 3, No. 3, pp. 16-18, 1900. Van Ingen, Gilbert, The Siluric fauna near Batesville, Ark., pt. 2, Paleontology [trilobites]: Columbia Univ. School of Mines Quart., vol. 23, pp. 34-74, 1901. Reed, F. C. R., The classification of the Phacopidæ: Geol. Mag., new ser., decade 5, vol. 2, p. 225, 1905.

been present on the axis; they are transverse, hardly if at all arching forward. Nine apparently ungrooved segments may be counted on each side. The apex of the pygidium is acute and slightly deflected upward, but whether prolonged into a terminal spine or not can not be stated, as the extreme apex is broken off.

Length (of pygidium) 17 millimeters, width 16.5 millimeters.

Locality: Ferruginous blocks of the Chapman sandstone on Edmunds Hill (locality 1099 C^2), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59883.

Comparisons.—The pygidium closely resembles that of the Oriskanian *Dalmanites* (*Synphoria*) *stommatus* var. *convergens* Clarke,[1] from Becraft Mountain, N. Y., but in that variety the outline is slightly less tapering and the axis is more profusely annulate.

Dalmanites (*Synphoria*) *meeki* Walcott,[2] from the Lower Devonian limestone of the Eureka district, Nev., is similar, but has the pygidium slightly less acute and the posterior extremity more strongly deflected upward.

Dalmanites (? Synphoria) β sp. nov.

Plate XXII, figure 5.

In a second species of Synphoria the pygidium is more gibbous and the axis is elevated above the sides. Twelve or thirteen annulations may be counted in the axis on the exterior; the last two annulations are not discernibly impressed on the interior. The axial rings arch forward prominently. Nine segments may be counted on each side; these are wider than the interspaces. The forward lateral segments of the pygidium are grooved, but the grooves are visible only on the exterior mold, and even there are exceedingly faint. The surface is devoid of tuberculations. In this as well as in the preceding form the margin is entire, and the posterior termination of the pygidium is hardly at all deflected upward.

Length of pygidium 12.66 millimeters; width, approximately 12 millimeters.

Locality: Chapman sandstone, with *Spirifer cyclopterus* Hall, west side of Edmunds Hill (locality 1099M), Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 59884.

Comparisons.—This species is closely allied to *Dalmanites* (*? Synphoria*) *alpha*, from which it is distinguished by its stronger convexity and by having its axial rings more strongly arched in the middle. The differences may, however, be due to deformation in the rock, and the specimens may possibly represent the same species.

The fossil is similar to the Eo-Devonian *Dalmanites* (*Synphoria*) *concinnus* Hall,[3] from the Schoharie grit, Schoharie, N. Y., in outline, number of segments, arched axial rings, and non-deflected apex, and in having the lateral segments broad and flat, but it lacks the well-demarcated border of the New York species, in which, moreover, the lateral segments are more strongly grooved than in the Chapman sandstone fossil.

OSTRACODA.

By E. O. Ulrich.

Family BEYRICHIIDÆ.

Genus CTENOBOLBINA Ulrich.

Ctenobolbina (?) cornuta n. sp.

Plate XXVII, figures 17–19.

This species is represented by a single specimen retaining both valves. These, though widely opened, are yet joined along their cardinal edges. The length is about 1.8 millimeters, height 1.1 millimeters, greatest thickness through middle of joined valves probably about 0.9 millimeter.

[1] Clarke, J. M., New York State Mus. Mem., vol. 3, No. 3, p. 19, pl. 2, fig. 4, 1900.
[2] See Hall, James, and Clarke, J. M., Paleontology of New York, vol. 7, p. 32, pl. 11 A, figs. 28–30, 1888.
[3] Idem, p. 30, pl. 11 A, figs. 9, 10, 11, 1888.

Surface of valves moderately and rather evenly convex except in the posterodorsal quarter. This contains a small but prominent conical node, located just within the dorsal edge and about one-fourth of the total length of the valves in front of the posterior extremity.[1] On the anterior side this node is outlined by a narrow curved sulcus which dies out before reaching halfway across the valve. The outline of the valves is subovate, straight along the dorsal side, and slightly narrower in front than behind. The anterodorsal angle terminates in a short spine, but the other extremity of the hinge line seems obtusely angular or narrowly rounded. A narrow border on the free edges. This overhangs and in a side view conceals the true contact rims.

Ctenobolbina (?) cornuta is characterized by an unusually simple type of carapace. The main sulcus alone remains, and this is much shorter than is the corresponding depression in nearly all of the species previously referred to the genus. The conical node also is situated nearer the dorsal edge than is the corresponding node in all of the other species of the genus in which anything of the kind has been observed. The brevity of the sulcus and the dorsad position of the node which, moreover, is an exceptionally prominent feature, will therefore readily serve in recognizing the species. There should be no trouble in distinguishing it from the associated species of Beyrichia.

Formation and locality: Chapman sandstone, right bank of South Branch of Presque Isle Stream, at end of Tweedy Road, Chapman Township, Aroostook County, Maine.

Genus ZYGOBEYRICHIA n. gen.

This new generic name is proposed for a group of large Beyrichiidæ that seems to represent a departure from the typical beyrichian stock at a time when other considerable changes in the family were inaugurated. So far as known the oldest of these species is an undescribed form found in the late Silurian Tonoloway limestone of Maryland. Three other species occur in this early Devonian fauna, one of them being identified with a species described from the Lower Devonian rocks of Devonshire, England, by Jones and Woodward under the name *Beyrichia devonica;* the other two are apparently new. At least one and probably two more species having the same generic features are included in unworked collections in the United States National Museum, procured, like the others, from rocks lying near the Silurian-Devonian boundary in eastern North America.

Judging from this representation the new genus is distinguished from Beyrichia (1) by the partial or complete obsolescence of the posterior lobe and (2) by the excessive development of the ventral junction of the median and anterior lobes. These peculiarities, especially on account of the looplike form of the confluent lobes, impart an aspect suggestive more or less strongly of species now referred to the *B. ungula* section of the genus Bollia. That this resemblance to Bollia is more apparent than truly indicative of genetic relationship seems reasonably certain from the negative fact that intermediate stages are unknown, and more particularly from the positive fact that in this proposed generic group there is scarcely a suggestion of the marginal ridge that from the Ordovician to the Middle Devonian was always a more or less clearly developed feature in species of Bollia. On the other hand, the beyrichian affinities of Zygobeyrichia are clearly established by comparing those specimens of the new genus in which the posterior lobe is more noticeable than usual with such typical Silurian species of Beyrichia as *B. kloedeni* and *B. buchiana.* The lobes in such specimens—one is shown in Plate XXVII, figure 12—are so readily correlatable with those of typical species of Beyrichia that detailed analysis seems unnecessary. When the range of these comparisons is extended so as to include the other species of the new genus, it will become increasingly evident that the only essential departures from the beyrichian stock are those mentioned in the opening sentence

[1] The final decision as to which of the two ends is the anterior in these small bivalved crustacea is yet a matter of the future. In the present work it was thought advisable to continue the method of orientation defended and employed by Ulrich and Bassler (U. S. Nat. Mus. Proc., vol. 35, pp. 277-340, 1909). To avoid confusion it should be understood that good authorities, among them Jones and Bonnema, have commonly denominated as posterior the end here described as anterior. However, the criteria followed by them appear not to have led to uniform results.

of this paragraph. The obsolescence of the posterior lobe is more or less clearly noticeable in all, being carried to an extreme in *Zygobeyrichia extrema*, and the strong development of the ventral part of the loop remains a constant feature.

Comparative studies of the Beyrichiidæ clearly show that of the three lobes always found in the genus Beyrichia the posterior one is the least stable. It became particularly variable with the beginning of the Devonian when the representatives of the type of structure that prevailed so abundantly in the Silurian, and to which the genus has been confined by Ulrich and Bassler,[1] were reduced to a few in part aberrant species. In most of these survivors the posterior lobe tends to obsolescence, while in the predominating Devonian and Mississippian representatives of the family, chiefly included in the genera Hollina, Treposella, and the new Zygobeyrichia, this lobe is commonly weak or quite effaced.

A similarly modest development of the posterior lobe is observed in nearly all of the species of Kloedenia, another genus that attained its acme in the latest Silurian and early Devonian. The swelling of the dorsal part of the median lobe, that is so well shown in the three species representing Zygobeyrichia in the Chapman sandstone, likewise recalls Kloedenia. These similarities, however, though suggesting genetic relationship, seem to indicate generic divergence from a common beyrichian root rather than specific modifications within the same generic group.

Zygobeyrichia apicalis n. sp. has been selected as the genotype.

ZYGOBEYRICHIA DEVONICA (Jones and Woodward).

Plate XXVII, figures 1-6.

1889. *Beyrichia devonica.* Jones and Woodward, Geol. Mag. Dec. 3, vol. 6, p. 386, pl. 9, figs. 3a-3d (? 4, 5).

This well-marked species is represented in the collections by four or five specimens that closely simulate the British (Devonshire) specimens on which Jones and Woodward founded the species. The middle lobe extends well-nigh to the dorsal edge and is inflated and somewhat conically prominent in its upper part. Beneath this the relatively attenuated though high ventral part curves forward to join the less sharply defined anterior lobe, the two forming a loop of the kind commonly developed in species of Beyrichia like *Beyrichia buchiana* and *B. kloedeni*. In the present species, however, the posterior lobe is so imperfectly developed that the loop formed by the junction of the median and anterior lobes is unusually conspicuous. In consequence the general aspect of the valves is decidedly suggestive of Bollia, particularly of species of the *B. ungula* section of the genus.

The ventral pouch of the female form of the species has been observed in only a single example. (See Pl. XXVII, fig. 4.) This shows the pouch to be uncommonly elongate, elliptical in form, and its longer axis more nearly parallel with the dorsal edge than in any species of Beyrichia or any other species of Zygobeyrichia known. In both respects the pouch of *Z. devonica* approaches the same structure in the nearly contemporaneous *Mesomphalus hartleyi* Ulrich and Bassler.

Some variability in dimensions and form is observable among the Chapman sandstone Ostracoda, here regarded as agreeing too closely to be distinguished even as a variety from the best of the British specimens originally figured and described by Jones and Woodward under the name *B. devonica.* Though much of this apparent variability doubtless is attributable to distortion of the valves subsequent to burial, it yet appears that as a rule the posterior ridge is a lesser feature, and the anterior ridge less sharply defined on its anterior side in these American species than in the Devonshire types of the species. It is to be remarked, however, that both of these ridges are no less obscurely developed and the anterior end equally obtuse in specimens originally, and also in others subsequently, referred to *B. devonica* by Jones himself.

It is of interest and possibly of stratigraphic significance to note here that the older Pembroke formation contains an abundance of more or less crushed valves of an ostracode that, in the features mentioned, agrees even better than these Chapman sandstones specimens with the

[1] Ulrich, E. O., and Bassler, R. S., Preliminary revision of the Beyrichiidæ, with descriptions of new genera: U. S. Nat. Mus. Proc., vol. 35, pp. 277-340, 1909.

anterodorsally angular British and Turkish specimens originally referred to *B. devonica* by Jones and Woodward. Possibly two closely allied species have been united under this name.

The length of the specimens commonly varies between 2.5 and 3.5 millimeters, the average being little more or less than 3 millimeters. Allowing for distortion by pressure, the height is approximately half the length.

Formation and locality: Chapman sandstone, right bank of south branch of Presque Isle Stream, at end of Tweedy road, and Edmunds Hill, Chapman Township, Aroostook County, Maine.

ZYGOBEYRICHIA APICALIS n. sp.

Plate XXVII, figures 11–16.

This fine species is related to the associated *Beyrichia devonica*. It is readily distinguished by its relatively shorter form, and because of the fact that the dorsal part of the median lobe is even more prominent and therefore also more distinctly separable from the lower curved part of the loop. Furthermore, the base of the median lobe does not reach the dorsal edge, the lobe as a whole appearing, in a side view of the valves, as occupying a position nearer the middle. Among other differences shown in the illustrations it should be noted that the dorsal extremity of the posterior lobe is more prominent and lies nearer the postdorsal angle. Also, that the flattened border on the free edges, especially in the testiferous specimens, is more distinctly developed.

Two excellently preserved valves—both right and left—of the female form of this variety show the ventral pouch to be of medium size and located wholly in the posterior three-fifths of the valves. Its thickest part projects a trifle beyond the ventral edge. The whole surface of the pouch is minutely and closely punctate, forming a neat reticulation in which the arrangement of the punctæ in longitudinal series predominates. This network extends some distance upward on the anterior lobe, but dies out long before reaching the dorsal edge. A similar punctation crowns the swollen part of the median lobe. The remaining parts of the surface of the valve are smooth.

Length of carapace 2.5 to 3.2 millimeters, with the average but little under 3 millimeters. Height somewhat greater than half the length, the two measurements commonly in the ratio of 3 to 5, respectively. Greatest thickness of complete carapace approximately equal to the height.

No other described species seems so closely allied as *B. devonica*, from which it has been distinguished. Further comparisons, therefore, are deemed unnecessary.

Formation and locality: Chapman sandstone, right bank of south branch of Presque Isle Stream, at end of Tweedy road, and 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

ZYGOBEYRICHIA EXTREMA n. sp.

Plate XXVII, figures 7–10.

The specimens for which this new specific name is proposed agree among themselves in the almost complete obsolescence of the posterior lobe. The main sulcus is centrally situated, deep, and extends from the dorsal edge at least three-fourths of the distance to the ventral margin. The ridge corresponding to the usual median lobe of Beyrichia is high, somewhat expanded above, but on the whole of moderate thickness. Below it joins, by means of a loop-like connection, the base of the anterior lobe. The latter is large, thick, and sharply defined on its inner side by the deep sulcus, but on its outer side merely slopes somewhat rapidly to the level of the valve margin. Remains of the test indicate that the elevated parts of the outer surface are covered with small pustules. Ventral pouch of female high, bulbous, strongly oblique with respect to the hinge line, and wholly confined to the posterior half

Length of a well-preserved left valve 2.3 millimeters, greatest height 1.5 millimeters, greatest thickness (to summit of median lobe and ventral part of loop) about 0.9 millimeter.

From its congeneric associates in the Chapman sandstone *Zygobeyrichia extrema* is distinguished at once by its shorter and more gibbous form, and especially by the narrowness of the space between the bulbous median lobe and the posterior margin. From species of Kloedenia it differs conspicuously in the practically complete loss of the posterior lobe, the greater depth and length of the sulcus, and the ventral prolongation, prominence, and looplike confluence of the median and anterior lobes. Compared with species of Beyrichia the total obsolescence of the posterior lobe and the great prominence and strength of the ventral loop modify its general expression so greatly that confusion seems almost impossible.

Formation and locality: Chapman sandstone, right bank of south branch of Presque Isle Stream, at end of Tweedy road, Chapman Township, Aroostook County, Maine.

VERTEBRATA.

Class AGNATHA Eastman.

Order ANTIARCHA Eastman.

Family ASTEROLEPIDÆ Traquair.

Genus ASTEROLEPIS Eichwald.

ASTEROLEPIS CLARKEI Eastman.

Plate XXII, figure 19.

1907. *Asterolepis clarkei.* Eastman, New York State Mus. Mem. 10, p. 40, pl. 7, figs. 7, 8.
Chapman sandstone: Chapman Plantation, Aroostook County, Maine.

The single specimen of this interesting fossil found in the Chapman sandstone was submitted for identification to Dr. Charles R. Eastman, who kindly reported as follows:

> The specimen you have sent me, as far as one can determine from its general configuration, proportions, and style of ornamentation, may be regarded with reasonable confidence as one of the dorsomedian plates of the imperfectly known Ostracophore which has been described from the same horizon—*Asterolepis clarkei.* Although somewhat smaller than the holotype, and with finer and more closely crowded stellate tubercles, the presence of a distinct median longitudinal ridge and the laterally sloping surface on either side of it are characteristics which render an association with this unique form fairly certain.

The dimensions of the original specimen were described as follows: "Extreme width of the plate is slightly in excess of the total length, which amounts to 4 centimeters in the type specimen."

The present specimen is about 2.5 centimeters long and about 2 centimeters wide, and the tubercles are smaller than those of the type specimen in the same proportion.

Locality: Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

U. S. National Museum, catalogue No. 7709.

PLANTÆ.

In some of the strata of the Chapman sandstone traces of plants have been discovered, but specimens which show sufficient characters to indicate possible relationship with described forms are rare. A few small branching stems have the habit of *Psilophyton princeps* Dawson. The material does not, however, show the spinose processes that appear on good specimens of that species. Other fragments are woody stems several inches in length, but these display no characteristic habit of growth, ornamentation, or, so far as is apparent, cellular structure. In suggesting a general resemblance in habit of some of the fragments to Psilophyton I do not intend any identification with Dawson's genus. Too often the name *Psilophyton princeps* Dawson and the generic name Psilophyton have been used as common receptacles for fragmental plant remains of the general Psilophyton aspect. David White [1] has indicated that plant remains of this general expression belong to a diversity of genera.

[1] Smith, G. O., and White, David, The geology of the Perry Basin in southeastern Maine: U. S. Geol. Survey Prof. Paper 35, pp. 58 et seq., 1905.

APPENDIX.

AGE AND CORRELATION OF THE CHAPMAN FAUNA.

In the preliminary report on the Chapman fauna its general affinity with the later phase of the American Helderbergian fauna was announced,[1] and attention was also directed to the presence of species linking it with corresponding faunas of England and other European countries. The detailed study of the species described in the present volume sufficiently demonstrates these correlations. It remains to summarize the nature of this evidence and to make the correlations more precise.[2]

In making an estimate of the correlation of the Chapman sandstone with outside formations, the greater importance attaches to the species recognized in other geographic areas; and in order to decide whether two distinct horizons are represented, the list of species common to both is of first importance.

1. The following species occur in both divisions of the Chapman sandstone—the presumably lower horizon of Presque Isle Stream and the country west thereof, and the higher horizon about Edmunds Hill:

Orbiculoidea discus Hall (Helderbergian).
Chonetes striatissimus sp. nov.
Rensselaeria mainensis Williams.
Spirifer concinnus Hall (Helderbergian).
Nucleospira ventricosa Hall (Helderbergian).
Paleoneilo mainensis Clarke.
Paleoneilo mainensis var. umbonata var. nov.
Preavicula oblonga (Hall) (Helderbergian).
Plectonotus trilobatus (Sowerby) (Silurian and Devonian).
Tropidodiscus obex Clarke.
Holopea (Auriptygma) beushauseni Clarke.
Homalonotus laticaudatus sp. nov.
Tentaculites schlotheimi Koken (Taunusian).
?Polypora cf. P. lilæa Hall (Helderbergian).
?Ostracodes (several species).

2. Species of the Chapman sandstone listed from other localities are as follows:

Orbiculoidea discus Hall (Helderbergian).
Leptostrophia perplana (Conrad) ("Corniferous" to Chemung).
Including L. planulata Hall, the commonest Chapman form (Helderbergian).
Leptæna rhomboidalis Wilckens (Trenton to Mississippian).
Schuchertella deformis (Hall) (Helderbergian).
Hipparionyx unguiformis Conrad (Oriskany).
Chonetes novascoticus Hall (Aymestry to Ludlow faunas).
Dalmanella planiconvexa Hall (Helderberg to Oriskany).
Dalmanella cf. D. circularis (Sowerby) (Taunusian to Lower Coblenzian).
Stenoscisma formosa Hall (Helderbergian).
Eatonia singularis (Vanuxem) (Helderbergian).
Cyrtina rostrata Hall (Oriskany to "Corniferous").
Spirifer concinnus Hall (Helderbergian).
Spirifer cyclopterus Hall (Helderberg to Oriskany).
Nucleospira ventricosa Hall (Helderbergian).
Meristella cf. M. bella Hall (Helderbergian).
Grammysia acadica Billings (late Silurian).
Tellinites gibbosa var. kayseri Beushausen (Lower Coblenzian).
Tellinites gibbosa var. crassa Beushausen (Lower Coblenzian).
Nuculoidea cf. N. aquisgranensis Beushausen (Lower Coblenzian).
Megambonia (Preavicula) oblonga Hall (Helderbergian).
Cypricardella cf. C. bicostula Krantz (Siegen graywacke).
Plectonotus trilobatus (Sowerby) (late Silurian to Coblenzian).
Cœlocaulus planogyrata Hall (Helderbergian).
Homalonotus vanuxemi Hall (Helderbergian).
Pleurodictyum problematicum Goldfuss (Gedinnian to Coblenzian).
Tentaculites schlotheimi Koken (Taunusian).
Cornulites serpularis Schlotheim (Silurian and Lower Devonian).
Polypora lilæa Hall (Helderbergian).
Polypora psyche Billings (Oriskany).

[1] Williams, H. S., U. S. Geol. Survey Bull. 165, pp. 82 and 88, 1900. See also Am. Jour. Sci., 4th ser., vol. 14, pp. 203 et seq., 1900.

[2] While correcting the proof sheets of this paper I have received Clarke's "Conceptions regarding the American Devonic" (New York State Mus. Bull. 177, pp. 115-133, 1915). It should be noted that the manuscript of this paper was completed five years ago and that no attempt is now made to refer to the large amount of literature bearing upon many points herein discussed which has been published since 1910.—H S. Williams, October, 1915.

Of the species common to both horizons of the Chapman sandstone (list 1) those positively identified with previously described American species whose horizon in the New York section is definitely known are Helderbergian; these species number 5 out of the 14 listed. None of these common species is recorded in America from any horizon known to be distinct from the Helderbergian. Of the described species with which specimens of the Chapman sandstone have been identified (list 2, above), 12 are reported from only the Helderbergian of North America, 1 is reported from the "Corniferous," 2 are common to the Helderberg and Oriskany, 3 come from strata above the Helderberg, 1 from strata below the Helderberg, 1 from the Silurian, and 9 from European localities in the Lower Devonian. Removing the 9 European species from the 30 listed leaves 21 species, of which 15 occur in the Helderberg of America; 6 appear in formations above the Helderberg, 4 of which are Oriskany species. The distribution of the species throughout the Chapman sandstone and the identifications with described species make clear the correlation with the general Helderbergian fauna. A few species appear which were not present in the typical Helderbergian of North America, though they were present in the following Oriskany.

3. The following species recognized in the Chapman sandstone signify affinity with eastern transatlantic faunas:

Dalmanella cf. D. circularis (Sowerby).
Tellinites gibbosa var. kayseri (Beushausen).
Tellinites gibbosa var. crassa (Beushausen).
Nuculoidea cf. N. aquisgranensis (Beushausen).
Cypricardella cf. C. bicostatula (Krantz).
Plectonotus trilobatus (Sowerby).
Pleurodictyum problematicum Goldfuss.
Tentaculites schlotheimi Koken.
Cornulites serpularius Schlotheim.

4. Other species listed by Clarke [1] are the following:

Platyceras kahlebergensis Beushausen (Spirifer sandstone, Harz).
Loxonema cf. L. funatum A. Roemer (Spirifer sandstone, Harz).
Holopea beushauseni Clarke (see Macrocheilus?) (Spirifer sandstone).
Modiomorpha vulcanalis Clarke (see Goniophora cognata and Modiomorpha elevata) (Lower Coblenzian).
Grammysia modiomorpha Clarke (Upper Coblenzian).
Spirifer macropleuroides Clarke (Lowest Devonian, Harz and Bohemia).
Chonetes aroostooki Clarke (Tilestone and Spirifer sandstone).
Leptostrophia magnifica parva Clarke (Coblenzian).
Dalmanella drevermanni Clarke (Coblenzian).
Cœlidium tenue Clarke (Spirifer sandstone).
Eotomaria hitchcocki Clarke (Tilestones and Spirife) sandstone).
Pterinea cf. P. fasciculata Goldfuss.
Paleoneilo mainensis Clarke (Coblenzian).
Nucula cf. N. krachtæ A. Roemer (Coblenzian).
Paleosolen simplex Maurer (Coblenzian).
Spirifer subcuspidatus lateincisus Scupin (Coblenzian).
Spirifer cymindis Clarke (Upper Coblenzian).
Spirifer cymindis var. sparsa Clarke (cf. Coblenzian).

From the foregoing lists it is evident that this fauna is intimately related on the one hand to the Tilestone fauna of England and on the other hand to the so-called Hercynian fauna of the Continent, the opinion expressed in 1900,[2] after a preliminary study of this fauna, being abundantly confirmed.

This faunal relationship must not be confused with either formational or chronologic identity. The fact that the same species occur in beds on the two sides of the Atlantic indicates that the sediments of the two regions were deposited within the period of time during which the species lived together in a faunal community; but it does not necessarily follow that there was, at the exact time of deposition of the Chapman sandstone, an open-sea connection between the two areas, through which the species were distributed by migration.

The conclusion advanced above is supported by the presence of identical species on both sides of the Atlantic, but, on the other hand, there is abundant evidence of unlike species distinguishing the Chapman fauna from both the Tilestone and the Coblenzian faunas of Europe.

On comparing the Chapman fauna with transatlantic faunas, it should be noticed that the fauna which succeeds the Tilestone (Downtonian) of Great Britain is of brackish-water habitat (the Old Red sandstone), and that in northern Europe the fauna preceding the Taunusian and the Coblenzian is the Gedinnian, which is not directly represented in America.

[1] Clarke, J. M., New York State Mus. Bull. 107, pp. 153–291, 1907.

[2] Williams, H. S., Silurian-Devonian boundary in North America; 1. The Chapman sandstone fauna: Am. Jour. Sci., 4th ser., vol. 9, pp. 203–213, March, 1900.

Similar differences are observed in the changes marking the sections of Gaspe and New York. Before Middle Devonian time brackish-water and land areas had developed along the eastern border of North America (New Brunswick and Nova Scotia), while over New York marine sedimentation was in progress. The fact that the marine faunas preceding this continental uplift have common species on both sides of the Appalachian divide and in Europe shows evidence of a connection whereby species could pass from one sea to the other. In Middle Devonian time, however, the faunas of New York and north continental Europe were evidently developed in separate basins.

These facts indicate that the elevation which brought in the Old Red sandstone sedimentation in central and northern Great Britain was connected with the upward lifting in eastern North America, but that the change from marine to land conditions in Great Britain may not have been quite contemporaneous with the corresponding change marking the passage from marine beds to brackish-water sandstone in the eastern provinces of Canada. It is not surprising, therefore, to find the faunas of this transition period in the marine region showing closer affinity with the Lower Devonian faunas of Europe than with the typical Lower Devonian faunas of New York; nor is it surprising to find the European Lower Devonian faunas carrying many species which are present in the New York Middle Devonian, these species making their way into New York across the Atlantic in Lower Devonian instead of Middle Devonian time and finding expression in these transition faunas of the eastern provinces. The remarkable combination of species in the more recent of the limestone blocks in the breccias of St. Helens Island [1] confirms this view.

In northern Europe the greatest faunal change in the early true Devonian appears to have taken place at the horizon separating the Upper Coblenzian from the Lower Coblenzian beds. As Frech [2] notes, the genera Tropidoleptus, Rensselaeria, and Cypricardella are lacking in the "zone of Spirifer paradoxus," although they are common in the lower beds, and *Orthis (Dalmanella) circularis* Sowerby is also found in the lower but not in the upper beds. The upper beds, however, contain many species which range below into the Lower Coblenzian; and the marine faunas, even with change of species, do not indicate so much a breaking up of the marine fauna as an introduction of new types and departure of old types with the advance in the succession. For purposes of correlation between the European and American sections, it should be remembered that the species in the Chapman fauna which are identical with the European forms belong to the faunas which are well developed before the beginning of the Upper Coblenzian, rather than to the fauna conspicuous after that time.

From both the European and the American relations of the Chapman fauna it seems to be strictly Lower Devonian; it presents close affinity with the Helderbergian fauna of New York, but shows a greater mixture of European types than the typical Helderbergian. In comparison with the northern Europe section, the Chapman fauna shows affinity with the Lower Devonian, particularly with that portion of it below the Upper Coblenzian. It is a later fauna than the Tilestone or Downtonian of Great Britain or the terminal marine fauna of Arisaig, Nova Scotia.

If in place of examining the fauna as a whole we select for comparison special biologic groups of species, the result points in the same direction.

The biologic group presenting the greatest number of species recognized as identical with species already registered is that of the brachiopods. Of these 28 species are listed in this report, and 19 of them are identified with species already described. The following species are listed by Schuchert [3] as restricted to the Helderberg:

Orbiculoidea (Roemerella) discus Hall.
Schuchertella deformis (Hall).
Stenocisma formosa Hall.
Eatonia singularis (Vanuxem).
Spirifer concinnus Hall.
Nucleospira ventricosa Hall.
Meristella cf. M. bella Hall.

[1] Williams, H. S., On the fossil faunas of the St. Helens breccias: Roy. Soc. Canada Trans., 3d ser., vol. 3, pp. 205-246, 1910.
[2] Frech, Fritz, Lethæa palæozoica, vol. 2, p. 151, 1897.
[3] Schuchert, Charles, A synopsis of American fossil Brachiopoda: U. S. Geol. Survey Bull. 87, pp. 43 et seq., 1897.

One species is exclusively Oriskany:

Hipparionyx unguiformis Conrad (=H. proximus Vanuxem).

The following species range through both the Helderberg and the Oriskany:

Leptæna rhomboidalis Wilckens.	Cyrtina rostrata Hall.
Dalmanella planiconvexa Hall.	Spirifer cyclopterus Hall.

Thus 12 of the previously registered species of Brachiopoda belong to the known Helderberg and Oriskany of America (as known in 1897). In Schuchert's revision [1] of the faunas in 1900, the species listed as strictly Helderbergian were still so restricted. I conclude, therefore, that the evidence furnished by the brachiopods strongly indicates the same fauna which characterized the deposits of Helderbergian age in the interior, with admixture of species belonging to an arenaceous phase of the deposits which was of later expression in the interior, and that the Chapman fauna is to be correlated with the Helderbergian fauna of the interior seas.

The species of brachiopods which constitute the most conspicuous part of the faunas collected in the Chapman sandstone are as follows:

Rensselaeria mainensis.	Spirifer concinnus.	Chonetes novascoticus.
Spirifer sparsus.	Spirifer cyclopterus.	Chonetes striatissimus.

This combination is decidedly distinct from any reported west of Hudson River in North America. Although *Spirifer concinnus* and *S. cyclopterus* are well represented in the Helderbergian faunas of New York, Maryland, and Virginia, *S. concinnus* is not reported from the interior North American localities of that fauna. The genus Rensselaeria is represented in both the Helderbergian and the Oriskanian faunas, but the three species of the Helderbergian fauna of interior North America are restricted in range to the outcrops of eastern New York. The particular species which is found abundantly in the Chapman sandstone shows affinity with the European *Rensselaeria strigiceps* in possessing a distinct cardinal area, a feature believed to be an early character of the race. But whether or not it is associated with an early stage of evolution, the dominance of this character places the species evolutionally at a time horizon different from that of the Oriskanian fauna of New York, in which the dominant characters of the genus are specifically distinct. The area of the pedicle valve appears to be present in small specimens, but it is conspicuous only in large specimens in which the shell substance is greatly thickened about the beaks and does not show in casts of the interior of shells showing both valves, though single shells show the area in the molds of the interior of pedicle valves. The Chonetes are of a type not seen in the Helderbergian fauna of the interior, though they are present in the still earlier Silurian. This type appears in the Arisaig succession.

Of the Chapman brachiopods the following identified species are listed also by J. M. Clarke in other faunas east of Hudson River:

Leptostrophia perplana (Conrad) (as L. blainvillei (Billings)), from the Gaspe sandstone.
Leptæna rhomboidalis Wilckens, from the St. Albans, Cape Bon Ami, Grande Greve, and Dalhousie formations.
Hipparionyx unguiformis (H. proximus Vanuxem), from the Grande Greve and the Moose River sandstone.
Anoplia nucleata Hall, from the Grande Greve beds.
Cyrtina rostrata Hall, from the Grande Greve beds.
Spirifer cyclopterus Hall, from the Grande Greve beds.
Nucleospira ventricosa Hall, from the Grande Greve beds and St. Albans beds.

Regarding the form listed above as *Leptostrophia perplana*, examination of the various forms of the *perplana* type found in the Helderberg and Oriskany fauna seems to indicate that the size, slight differences in outline, and apparent differences in fineness of the striæ are not constant, and I have adopted *perplana* as a specific name, recognizing such forms as *magnifica* of Hall and *irene*, *tullia*, and *blainvillei* of Billings as local varieties. In correlation, therefore, Clarke's identification of *magnifica* and *tullia* brings the form listed in this volume in the Chapman fauna among those listed by Clarke from the Grande Greve and St. Albans beds. Therefore seven of the specifically identified species of brachiopods of the Chapman sandstone occur also in the Grande Greve beds of Gaspe Peninsula.

[1] Schuchert, Charles, Lower Devonic aspect of the Lower Helderberg and Oriskany formations: Geol. Soc. America Bull., vol. 11, pp. 241-332, 1900.

There are fewer of the Oriskanian species in the Chapman fauna than in the Grande Greve fauna, and the evidence seems to indicate a somewhat earlier stage for the Chapman than for the Grande Greve. The community of characteristic species, however, indicates close association of the two faunas.

This brachiopod evidence leads to the conclusion that the Chapman fauna is probably somewhat older than the Grande Greve fauna and certainly older than that of the York River (Gaspe sandstone) beds. It is also older than the faunas of the Moose River sandstone of Maine and the Nictaux beds of New Brunswick.

FAUNA OF THE MOOSE RIVER SANDSTONE.

In this work several species from the Moose River sandstone have been mentioned and figured. It has not been the purpose to describe the fauna of this formation; the species selected were brought in for comparison, chiefly to show that stratigraphically the Chapman fauna lies below this eastern representative of the Oriskanian fauna of New York. From the species cited it is evident that this Moose River sandstone is roughly equivalent to the Oriskany sandstone of New York and the York River (Gaspe sandstone) of Gaspe Peninsula. As has been shown in the descriptions, most of the Moose River species cited do not occur in the Chapman fauna. With regard to the species of the Chapman fauna that are closely related to Moose River species the evidence is clear that the Chapman forms are earlier representatives of the evolutional lines to which they belong than the Moose River forms. In conclusion, attention is directed to the correlations of individual species to be found in the body of the paper.

SOURCE OF THE SPECIES OF THE CHAPMAN FAUNA.

While the species and genera have been under investigation, the question of their source has been constantly in mind. The evidence is clear that compared with corresponding faunas to the west the Chapman fauna shows greater affinities with transatlantic faunas; but the number of species identical with European forms is too few to lead to the supposition that the Chapman fauna had a different source from the corresponding New York faunas. It is more probable that the slight differences between it and the New York Helderbergian may be accounted for by local conditions and slight differences in age, rather than by a different source.

The details of comparison from which these conclusions are drawn are brought out in the discussions of the genera and species in the body of the work, in which are recorded an abundance of references to closely allied species in every part of the world. These references furnish a contribution to the solution of the problem of sources, the study of which must be carried much further before generalizations of permanent value can be made.

PLATES.

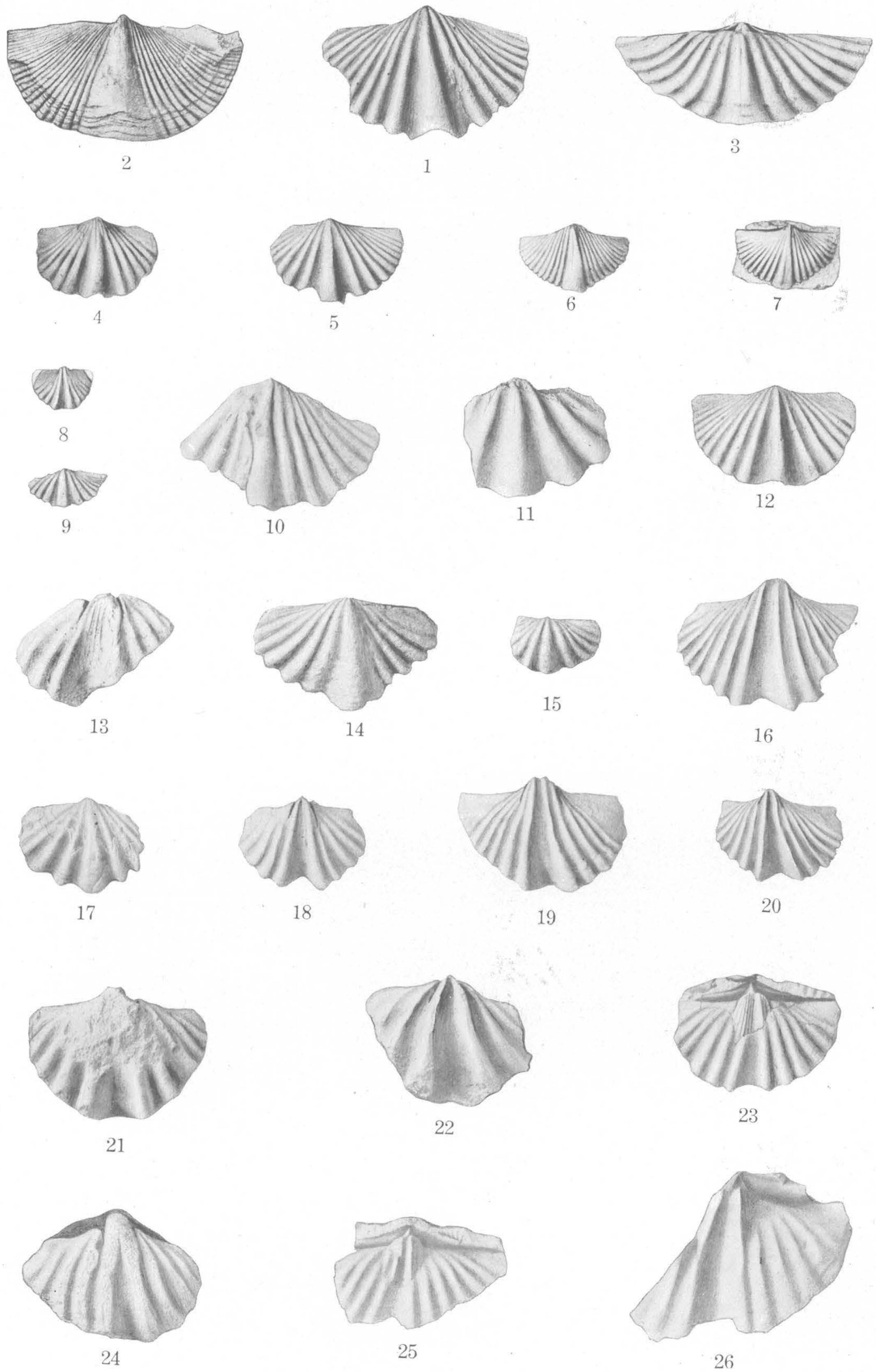
PLATE I.

[All the figures on this plate are approximately of natural size.]

Figures 1, 4, 5, 8, 9, 12, 16, 18, 19, 20, *Spirifer cyclopterus* Hall (p. 88). (See also Pl. II, figs. 3, 5, 6, 7, 8, 10, 13, 14, 20, and Pl. IV, figs. 1, 10.)
Figure 2, *Spirifer montrealensis* Williams (p. 113). (See also Pl. II, figs. 2, 18.)
Figures 3, 10, 23, 25, 26, *Spirifer murchisoni* Castelnau (p. —). (See also Pl. II, fig. 9, and Pl. IV, figs. 8 (?), 9 (?).)
Figures 6, 7, *Spirifer concinnus* Hall (p. 89). (See also Pl. II, figs. 1, 4, 11, 12; Pl. III, fig. 8; Pl. IV, figs. 5, 6; Pl. V, figs. 16, 17.)
Figures 11, 13, 14, 15, 17, 21, 22, 24, *Spirifer sparsus* Clarke (p. 105). (See also Pl. II, fig. 17; Pl. IV, fig. 2.)

1. *Spirifer cyclopterus* Hall. Internal mold of a very large brachial valve, the largest seen. There are eight or nine ribs on each side. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
2. *Spirifer montrealensis* Williams (="Spirifer cf. *S. granulosus* Conrad" Schuchert). A large brachial valve in partial cast, showing between 16 and 22 narrow ribs on each side of the rounded fold. There are faint indications in the original of a slight groove in the upper part of the fold, but in the retouching the fold has been made to appear smooth. Breccias of St. Helens Island, Montreal, Canada.
3. *Spirifer murchisoni* Castelnau. An average brachial valve in internal mold, showing a rather low rounded fold and six ribs on each side. Moose River sandstone, Detroit, Somerset County, Maine.
4. *Spirifer cyclopterus* Hall. A brachial valve of average size in internal mold. There are only five or six ribs on each side; the outline is less transverse and more nearly square than in the specimen shown in figure 1. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
5. *Spirifer cyclopterus* Hall. Another brachial valve in internal mold, showing the rounded cardinal extremity on the right. There are on this side only seven ribs in the original, possibly eight. In retouching, the specimen has been made to appear to have nine ribs on the side. Chapman sandstone, same locality as figure 4.
6. *Spirifer concinnus* Hall. Internal mold of a gibbous brachial valve with nine or ten ribs on each side and of average size and proportions but having the fold simple. Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.
7. *Spirifer concinnus* Hall. A brachial valve in internal mold. This shows a deep median groove in the median fold, almost dividing the fold into two ribs. This character is more or less developed in most Maine specimens and shows a similarity to *S. excavatus* Kayser. Chapman sandstone, same locality as figure 6.
8. *Spirifer cyclopterus* Hall. A small pedicle valve in internal mold; six ribs on each side. This is the smallest specimen of the species in the collection. Chapman sandstone, same locality as figure 4.
9. *Spirifer cyclopterus* Hall. A small brachial valve in internal mold; seven ribs on each side. Chapman sandstone, same locality as figure 4.
10. *Spirifer murchisoni* Castelnau. A brachial valve of average size in partial cast; six ribs on each side. Moose River sandstone, Detroit, Somerset County, Maine.
11. *Spirifer sparsus* Clarke. A brachial valve in internal mold with three strong undulations or folds on each side. This is not the normal aspect of the species but shows a close similarity to *Delthyris raricosta*. Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
12. *Spirifer cyclopterus* Hall. A brachial valve of rather large size; internal mold; eight ribs on each side. Chapman sandstone, same locality as figure 4.
13. *Spirifer sparsus* Clarke. A pedicle valve in internal mold; four ribs on each side. The musculature is impressed a little more strongly than usual in the species, though not so strongly as in *S. murchisoni* (cf. figs. 25, 26). Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.
14. *Spirifer sparsus* Clarke. A rather large complete brachial valve in internal mold, showing the broadly rounded hinge extremities, the high subcarinate median fold extended in front, and with four or five ribs on each side. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
15. *Spirifer sparsus* Clarke. A rather small brachial valve in partial cast, showing strongly elevated, rounded to subangular ribs, four on each side of the fold. Chapman sandstone, same locality as figure 14.
16. *Spirifer cyclopterus* Hall. A large pedicle valve in internal mold, showing the deep sinus with eight ribs on each side; the musculature is impressed strongly for this species, but is relatively weak compared with that in *S. murchisoni* (cf. figs. 25, 26). Chapman sandstone, same locality as figure 4.
17. *Spirifer sparsus* Clarke. A brachial valve somewhat similar in appearance to that shown in figure 11. Chapman sandstone, same locality as figure 4.
18. *Spirifer cyclopterus* Hall. A pedicle valve in internal mold, with a strongly impressed musculature; only five ribs on each side the median sinus. Chapman sandstone, same locality as figure 4.

19. *Spirifer cyclopterus* Hall. Another pedicle valve; five or six ribs on each side. Chapman sandstone, same locality as figure 4.
20. *Spirifer cyclopterus* Hall. Another pedicle valve; six or seven ribs on each side. Chapman sandstone, same locality as figure 4.
21. *Spirifer sparsus* Clarke. A rather large internal mold of a pedicle valve, showing a common aspect of the species with regard to the number of plications, their appearance, the outline, etc. Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.
22. *Spirifer sparsus* Clarke. Internal mold of a pedicle valve with three or four strong undulations or ribs, somewhat resembling *S. macropleurus*. This is not the usual aspect of the Maine species but represents the same form as figure 11. Chapman sandstone, same locality as figure 11.
23. *Spirifer murchisoni* Castelnau. A pedicle valve, the right side below the musculature in external cast, the remainder in internal mold; five or six rounded ribs on each side. Note the high and arched cardinal area and the normally very pronounced musculature of the species. Moose River sandstone, Detroit, Somerset County, Maine.
24. *Spirifer sparsus* Clarke. A pedicle valve of normal aspect with cardinal area of moderate height and arched. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
25, 26. *Spirifer murchisoni* Castelnau. Two pedicle valves, a little different in outline, showing the typical musculature of the species and the moderately high arched cardinal area. Moose River sandstone, Detroit, Somerset County, Maine.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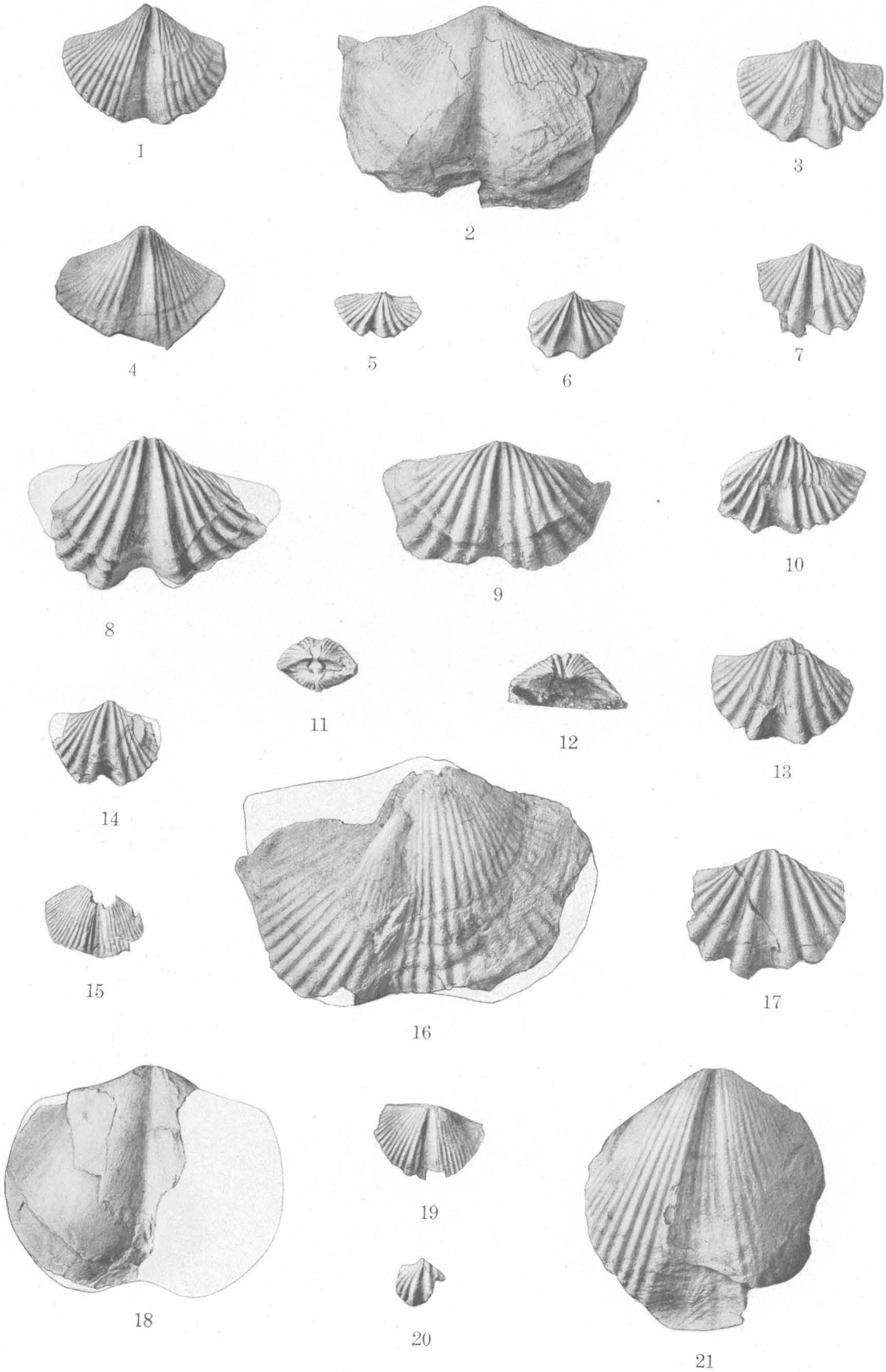
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PLATE II.

[All the figures on this plate are of approximately natural size.]

Figures 1, 4, 11, 12, *Spirifer concinnus* Hall (p. 80). (See also Pl. I, figs. 6, 7; Pl. III, fig. 8; Pl. IV, figs. 5, 6; Pl. V, figs. 16, 17.)
Figures 2, 18, *Spirifer montrealensis* Williams (p. 113). (See also Pl. I, fig. 2.)
Figures 3, 5, 6, 7, 8, 10, 13, 14, 20, *Spirifer cyclopterus* Hall (p. 88). (See also Pl. I, figs. 1, 4, 5, 8, 9, 12, 16, 18, 19, 20; Pl. IV, figs. 1, 10.)
Figure 9, *Spirifer murchisoni* Castelnau (p. 95). (See also Pl. I, figs. 3, 10, 23, 25, 26; Pl. IV, figs. 8 (?), 9 (?).)
Figures 15, 16, 19, 21, *Spirifer arenosus* Conrad (p. 84). (See also Pl. III, fig. 1; Pl. V, fig. 18.)
Figure 17, *Spirifer sparsus* Clarke (p. 105). (See also Pl. I, figs. 11, 13, 14, 15, 17, 21, 22, 24; Pl. IV, fig. 2.)

1. *Spirifer concinnus* Hall. A large pedicle valve in partial cast, with nine to ten or eleven ribs on each side of the angular sinus. Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.
2. *Spirifer montrealensis* Williams. Ventral view of a large pedicle valve showing the sinus without any riblet in the middle and its bounds not sharply defined. Breccias of St. Helens Island, Montreal, Canada.
3. *Spirifer cyclopterus* Hall. External cast of pedicle valve; seven or eight ribs on each side. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
4. *Spirifer concinnus* Hall. A pedicle valve in external cast; eleven ribs are discernible on each side; there may have been twelve to thirteen or fourteen. Breccias of St. Helens Island, Montreal, Canada.
5. *Spirifer cyclopterus* Hall. A small pedicle valve showing very low beak. Compare with the umbo in figures 3 and 8. Chapman sandstone, same locality as figure 3.
6. *Spirifer cyclopterus* Hall. A small pedicle valve in partial cast, with only four or five ribs on each side. Chapman sandstone, same locality as figure 3.
7. *Spirifer cyclopterus* Hall. External cast of pedicle valve, internal mold in front; only five or six ribs on mold, seven or eight ribs on external surface. Chapman sandstone, same locality as figure 3.
8. *Spirifer cyclopterus* Hall. Very large pedicle valve in external cast; seven or eight ribs on each side. This is the largest specimen of the species in the collection. Chapman sandstone, same locality as figure 3.
9. *Spirifer murchisoni* Castelnau. Exterior cast of pedicle valve. Note the weak ribs bounding the sinus and the characteristic transverse extension of the species. Moose River sandstone, Detroit, Somerset County, Maine.
10. *Spirifer cyclopterus* Hall. A gibbous pedicle valve with seven or eight ribs on each side and acute lateral extremities. Chapman sandstone, same locality as figure 3.
11. *Spirifer concinnus* Hall. Cardinal view of a small internal mold, showing the pedicle valve not much more convex than the brachial and with an arched cardinal area of moderate height. Chapman sandstone, same locality as figure 1.
12. *Spirifer concinnus* Hall. Cardinal view of another pedicle valve to show the area. Chapman sandstone, same locality as figure 1.

13, 14. *Spirifer cyclopterus* Hall. Two small pedicle valves, exterior cast, with six or seven ribs on each side. Chapman sandstone, same locality as figure 3.

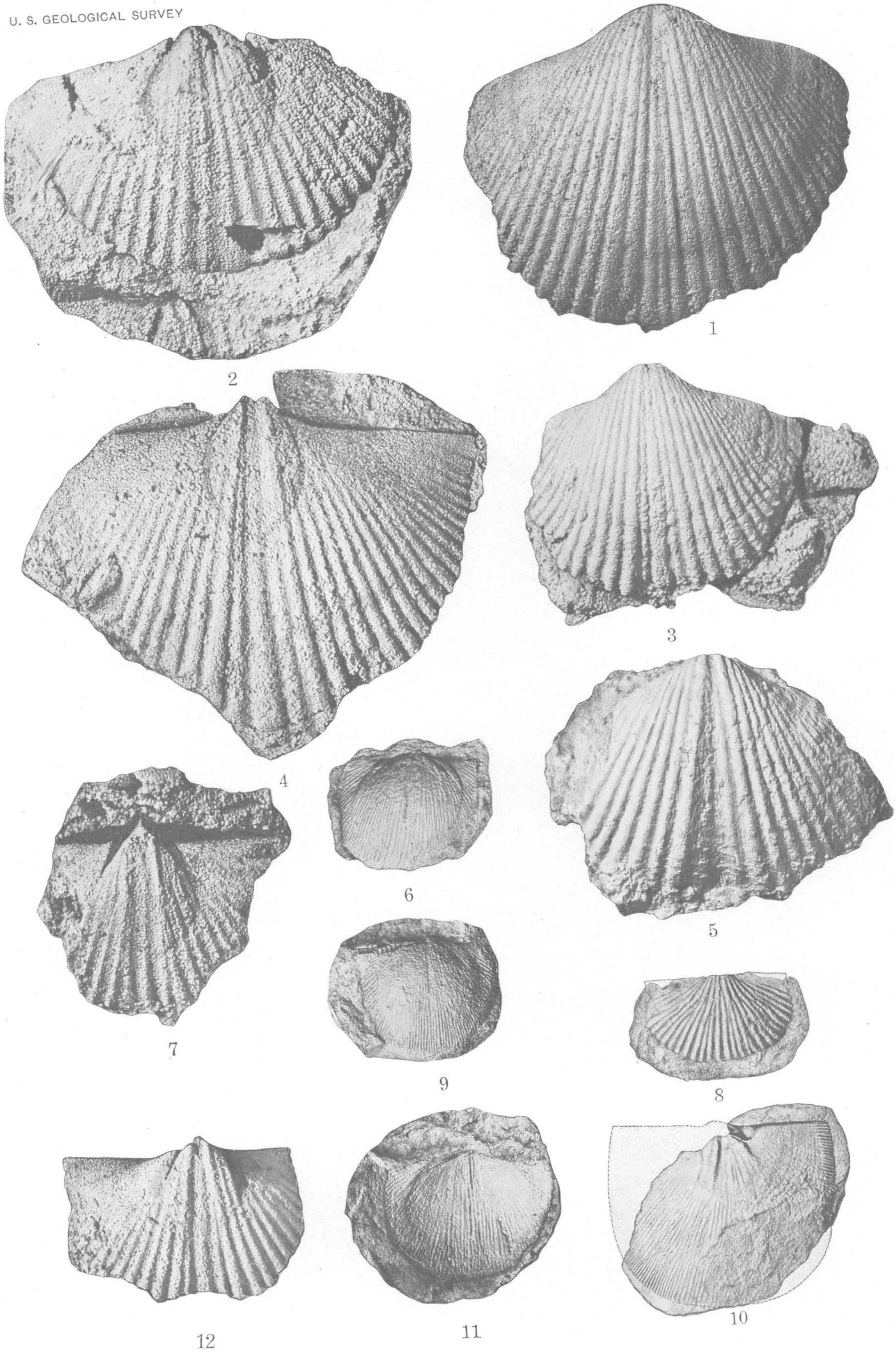
15. *Spirifer arenosus* Conrad. Exterior of a small pedicle valve with sixteen or more ribs on each side. Moose River sandstone, Detroit, Somerset County, Maine.
16. *Spirifer arenosus* Conrad. A mature pedicle valve in partial cast, showing traces of the large *S. murchisoni* type of musculature; about eighteen simple ribs on each side. Moose River sandstone, same locality as figure 15.
17. *Spirifer sparsus* Clarke. A pedicle valve (exterior cast) showing the characteristic three strong ribs on each side of the narrow sinus and two faint ones beyond. In retouching the photograph the fourth rib on the right side has been made to appear a trifle too strong. Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
18. *Spirifer montrealensis* Williams. A partial cast of a mature pedicle valve, showing the sinus angular in the bottom with undefined margins and without a median riblet. Breccias of St. Helens Island, Montreal, Canada.
19. *Spirifer arenosus* Conrad. A small pedicle valve, exterior cast, similar to that shown in figure 15. Moose River sandstone, same locality as figure 15.
20. *Spirifer cyclopterus* Hall. Exterior cast of a small pedicle valve only 8 millimeters long, with four or five ribs on each side. Chapman sandstone, same locality as figure 3.
21. *Spirifer arenosus* Conrad. An exterior cast in wax. Moose River sandstone, same locality as figure 15.

PLATE III.

[All the figures on this plate are enlarged 2 diameters except fig. 10.]

Figure 1, *Spirifer arenosus* Conrad (p. 84). (See also Pl. II, figs. 15, 16, 19, 21; Pl. V, fig. 18.)
Figures 2, 3, 4, 7, 12, *Spirifer arenosus* var. *simplex* var. nov. (p. 86).
Figure 5, *Spirifer concinnus* Hall (p. 80). (See also Pl. I, figs. 6, 7; Pl. II, figs. 1, 4, 11, 12; Pl. IV, figs. 5, 6; Pl. V, figs. 16, 17.)
Figures 6, 9, 11, *Chonetes* (*Eodevonaria*) *arcuatus* Hall (p. 53).
Figure 8, *Chonetes vicinus* var. *deflectus* Hall (p. 49).
Figure 10, *Schuchertella woolworthana* Hall (p. 34).

1. *Spirifer arenosus* Conrad. Exterior of a silicified pedicle valve, showing a mature type of plicated sinus in the typical form of the species, the median rib bifurcating early in its growth and halfway down developing a secondary rib by implantation between the two branches of the original rib. × 2. Oriskany sandstone, Keyser, Mineral County, W. Va.
2. *Spirifer arenosus* var. *simplex* var. nov. Internal mold of a pedicle valve in a coarse quartzitic sandstone. × 2. Oriskany sandstone, Keyser, Mineral County, W. Va.
3. *Spirifer arenosus* var. *simplex* var. nov. Exterior of a silicified pedicle valve, showing the typical feature of the variety—a thick, undivided rib in the middle of the sinus and a single weaker rib on each side, formed by bifurcation of the marginal ribs of the sinus. × 2. Oriskany sandstone, same locality as figure 1.
4. *Spirifer arenosus* var. *simplex* var. nov. Internal mold of a pedicle valve, showing the characteristic embryonic type of plicated sinus of this variety; this specimen is larger than that shown in figure 1, which bears the normal or mature plicated sinus of the typical form of the species. × 2. Oriskany sandstone, same locality as figure 2.
5. *Spirifer concinnus* Hall. Partial cast of pedicle valve, showing the large form of the species, with 13 or 14 ribs on each side, the sinus shallow, and the faintly appearing riblet on each side. × 2. Oriskany sandstone, Covington, Alleghany County, Va.
6. *Chonetes* (*Eodevonaria*) *arcuatus* Hall. Mold of interior of pedicle valve, showing the gibbous body and flattened ears, the septum and lineation of surface. × 2. Moose River sandstone, Little Brassua Lake, Somerset County, Maine.
7. *Spirifer arenosus* var. *simplex* var. nov. Fragment of internal mold of this variety, the usual form in the collections from this locality. × 2. Oriskany sandstone, same locality as figure 2.
8. *Chonetes vicinus* var. *deflectus* Hall. A small imperfect pedicle valve, showing the lineation of the surface; the hinge margin imperfect. × 2. Moose River sandstone, same locality as figure 6.
9. *Chonetes* (*Eodevonaria*) *arcuatus* Hall. Mold of interior of pedicle valve, showing on the left side the crenulate hinge area. × 2. Moose River sandstone, same locality as figure 6.
10. *Schuchertella woolworthana* Hall. An internal mold of a brachial valve, showing the outlines and portions of the shell perfectly. Natural size. Moose River sandstone, Big Brassua Lake, Somerset County, Maine.
11. *Chonetes* (*Eodevonaria*) *arcuatus* Hall. A somewhat larger pedicle valve than those shown in figures 6 and 9, illustrating strongly gibbous body part of shell, flattened ears and septum; also on the right the crenulate hinge area. × 2. Moose River sandstone, same locality as figure 6.
12. *Spirifer arenosus* var. *simplex* var. nov. Fragment of internal mold of pedicle valve showing impressions of the plications on the umbonal area, musculature weak. × 2. Oriskany sandstone, same locality as figure 2.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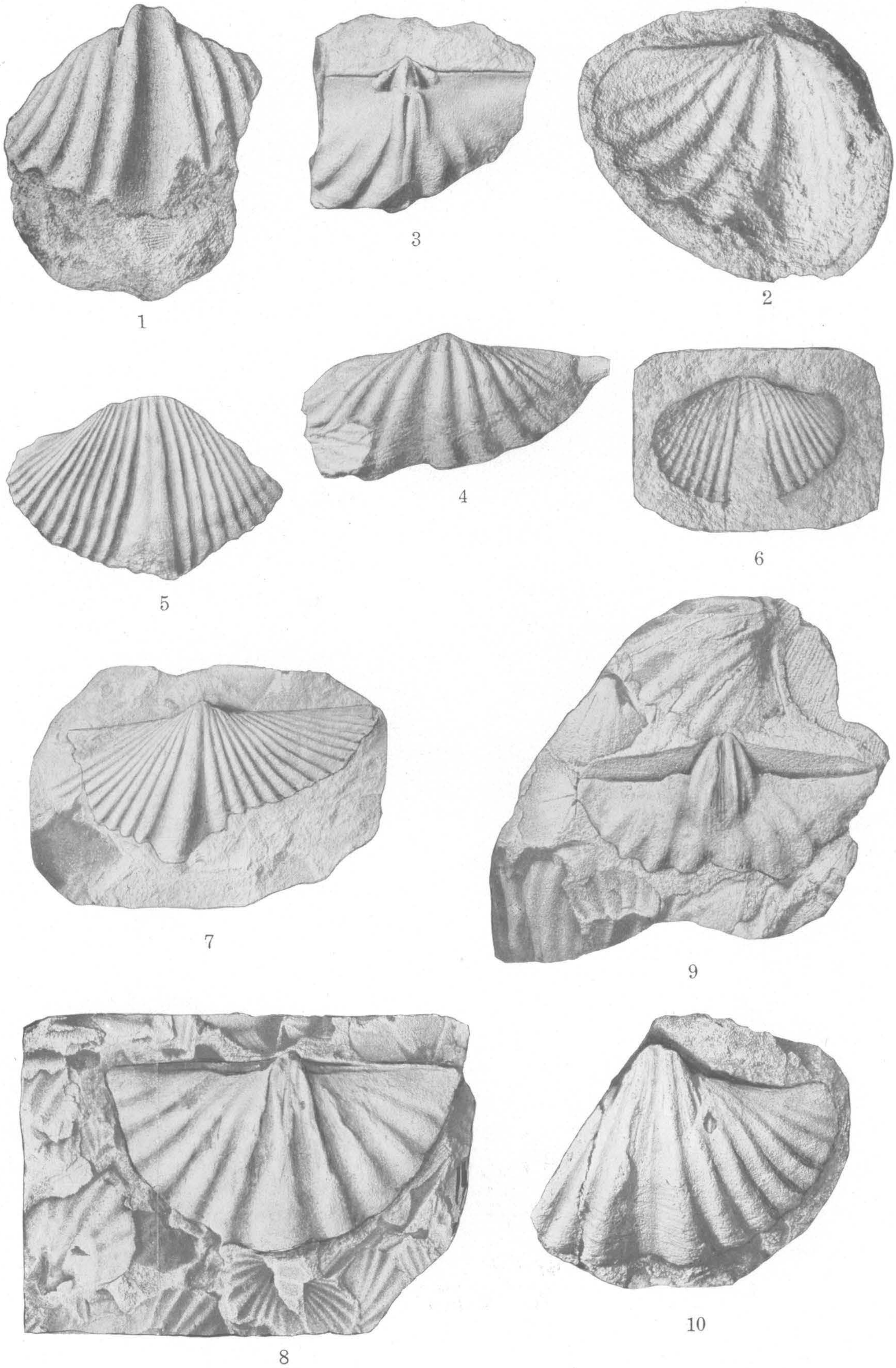
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PLATE IV.

[All the figures on this plate are enlarged 2 diameters.]

Figures 1, 10, *Spirifer cyclopterus* Hall (p. 88). See also Pl. I, figs. 1, 4, 5, 8, 9, 12, 16, 18, 19, 20; Pl. II, figs. 3, 5, 6, 7, 8, 10, 13, 14, 20.)
Figure 2, *Spirifer sparsus* Clarke (p. 105). See also Pl. I, figs. 11, 13, 14, 15, 17, 21, 22, 24; Pl. II, fig. 17.)
Figures 3, 4, Spirifer cf. *S. duodenarius* Hall (p. 104).
Figures 5, 6, *Spirifer concinnus* Hall (p. 80). (See also Pl. I, figs. 6, 7; Pl. II, figs. 1, 4, 11, 12; Pl. III, fig. 8; Pl. V, figs. 16, 17.)
Figure 7, *Spirifer gaspensis* Billings (p. 107).
Figures 8, 9, *Antispirifer harroldi* var. *transversa* gen., sp., et var. nov. (p. 117).

1. *Spirifer cyclopterus* Hall. Internal mold of a pedicle valve. × 2. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
2. *Spirifer sparsus* Clarke. Brachial valve; internal mold, left side. × 2. Chapman sandstone, same locality as figure 1.
3. *Spirifer duodenarius* Hall. Internal mold of a fragment of a brachial valve, showing a slight cardinal area, the muscular and septal scars, etc. × 2. Moose River sandstone, Big Brassua Lake, Somerset County, Maine.
4. *Spirifer duodenarius* Hall. Ventral view of a rather small individual in partial cast, showing the transverse outline, five or six rounded ribs, and a relatively narrow rounded sinus. × 2. Moose River sandstone, same locality as figure 3.
5. *Spirifer concinnus* Hall. A rather large brachial valve with 11 or 12 ribs on each side. The exterior of the fold must have been strongly bifid, as in *S. excavatus* Kayser. × 2. Chapman sandstone, west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
6. *Spirifer concinnus* Hall. A small specimen with small rounded cardinal extremities, showing sulcus along the center of the medial fold of the brachial valve. × 2. Chapman sandstone, same locality as figure 5.
7. *Spirifer gaspensis* Billings. Internal mold of a medium-sized brachial valve, showing the characteristic transverse outline and high medial fold, with 12 or 13 ribs on the side. × 2. Moose River sandstone, Little Brassua Lake, Somerset County, Maine.
8. *Antispirifer harroldi* var. *transversa* gen., sp. et var. nov. A large brachial valve in internal mold, showing the close resemblance of this valve to the corresponding valve of *Spirifer murchisoni*. (Compare Pl. I, fig. 3.) Common in a mass of *Leptocœlia flabellites*. Moose River sandstone, Parlin Pond, Somerset County, Maine.
9. *Antispirifer harroldi* var. *transversa* gen., sp. et var. nov. Pedicle valve, internal mold, showing the characteristic flat cardinal area of the species. × 2. Moose River sandstone, Parlin Pond, Somerset County, Maine.
10. *Spirifer cyclopterus* Hall. Pedicle valve with unusually strong musculature. × 2. Chapman sandstone, west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

PLATE V.

[All the figures on this plate are of approximately natural size.]

Figures 1-13, *Antispirifer harroldi* gen. et sp. nov. (p. 116).
Figure 14, *Cyrtina rostrata* Hall (p. 76).
Figure 15, *Cyrtina heteroclita* Defrance var. (p. 79).
Figures 16, 17, *Spirifer concinnus* Hall (p. 80). (See also Pl. I, figs. 6, 7; Pl. II, figs. 1, 4, 11, 12; Pl. III, fig. 8; Pl. IV, figs. 5, 6.)
Figure 18, *Spirifer arenosus* Conrad (p. 84). (See also Pl. II, figs. 15, 16, 19, 21; Pl. III, fig. 1.)
Figures 19-30, *Leptocœlia flabellites* Conrad (p. 120).
Figures 31-33, *Nucleospira ventricosa* Hall (p. 118).

1. *Antispirifer harroldi* gen. et sp. nov. Wax impression of the external mold of a pedicle valve, showing the outline and proportions, very depressed convexity, five or six rounded ribs on each side, the narrow, abrupt median sinus, and the lamellose concentric ornamentation. Moose River sandstone, Parlin Pond, Somerset County, Maine.

2. *Antispirifer harroldi* gen. et sp. nov. External mold of pedicle valve, showing the flat surface and lamellose concentric ornamentation. Fine radial lines, especially well developed near the edges of the lamellæ, are present on the original but do not appear in the figure. (See fig. 8.) Moose River sandstone, Detroit, Somerset County, Maine.

3. *Antispirifer harroldi* gen. et sp. nov. Wax impression of external mold of exterior of pedicle valve, showing six or seven rounded ribs and narrow abrupt sinus. (See fig. 9.) Moose River sandstone, same locality as figure 2.

4. *Antispirifer harroldi* gen. et sp. nov. The convex or brachial valve in partial cast with six rounded ribs on each side of the low rounded fold. Moose River sandstone, same locality as figure 2.

5, 6, 7. *Antispirifer harroldi* gen. et sp. nov. Internal molds of pedicle valves, showing the characteristic very wide, strongly impressed musculature and the flat cardinal area of medium height; the latter character well indicated in figures 6 and 7. Moose River sandstone, same locality as figure 2.

8. *Antispirifer harroldi* gen. et sp. nov. Wax impression of the original specimen of figure 2.

9. *Antispirifer harroldi* gen. et sp. nov. External mold of the original specimen from which was taken the wax impression shown in figure 3. Moose River sandstone, same locality as figure 2.

10, 11, 12. *Antispirifer harroldi* gen. et sp. nov. Three flat pedicle valves in partial cast, illustrating the usual appearance in the hard unweathered rock. Moose River sandstone, same locality as figure 2.

13. *Antispirifer harroldi* gen. et sp. nov. Fragments of two brachial valves in internal mold, so superimposed that the figure seems to represent only one fractured valve. Moose River sandstone, same locality as figure 2.

14. *Cyrtina rostrata* Hall. Cardinal view of an internal mold of a pedicle valve, showing the high, nonarching cardinal area and narrow covered delthyrium. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

15. *Cyrtina heteroclita* Defrance var. *alpha*. A worn internal mold of pedicle valve, showing faint indications of ribs. Chapman sandstone, same locality as figure 14.

16, 17. *?Spirifer concinnus* Hall. Two decorticated brachial valves referred to this species. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

18. *Spirifer arenosus* Conrad. Internal mold of a small pedicle valve. Moose River sandstone, Detroit, Somerset County, Maine.

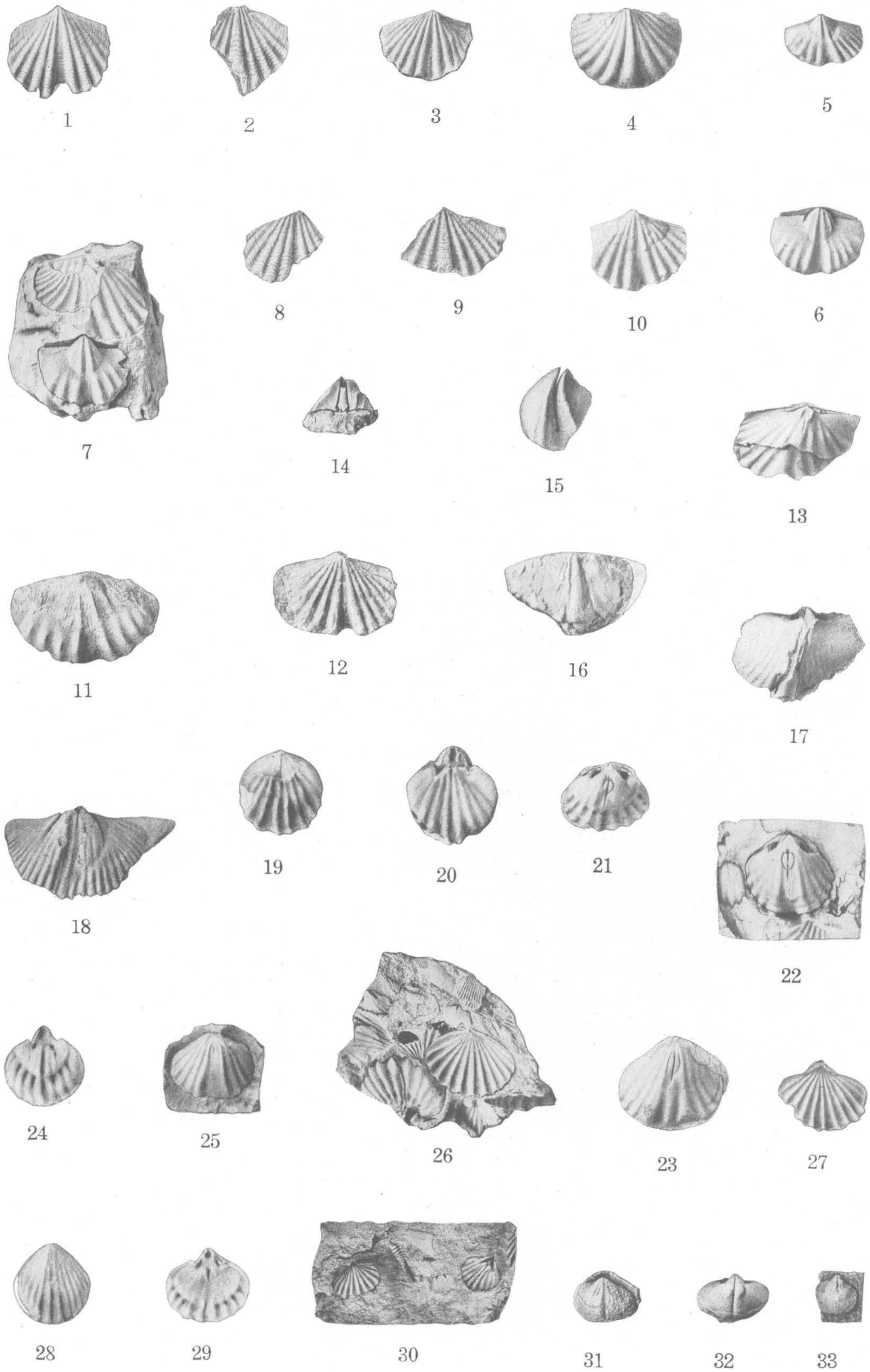
19. *Leptocœlia flabellites* Conrad. A brachial valve in partial cast, showing the two median ribs slightly elevated into a fold, with three ribs and possibly a fourth on each side. Moose River sandstone, Detroit, Somerset County, Maine.

20. *Leptocœlia flabellites* Conrad. Brachial valve of another individual, internal mold; shows the cavity in the umbo, impressed by the massive cardinal process, hinge plate, etc. There seem to be only eight ribs, as in the specimen shown in figure 19. Moose River sandstone, same locality as figure 19.

21-23. *Leptocœlia flabellites* Conrad. Three pedicle valves in internal mold. Note the median septum, distinct adductor muscular scars, and faintly expressed diductors. The median sinus is well developed in the specimen shown in figure 22. Figure 23 shows a median rib, which is not developed in the valve shown in figure 21. Note the cavities left by the large teeth shown in figures 21 and 22. Moose River sandstone, same locality as figure 19.

24. *Leptocœlia flabellites* Conrad. Brachial valve in internal mold, showing the deep impressions of the crural bases and the massive cardinal process. Moose River sandstone, same locality as figure 19.

25. *Leptocœlia flabellites* Conrad. Pedicle valve in partial cast, showing a well-developed sinus without median rib, similar to that shown in figure 22. There are four or five ribs on each side. Moose River sandstone, same locality as figure 19.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26–27. *Leptocœlia flabellites* Conrad. Two brachial valves in external mold, each with 10 ribs. There is no indication of a median fold. Moose River sandstone, same locality as figure 19.

28. *Leptocœlia flabellites* Conrad. A brachial valve in partial cast, showing a duplicate median fold and three, possibly four, ribs on each side, as in figure 19, but showing a different outline. Moose River sandstone, same locality as figure 19.

29. *Leptocœlia flabellites* Conrad. Another brachial valve in internal mold, showing the impressions of the cardinal process, crural bases, and median septum. Moose River sandstone, same locality as figure 19.

30. *Leptocœlia flabellites* Conrad. Two small brachial valves, one in external mold and one in internal mold. Moose River sandstone, same locality as figure 19.

31. *Nucleospira ventricosa* Hall. A small pedicle valve in internal mold, illustrating the strong convexity of the species. Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

32. *Nucleospira ventricosa* Hall. Pedicle valve of another strongly convex individual in internal mold, showing the impressions of the teeth, the muscular scars, and the median septum. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

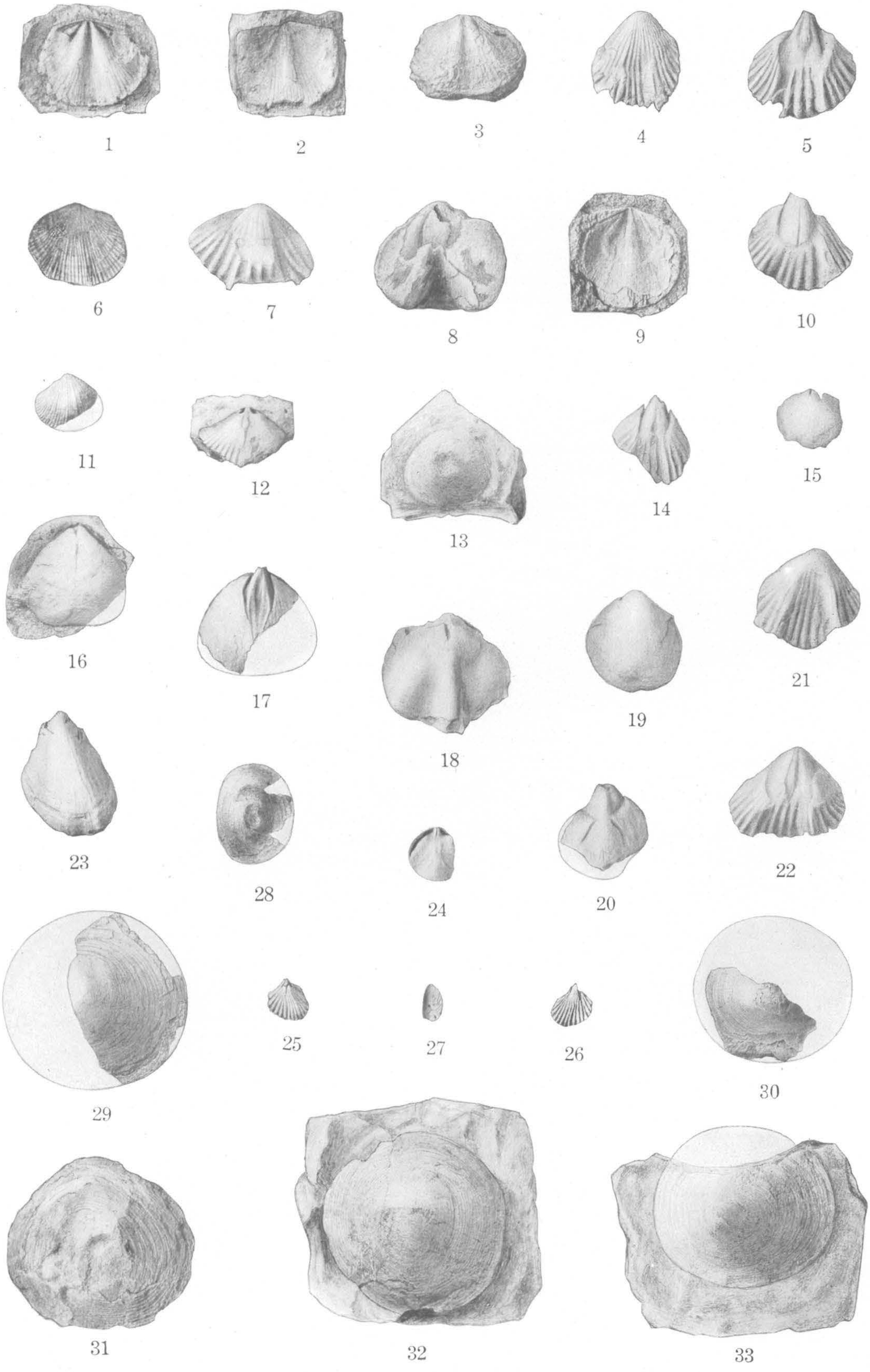
33. *Nucleospira ventricosa* Hall. A pedicle (?) valve in partial cast. Chapman sandstone, same locality as figure 32.

PLATE VI.

[All the figures on this plate are of approximately natural size.]

Figures 1, 2, 3, 6, 9, *Dalmanella elevata* sp. nov. (p. 62). (See also Pl. VII, figs. 12, 19, 23; Pl. VIII, figs. 17–22.)
Figures 4, 5, 7, 10, 14, 21, 22, 25, 26, *Stenoscisma formosa* Hall (p. 64).
Figures 8, 18, *Eatonia singularis* Vanuxem (p. 69).
Figure 11, *Rensselaeria mainensis* Williams (p. 72). (See also Pl. XI, figs. 1–15.)
Figure 12, Rhynchonella cf. *R. mainensis* Billings (p. 27).
Figure 13, Crania sp. indet. (p. 24).
Figure 15, Megalanteris? sp. (p. 71). (See also Pl. VII, fig. 15.)
Figures 16, 19, 20, *Meristella bella* Hall (p. 124).
Figure 17, *Dalmanella planiconvexa* Hall (p. 57). (See also Pl. VII, figs. 11, 13, 14, 16, 17, 18, 20, 21, 24, 24–30.)
Figure 23, *Eunella ellsi* (Clarke) (p. 76).
Figure 24, cf. Pentagonia gen. et sp. indet. (p. 125).
Figure 27, *Lingula minuscula* sp. nov. (p. 20).
Figures 28–33, *Orbiculoidea (Roemerella) discus* Hall (p. 21).

1. *Dalmanella elevata* sp. nov. Brachial valve, showing the cardinal area. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
2. *Dalmanella elevata* sp. nov. Partial interior cast of brachial valve. Chapman sandstone, same locality as figure 1.
3. *Dalmanella elevata* sp. nov. Partial exterior cast of brachial valve. Chapman sandstone, same locality as figure 1.
4. *Stenoscisma formosa* Hall. Pedicle valve in partial exterior cast, showing three or four ribs in the sinus and six on each side. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
5. *Stenoscisma formosa* Hall. An old pedicle valve in internal mold, showing strong diductor and adductor, dental lamellæ obsolescent; three ribs in sinus and five or six on each side. Chapman sandstone, same locality as figure 4.
6. *Dalmanella elevata* sp. nov. Brachial valve in external mold; the only specimen showing the characteristic coarse striations. Chapman sandstone, same locality as figure 1.
7. *Stenoscisma formosa* Hall. Brachial valve in partial external cast; four ribs on the fold, five on each side. Chapman sandstone, same locality as figure 4.
8. *Eatonia singularis* Vanuxem. Ventral view of an individual in external cast and internal mold. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
9. *Dalmanella elevata* sp. nov. Brachial valve in internal cast, showing muscular scars similar to those in figure 1. Note the conspicuous sinus in all the brachial valves. Chapman sandstone, same locality as figure 1.
10. *Stenoscisma formosa* Hall. Pedicle valve in internal mold, showing strong muscular scars, four ribs in the sinus and six or seven on each side, with bifurcating rib bordering the sinus on the left side. Chapman sandstone, same locality as figure 4.
11. *Rensselaeria mainensis* Williams. A very small pedicle valve in exterior cast. (See Pl. XI, figs. 1–15.) Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
12. Rhynchonella (cf. *R. mainensis* Billings). Brachial valve in internal mold, showing the crural bases and absence of a median septum. Chapman sandstone, same locality as figure 1.
13. Crania sp. Brachial valve in internal mold. Chapman sandstone, same locality as figure 4.
14. *Stenoscisma formosa* Hall. A pedicle valve in internal mold, showing the incisions made by the dental lamellæ, the presence of which removes this species from the genus Rhynchotrema. Chapman sandstone, same locality as figure 4.
15. Megalanteris? sp. Fragment of a pedicle valve in internal mold, showing the incisions of the short subparallel dental lamellæ, the absence of muscular impressions, and the smooth surface appearance. Chapman sandstone, same locality as figure 4.
16. Meristella cf. *M. bella* Hall. Large brachial valve in internal mold, showing small size of the species and the obscure sinus. Chapman sandstone, same locality as figure 4.
17. *Dalmanella planiconvexa* Hall. Pedicle valve in internal mold, showing the rounded outline, short hinge, and narrow elongate musculature. Chapman sandstone, same locality as figure 4.
18. *Eatonia singularis* Vanuxem. Dorsal view of same individual as figure 8, in internal mold, showing the fold extending as far as the beak. Chapman sandstone, same locality as figure 4.
19. *Meristella* cf. *M. bella* Hall. Pedicle valve in partial internal mold. Chapman sandstone, same locality as figure 4.
20. *Meristella* cf. *M. bella* Hall. Pedicle valve in internal mold, showing the depression formed by the hinge plate and the musculature in front of it. Chapman sandstone, same locality as figure 4.
21. *Stenoscisma formosa* Hall. Pedicle valve in exterior cast; four ribs in the sinus, six on each side. Chapman sandstone, same locality as figure 4.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22. *Stenoscisma formosa* Hall. A large pedicle valve in internal mold with three ribs in the sinus and six or seven on each side. Chapman sandstone, same locality as figure 4.
23. *Eunella ellsi* Clarke. A single internal mold of a pedicle valve, having the outline, convexity, size, and other features of this species. Chapman sandstone, same locality as figure 4.
24. cf. Pentagonia sp. indet. Internal mold of a brachial valve with the curvature of this genus but without a visible median septum. Chapman sandstone, same locality as figure 1.
25. *Stenoscisma formosa* Hall. Internal mold of a very small individual, dorsal view, showing the median septum, which is divided posteriorly. Chapman sandstone, same locality as figure 4.
26. *Stenoscisma formosa* Hall. Ventral view of the individual illustrated in figure 25, showing the very well developed dental lamellæ. In this specimen, which is a young individual, the fold and sinus are just beginning to develop on the front margin. Chapman sandstone, same locality as figure 4.
27. *Lingula minuscula* sp. nov. Ventral view of a complete individual, slightly fractured. Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
28. *Orbiculoidea* (*Roemerella*) *discus* Hall. Exterior of an elongate pedicle valve, with strong radial ornamentation obscure in the figure, showing the large pedicle opening and posterior slit. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
29. *Orbiculoidea* (*Roemerella*) *discus* Hall. Fragment of exterior of large brachial valve. Chapman sandstone, same locality as figure 27.
30. *Orbiculoidea* (*Roemerella*) *discus* Hall. Fragment of exterior of a brachial (possibly a pedicle) valve, showing obscure, very fine radial markings. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
31. *Orbiculoidea* (*Roemerella*) *discus* Hall. Interior view of a large concave pedicle valve, showing only concentric lineation. Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.
32, 33. *Orbiculoidea* (*Roemerella*) *discus* Hall. External molds of two large convex brachial valves, showing only concentric lineation. Chapman sandstone, same locality as figure 31.

PLATE VII.

[All the figures on this plate are of approximately natural size.]

Figures 1, 2, 3, 4, 5, 7, 8, *Hipparionyx unguiformis* Conrad (p. 41).
Figures 6a, 6b, *Schuchertella deformis* (Hall) (p. 40).
Figure 9, *Dalmanella circularis?* (Sowerby) (p. 59).
Figure 10, *Dalmanella planoconvexa* Hall, with *Chonetes novascoticus* Hall (p. 57).
Figures 11, 13, 14, 16, 17, 18, 20, 21, 22, 24–30, *Dalmanella planiconvexa* Hall (p. 71). (See also Pl. VI, fig. 17.)
Figure 15, Megalanteris? sp. (p. 71). (See also Pl. VI, fig. 15.)
Figures 12, 19, 23, *Dalmanella elevata* sp. nov. (p. 62). (See also Pl. VI, figs. 1, 2, 3, 6, 9; Pl. VIII, figs. 17–22.)

1. *Hipparionyx unguiformis* Conrad. The flat pedicle valve in external mold, showing the fine radial striæ which increase by implantation and arch backward on the cardinal slopes. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
2. *Hipparionyx unguiformis* Conrad. The flat or resupinate pedicle valve in internal mold, showing the ovarian area and strong musculature. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
3. *Hipparionyx unguiformis* Conrad. Another flat (resupinate) pedicle valve in external mold, showing a rather elongate form similar to that of the shell shown in figure 1 (due possibly to lateral compression). Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
4. *Hipparionyx unguiformis* Conrad. A pedicle valve in external cast; the shell broken away at the beak, exposing part of the musculature. Illustrates the short, wide form of the species. Chapman sandstone, same locality as figure 2.
5. *Hipparionyx unguiformis* Conrad. Fragment of pedicle valve in internal mold, showing the characteristic upward curve of the striæ on the latero-posterior margin. (Compare fig. 2.) Chapman sandstone, same locality as figure 3.

6a. *Schuchertella deformis* Hall. Partial cast of a convex pedicle valve, with gibbous umbo, which has not yet become resupinate or irregular in growth. Chapman sandstone, same locality as figure 2.

6b. *Schuchertella deformis* Hall. Brachial valve in partial cast. This resembles a brachial valve of Hipparionyx but the striation is different. Chapman sandstone, same locality as figure 2.

7. *Hipparionyx unguiformis* Conrad. Another comparatively wide pedicle valve. Chapman sandstone, same locality as figure 2.
8. *Hipparionyx unguiformis* Conrad. A pedicle valve in external mold, illustrating the elongate form of the species of this locality. Chapman sandstone, same locality as figure 3.
9. Dalmanella cf. *D. circularis* (Sowerby). A brachial valve in external mold, showing the flat valve with indistinct sinus and having the striæ bifurcating but nonfasciculate. Chapman sandstone, same locality as figure 2.
10. *Dalmanella planoconvexa* Hall. A pedicle valve in internal mold, showing the outline of the species and the musculature; with *Chonetes novascoticus* Hall on the same block. Chapman sandstone, same locality as figure 2.
11. *Dalmanella planiconvexa* Hall. Flat brachial valve with obscure sinus showing the fasciculate striæ. Chapman sandstone, same locality as figure 2.
12. *Dalmanella elevata* sp. nov. A pedicle valve of this species, showing traces of the very coarse ornamentation and illustrating the acuminate umbo and sharp cardinal extremities of the species. Chapman sandstone, same locality as figure 3.
13. *Dalmanella planoconvexa* Hall. A flat brachial valve, external mold, with very obscure sinus and fasciculate striæ. Chapman sandstone, same locality as figure 2.
14. *Dalmanella planoconvexa* Hall. A small brachial valve in external mold, with strongly fasciculate striæ. Chapman sandstone, same locality as figure 2.
15. Megalanteris? sp. A pedicle valve in internal mold, showing the smooth form and nearly horizontal posterior margin; there is no muscular impression. Chapman sandstone, same locality as figure 2.
16. *Dalmanella planoconvexa* Hall. A brachial valve in internal mold, showing the characteristic appearance of muscular scars and cardinal process. Chapman sandstone, same locality as figure 3.
17. *Dalmanella planoconvexa* Hall. A pedicle valve. Chapman sandstone, same locality as figure 3.

18, 20. *Dalmanella planoconvexa* Hall. Two pedicle valves in internal mold, showing the outline, the somewhat characteristic musculature, and the marginal fringe of striæ. Chapman sandstone, same locality as figure 2.

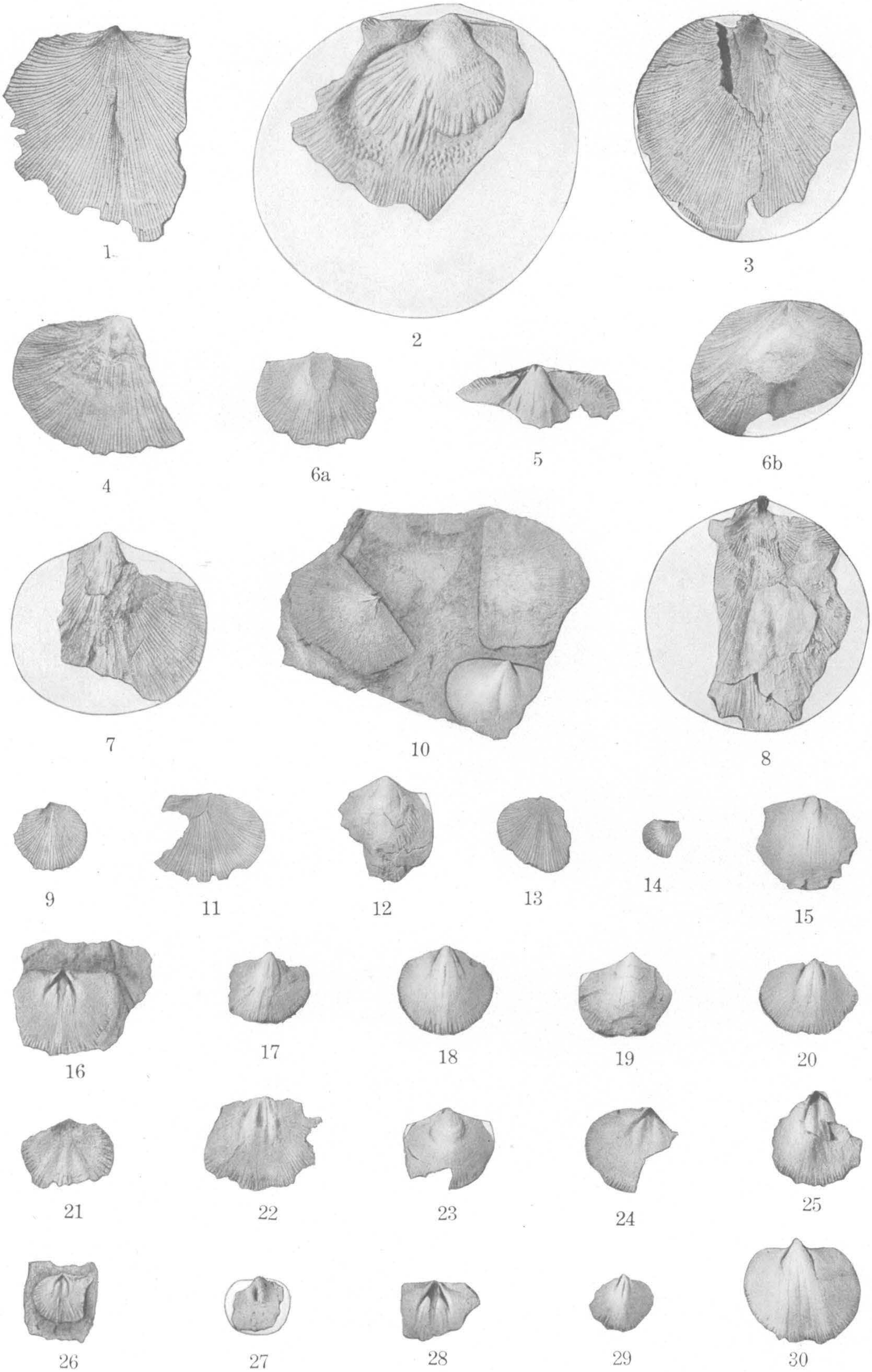
19. *Dalmanella elevata* sp. nov. Pedicle valve in partial external cast, showing the acuminate beak, broad hinge, with sharp extremities, and the coarse striæ. Chapman sandstone, same locality as figure 3.
20. See figure 18.

21, 22. *Dalmanella planoconvexa* Hall. Two brachial valves in partial internal cast. Chapman sandstone, same locality as figure 2.

23. *Dalmanella elevata* sp. nov. Pedicle valve in internal mold, showing acuminate beak, sharp hinge extremities, and cordate musculature. Chapman sandstone, same locality as figure 3.

24–28. *Dalmanella planoconvexa* Hall. Brachial valves in internal molds, showing the musculature and cardinal process. The latter is very plainly seen to be bilobed in the specimen of figure 28, but not in the others. Chapman sandstone, same locality as figure 2.

29, 30. *Dalmanella planoconvexa* Hall. Internal molds of two pedicle valves, showing the outline, the musculature, and the marginal fringe of striæ. Chapman sandstone, same locality as figure 2.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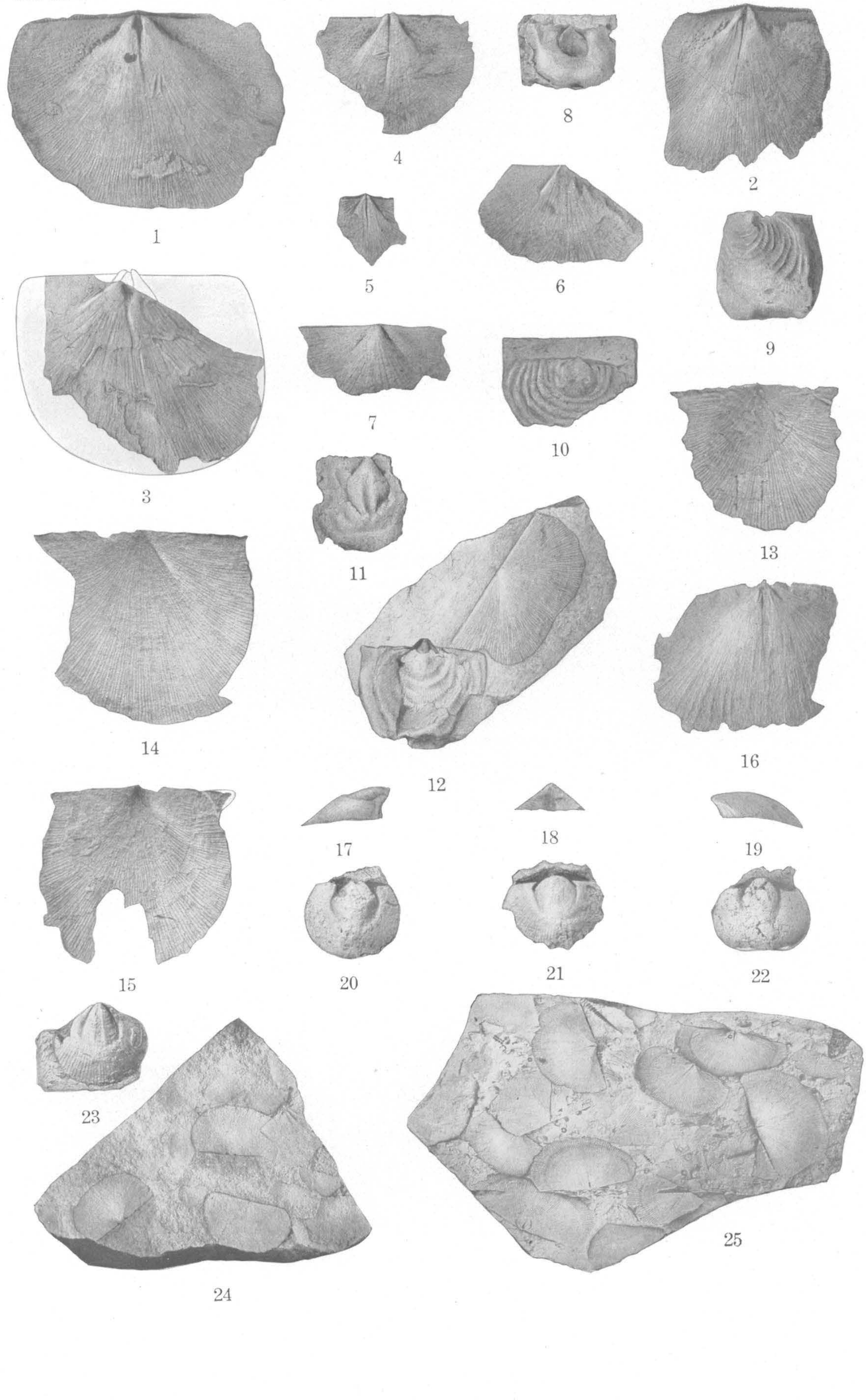
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PLATE VIII.

[All the figures on this plate are of approximately natural size.]

Figures 1-7, 13, 14, 15, 16, *Leptostrophia perplana* Conrad (p. 27). (See also Pl. III, fig. 9; Pl. XI, fig. 17.)
Figures 8-12, *Leptæna rhomboidalis* Wilckens (p. 32).
Figures 17-23, *Dalmanella elevata* sp. nov. (p. 62). (See also Pl. VI, figs. 1, 2, 3, 6, 9; Pl. VII, figs. 12, 19, 23.)
Figure 24, *Chonetes striatissimus* sp. nov. (p. 44). (See also Pl. IX, figs. 1-10, 13, 14, 17, 18; Pl. X, fig. 17.)
Figure 25, *Chonetes bastini* Williams (p. 48).

1, 2. *Leptostrophia perplana* Conrad. Two pedicle valves in internal mold, showing the coarse appearance, the absence of wrinkles, and the broad obtuse musculature. These are typical forms of Billings's *L. blainvillei*. Moose River sandstone, Detroit, Somerset County, Maine.

3. *Leptostrophia perplana* Conrad. Internal mold of a pedicle valve, with musculature similar to that shown in figures 1 and 2 (=the form called *L. blainvillei* Billings). Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

4, 5. *Leptostrophia perplana* Conrad. Two pedicle valves in internal mold, corresponding in the acute angle between the sides of the musculature with the form of the species called *L. planulata* Hall. Moose River sandstone, same locality as figure 1.

6. *Leptostrophia perplana* Conrad. Internal mold of a pedicle valve with the acute and short musculature of the form of the species called *L. tullia* Billings. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

7. *Leptostrophia perplana* Conrad. Internal mold of a pedicle valve with the acute musculature of *L. planulata* Hall, Chapman sandstone, same locality as figure 3.

8. *Leptæna rhomboidalis* Wilckens. Internal mold of a pedicle valve, showing the geniculate downward curvature in front and the strongly impressed cordate musculature, but without the concentric corrugations. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

9. *Leptæna rhomboidalis* Wilckens. External mold of a brachial valve, showing the corrugations over the flat part of the surface, the abruptly geniculate front, and the radial striæ. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

10. *Leptæna rhomboidalis* Wilckens. Partial cast and internal mold of a pedicle valve, showing the cardinal area, musculature, corrugations, etc. Chapman sandstone, same locality as figure 8.

11. *Leptæna rhomboidalis* Wilckens. Pedicle valve in internal mold, showing the musculature. Chapman sandstone, same locality as figure 8.

12. *Leptæna rhomboidalis* Wilckens. Another pedicle valve in internal mold, preserving the shell in places, accompanied by *Chonetes novascoticus* Hall. Chapman sandstone, same locality as figure 9.

13. *Leptostrophia perplana* Wilckens. External mold of pedicle valve of an elongate form with acute musculature comparable with *M. tullia* Billings and *L. planulata* Hall. Chapman sandstone, same locality as figure 3.

14. *Leptostrophia perplana* Conrad. External mold of pedicle valve of the form of the species called *L. planulata* Hall, showing fine striation, acute musculature, and faint, obscure concentric wrinkles. Chapman sandstone, same locality as figure 6.

15. *Leptostrophia perplana* Conrad. External mold of pedicle valve of the form of the species called *L. tullia* Billings, showing the rather elongated outline and indications of the acute musculature; there are no appreciable wrinkles. Chapman sandstone, same locality as figure 3.

16. *Leptostrophia perplana* Conrad. "Sculpture cast" of a pedicle valve of the *L. blainvillei* form of the species. Chapman sandstone, same locality as figure 1.

17, 18. *Dalmanella elevata* sp. nov. Lateral and cardinal views of specimen figure 23 (the type of the species), showing the profile, musculature, high and broad cardinal area, and narrow, very acute delthyrium. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

19. *Dalmanella elevata* sp. nov. Lateral view of specimen shown in Plate VII, figure 23. Chapman sandstone, same locality as figure 17.

20-22. *Dalmanella elevata* sp. nov. Three pedicle valves in internal mold, showing the characteristic musculature and high, broad cardinal area. Figure 21 shows indications of the coarse striæ, and figure 22 represents a specimen with an insinuated front margin. Chapman sandstone, same locality as figure 17.

23. *Dalmanella elevata* sp. nov. Internal mold of pedicle valve, showing also the surface ornamentation, elevation of beak, and musculature. Same specimen as figure 18. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

24. *Chonetes striatissimus* sp. nov. A slab of sculpture casts or internal molds, showing the size and proportions and the flat surface, with extremely fine striation. (See Pl. IX, fig. 10.) Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

25. *Chonetes bastini* Williams. A slab containing specimens of the species introduced here for comparison with *Chonetes striatissimus* and *Chonetes novascoticus* Hall. The original of this slab was collected by Prof. Shaler and party and was labeled "Silurian, Dennys River, Cobscook Bay district, Maine." (See Shaler, N. S., Am. Jour. Sci., 3d ser., vol. 32, pp. 35-60, July, 1886.)

PLATE IX.

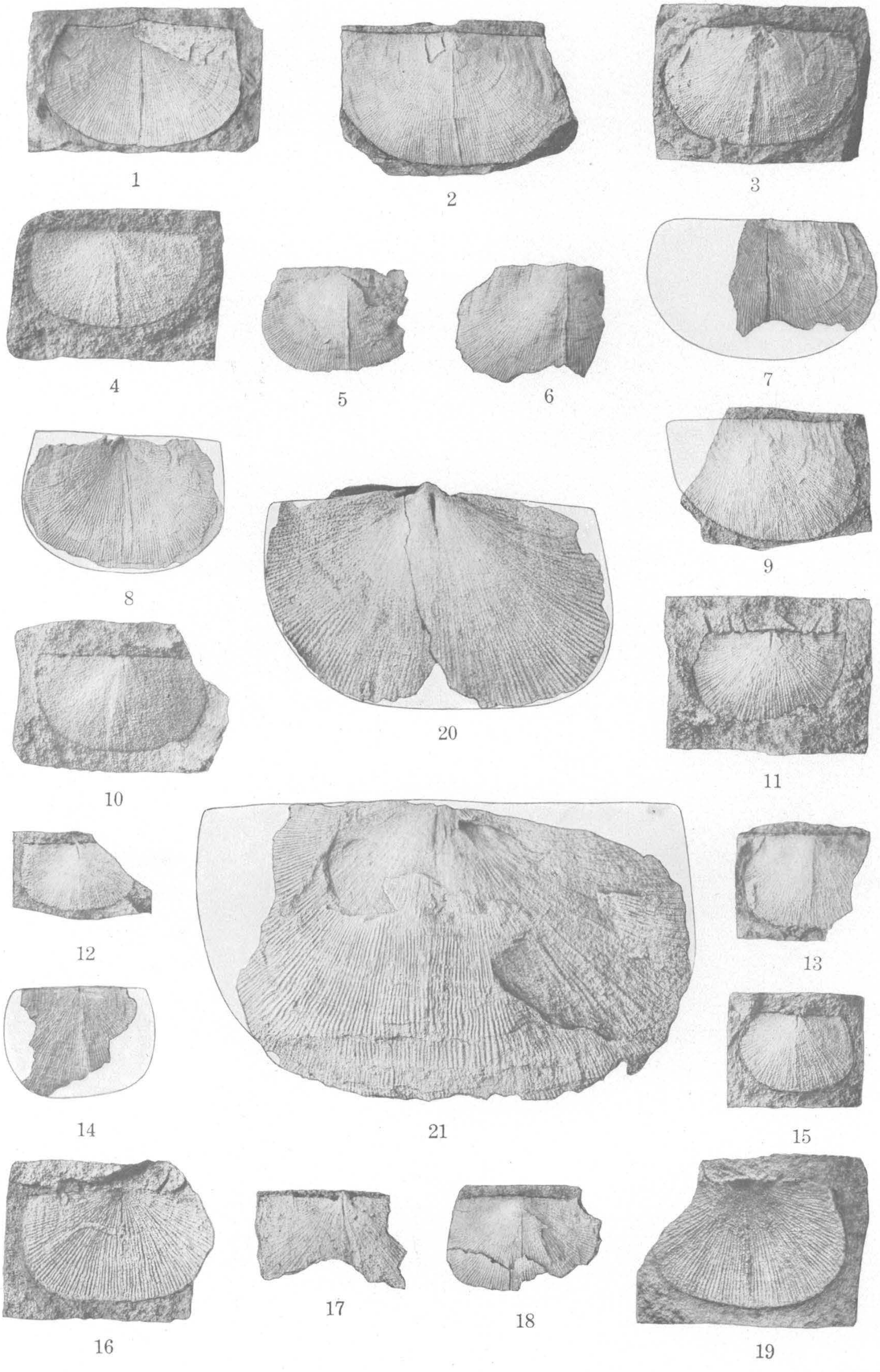
[All the figures on this plate are enlarged 2 diameters.]

Figures 1–10, 13, 14, 17, 18, *Chonetes striatissimus* sp. nov. (p. 44). (See also Pl. VIII, fig. 24; Pl. X, fig. 17.)
Figures 11, 12, 15, 16, 19, *Chonetes novascoticus* Hall (p. 45).
Figures 20, 21, *Chonetes novascoticus* Hall var. *canadensis* Billings (p. 49). (See also Pl. X, figs. 30, 31; Pl. XI, fig. 16.)

1. *Chonetes striatissimus* sp. nov. Pedicle valve in external mold, showing the very fine, flexuous striæ and conspicuous midrib. × 2. Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
2. *Chonetes striatissimus* sp. nov. Type specimen of the species, a pedicle valve preserving the exterior of the shell, showing the depressed convexity, fine flexuous striæ, midrib, and obtuse hinge extremities. × 2. Chapman sandstone, same locality as figure 1.
3. *Chonetes striatissimus* sp. nov. Pedicle valve in partial cast, showing midrib and, on the right side of the hinge, a couple of cardinal spines. × 2. Chapman sandstone, same locality as figure 1.
4. *Chonetes striatissimus* sp. nov. A partly exfoliated pedicle valve, preserving indications of the very fine striæ and the midrib. Same specimen as Plate X, figure 17. × 2. Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

5, 6. *Chonetes striatissimus* sp. nov. Two pedicle valves, showing the strength of the midrib on the external surface. × 2. Chapman sandstone, same locality as figure 1.

7. *Chonetes striatissimus* sp. nov. Pedicle valve in external mold. × 2. Chapman sandstone, same locality as figure 1.
8. *Chonetes striatissimus* sp. nov. Interior cast of a pedicle valve, showing only faint indications of the midrib on the interior surface of the shell. × 2. Chapman sandstone, same locality as figure 1.
9. *Chonetes striatissimus* sp. nov. Brachial valve in external mold, showing entire absence of midrib. × 2. Chapman sandstone, same locality as figure 1.
10. *Chonetes striatissimus* sp. nov. Internal mold of a pedicle valve (one of those on the slab in Pl. VIII, fig. 24), showing the extreme indistinctness of the superficial midrib on the interior. × 2. Chapman sandstone, same locality as figure 4.
11. *Chonetes novascoticus* Hall. A rather small pedicle valve in internal mold preserving the narrow cardinal area and some of the spines. Note also the coarser striation of this species. × 2. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
12. *Chonetes novascoticus* Hall. A small pedicle valve in internal mold, indicating the coarser striation of this species. Same specimen as Plate X, figure 1. × 2. Chapman sandstone, same locality as figure 1.
13. *Chonetes striatissimus* sp. nov. Partly exfoliated pedicle valve, preserving the midrib. In retouching this photograph the striæ have been made to appear too distant in places. Chapman sandstone, same locality as figure 1.
14. *Chonetes striatissimus* sp. nov. Exterior of a small flat brachial valve, showing fine striation and absence of midrib. × 2. Chapman sandstone, same locality as figure 1.
15. *Chonetes novascoticus* Hall. Another small pedicle valve in internal mold. Same specimen as Plate X, figure 2. × 2. Chapman sandstone, same locality as figure 11.
16. *Chonetes novascoticus* Hall. A characteristic typical valve of this species in external mold, showing the absence of midrib, the coarser striæ, and some of the cardinal spines. × 2. Chapman sandstone, same locality as figure 11.
17. *Chonetes striatissimus* sp. nov. An imperfect fragment of a pedicle valve in internal mold. × 2. Chapman sandstone, same locality as figure 1.
18. *Chonetes striatissimus* sp. nov. Exterior of the shell of the pedicle valve, showing the midrib and very fine flexuous striæ. Chapman sandstone, same locality as figure 1.
19. *Chonetes novascoticus* Hall. Another characteristic pedicle valve in external mold, showing the spines, the coarser striation, the absence of midrib, etc. Chapman sandstone, same locality as figure 11.
20. *Chonetes novascoticus* Hall var. *canadensis* Billings. A medium-sized or rather small pedicle valve in internal mold, indicating the large size of this form. The outline, depressed convexity, and striation are similar to those of *C. novascoticus*. Moose River sandstone, Detroit, Somerset County, Maine.
21. *Chonetes novascoticus* Hall var. *canadensis* Billings. A large pedicle valve preserving the exterior of the shell. This specimen in its rounded flexuous striæ and appearance (?) of a midrib recalls *C. striatissimus* sp. nov. Moose River sandstone, same locality as figure 20.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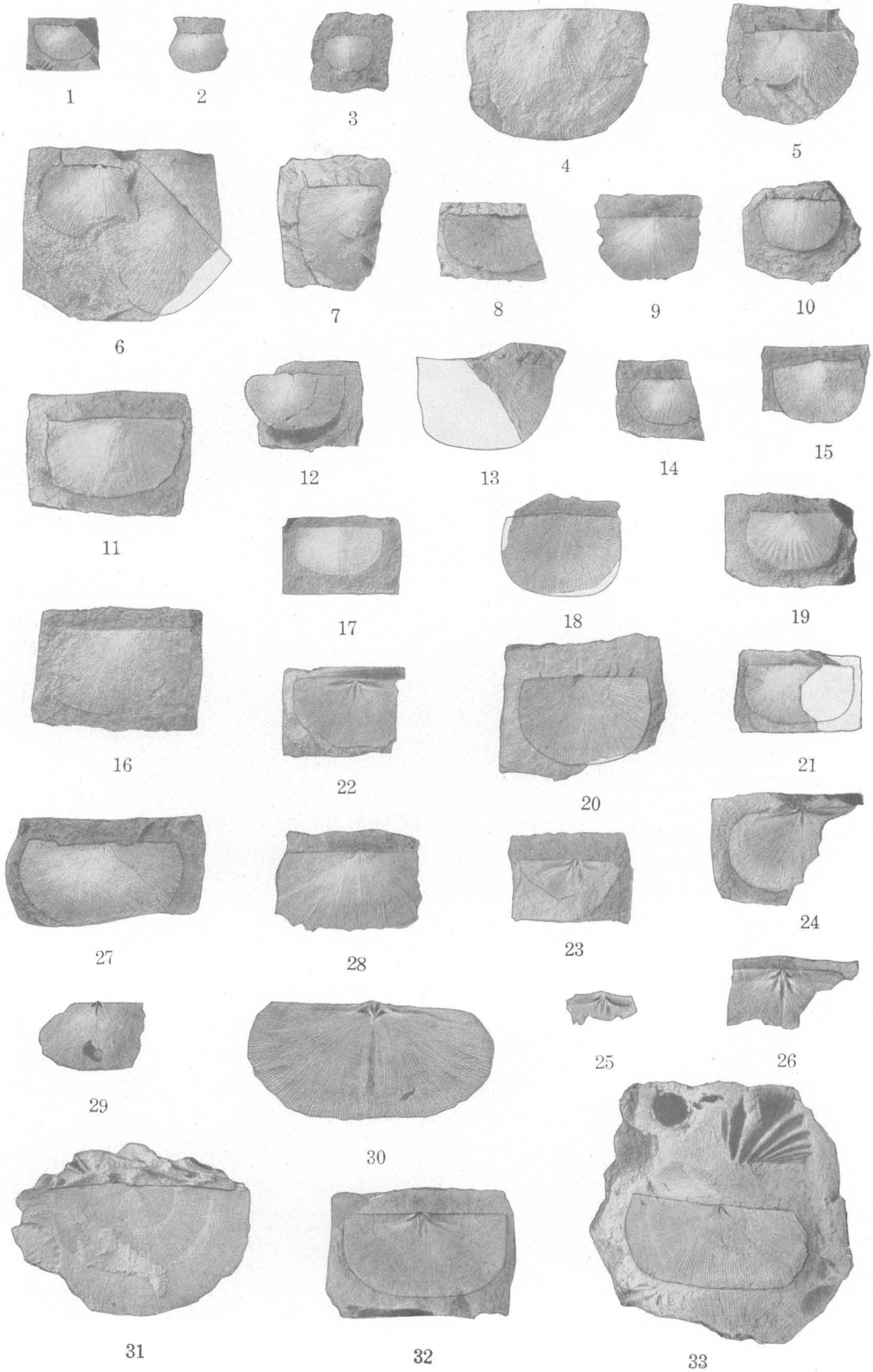
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PLATE X.

[All the figures on this plate are of approximately natural size.]

Figures 1, 2, 3, 5–16, 18–29, 32, 33, *Chonetes novascoticus* Hall (p. 45). (See also Pl. IX, figs. 1–10, 13, 14, 17, 18.)
Figure 4, *Chonostrophia complanata* Hall (p. 55).
Figure 17, *Chonetes striatissimus* sp. nov. (p. 44). (See also Pl. VIII, fig. 24; Pl. IX, figs. 1–10, 13, 14, 17, 18.)
Figures 30, 31, *Chonetes novascoticus* Hall var. *canadensis* Billings (p. 49). (See also Pl. IX, figs. 20, 21; Pl. XI, fig. 16.)

1–3. *Chonetes novascoticus* Hall. Three small pedicle valves in internal mold. Figure 3 shows obscure indications of a midrib. Figure 1 shows same specimen as Plate IX, figure 12; figure 2 same as Plate IX, figure 15. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

4. *Chonostrophia complanata* Hall. Partial interior cast and exterior mold of a brachial valve of flat, slightly resupinate convexity. Moose River sandstone, Detroit, Somerset County, Maine.

5. *Chonetes novascoticus* Hall. Exterior cast of characteristic pedicle valve, showing the coarse striæ (relatively coarse compared with those of *C. striatissimus*), depressed convexity, absence of midrib, and cardinal spines apparently complete on the left side. Chapman sandstone, same locality as figure 1.

6. *Chonetes novascoticus* Hall. A pedicle valve in internal mold (upper shell) and a concave brachial valve in external mold (lower shell), showing the usual size of the species. Chapman sandstone, same locality as figure 1.

7. *Chonetes novascoticus* Hall. A pedicle valve in internal mold, with five spines on one side. Chapman sandstone, same locality as figure 1.

8. *Chonetes novascoticus* Hall. A pedicle valve in external mold. A single median stria seems to be a trifle stronger than the others. Chapman sandstone, same locality as figure 1.

9–15. *Chonetes novascoticus* Hall. Pedicle valves of medium to rather small size, all in internal mold except that shown in figure 13, which is an external mold. Chapman sandstone, same locality as figure 1.

16. *Chonetes novascoticus* Hall. Brachial valve in external mold. Chapman sandstone, same locality as figure 1.

17. *Chonetes striatissimus* sp. nov. An exfoliated shell or internal mold, preserving the midrib and fine striation. Same specimen as Plate IX, figure 4. Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

18–21. *Chonetes novascoticus* Hall. Pedicle valves in external mold (figs. 18, 20) and internal mold (figs. 19, 21). Chapman sandstone, same locality as figure 1.

22–26. *Chonetes novascoticus* Hall. Brachial valves in internal mold, showing the bifid cardinal process, the dental sockets and crural bases, and the blunt median and lateral ridges. Chapman sandstone, same locality as figure 1.

27–29. *Chonetes novascoticus* Hall. Pedicle valves in internal mold. Chapman sandstone, same locality as figure 1.

30. *Chonetes novascoticus* Hall var. *canadensis* Billings. A flattish brachial valve in external mold showing the strongly bifid cardinal process. Note the remarkable curve of the striæ in the middle; this appears to have been due to an injury to the shell during the life of the animal. Moose River sandstone, Detroit, Somerset County, Maine.

31. ?*Chonetes novascoticus* Hall var. *canadensis* Billings. A large, very depressed convex specimen, apparently the external mold of a Chonetes referred here on account of its large size. Moose River sandstone, same locality as figure 30.

32. *Chonetes novascoticus* Hall. A brachial valve similar to those shown in figures 22–26. Chapman sandstone, same locality as figure 1.

33. *Chonetes novascoticus* Hall. A broad pedicle valve in external mold, with *Spirifer cyclopterus*. Chapman sandstone, same locality as figure 1.

PLATE XI.

[All the figures on this plate are of approximately natural size except figures 16 and 17, which are enlarged 2 diameters.]

Figures 1-15, *Rensselaeria mainensis* Williams (p. 72). (See also Pl. VI, fig. 11.)
Figure 16, *Chonetes novascoticus* Hall var. *canadensis* Billings (p. 49). (See also Pl. IX, figs. 20, 21; Pl. X, figs. 30, 31.)
Figure 17, *Leptostrophia perplana* Conrad (p. 27). (See also Pl. III, fig. 9; Pl. VIII, figs. 1-7, 13-16.)

1-3. *Rensselaeria mainensis* Williams. Dorsal, ventral, and lateral views of the type specimen, preserving the shell, showing the outline, convexity, and especially the strong ribs, and in the pedicle valve the cardinal area and elevated beak with perforate apex. Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.

4. *Rensselaeria mainensis* Williams. A large pedicle valve retaining parts of the shell, showing the ventricose and elevated beak, the "parabolic" profile, and the strong continuous simple ribs. Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

5. *Rensselaeria mainensis* Williams. Pedicle valve, internal mold, showing the large, strongly impressed musculature, the cardinal area, and the presence of the ribs on the interior (except about the musculature). The aspect of the cardinal area indicates that the cavity on the inside had been filled in solid by the thickening of the shell. Note at the apex the sand filling of the circular foramen. Chapman sandstone, Presque Isle Stream at end of Tweedy road, Chapman Township, Aroostook County, Maine.

6. *Rensselaeria mainensis* Williams. Same specimen as figure 4, cardinal view, showing the high, very distinct cardinal area, the delthyrium, and the circular apical foramen.

7. *Rensselaeria mainensis* Williams. Pedicle valve in internal mold, showing plicated interior and musculature. Note the vertical pedicle area seen in perspective. The aspect of the cardinal area indicates that this valve had been enormously thickened on the interior along the umbonal slopes. Chapman sandstone, same locality as figure 5.

8. *Rensselaeria mainensis* Williams. Lateral view of specimen shown in figure 7, showing the erect, large pedicle area. Chapman sandstone, same locality as figure 5.

9. *Rensselaeria mainensis* Williams. Pedicle valve in internal mold, showing the cardinal area in which the shell is only slightly thickened on the interior. This figure in comparison with figure 7 shows the variability in the size of the ribs. Chapman sandstone, same locality as figure 5.

10. *Rensselaeria mainensis* Williams. Internal mold of a pedicle valve, with the cardinal area indicating only a slight thickening of the shell. Compare with figures 5, 7, and 9 and note variability in the appearance of the musculature. Chapman sandstone, same locality as figure 5.

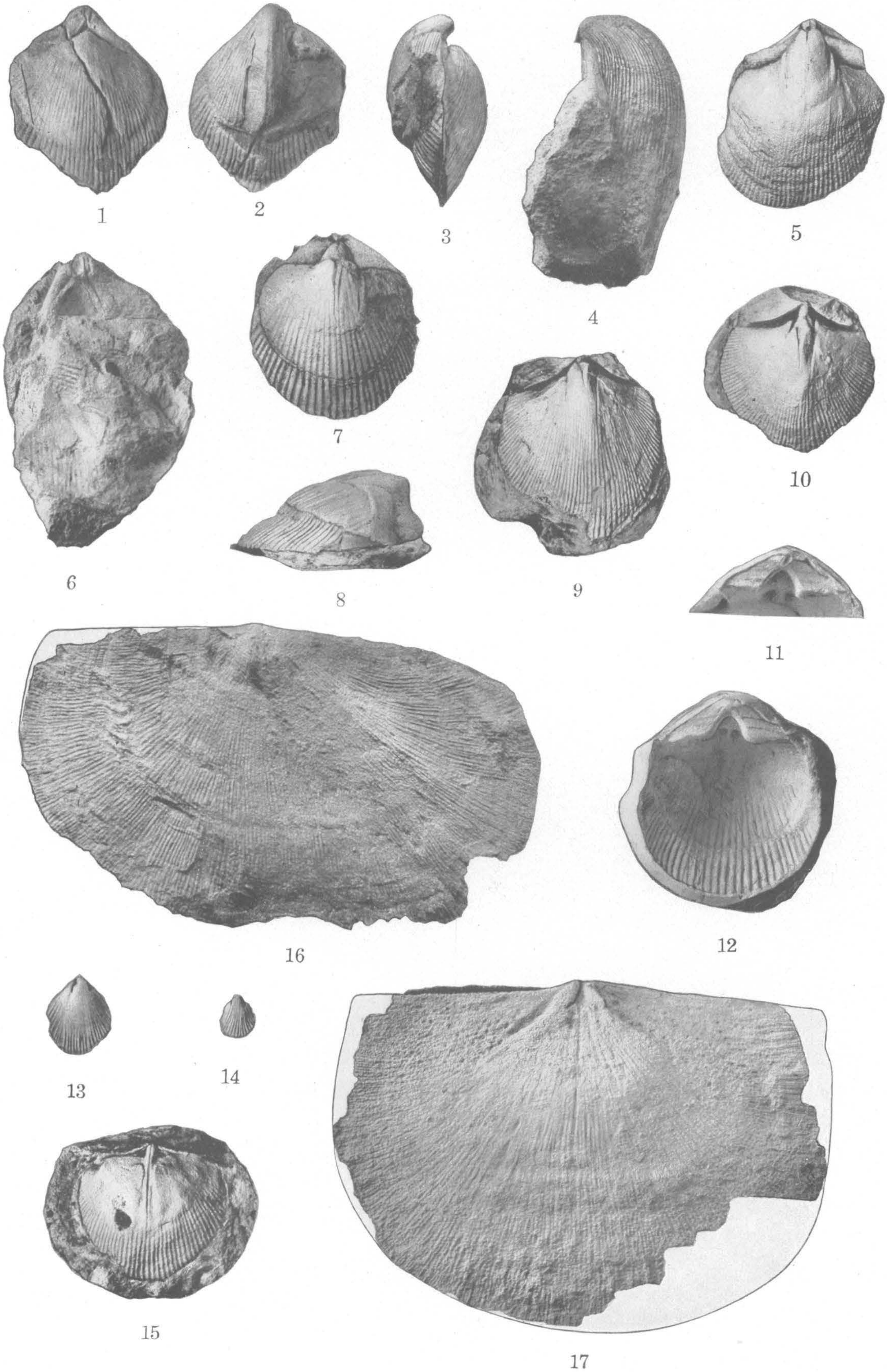
11, 12. *Rensselaeria mainensis* Williams. Wax impressions from the original of figure 7, showing the characteristic cardinal area and erect beak of the species. Chapman sandstone, same locality as figure 5.

13, 14. *Rensselaeria mainensis* Williams. Interior molds of two small pedicle valves, showing the incisions left by the dental lamellæ. Chapman sandstone, same locality as figure 5.

15. *Rensselaeria mainensis* Williams. Brachial valve in internal mold, showing the horizontal posterior margin, strong musculature, faint median septum, and the filling of the "visceral canal" or tunnel through the massive hinge plate. Chapman sandstone, same locality as figure 5.

16. *Chonetes novascoticus* Hall var. *canadensis* Billings. Exterior cast of a large depressed pedicle valve. × 2. Moose River sandstone, Detroit, Somerset County, Maine.

17. *Leptostrophia perplana* Hall. Pedicle valve, in internal mold, of a typical specimen of the form of the species called *L. blainvillei* Billings, showing the medium size and obtuse musculature. × 2. Moose River sandstone, same locality as figure 16.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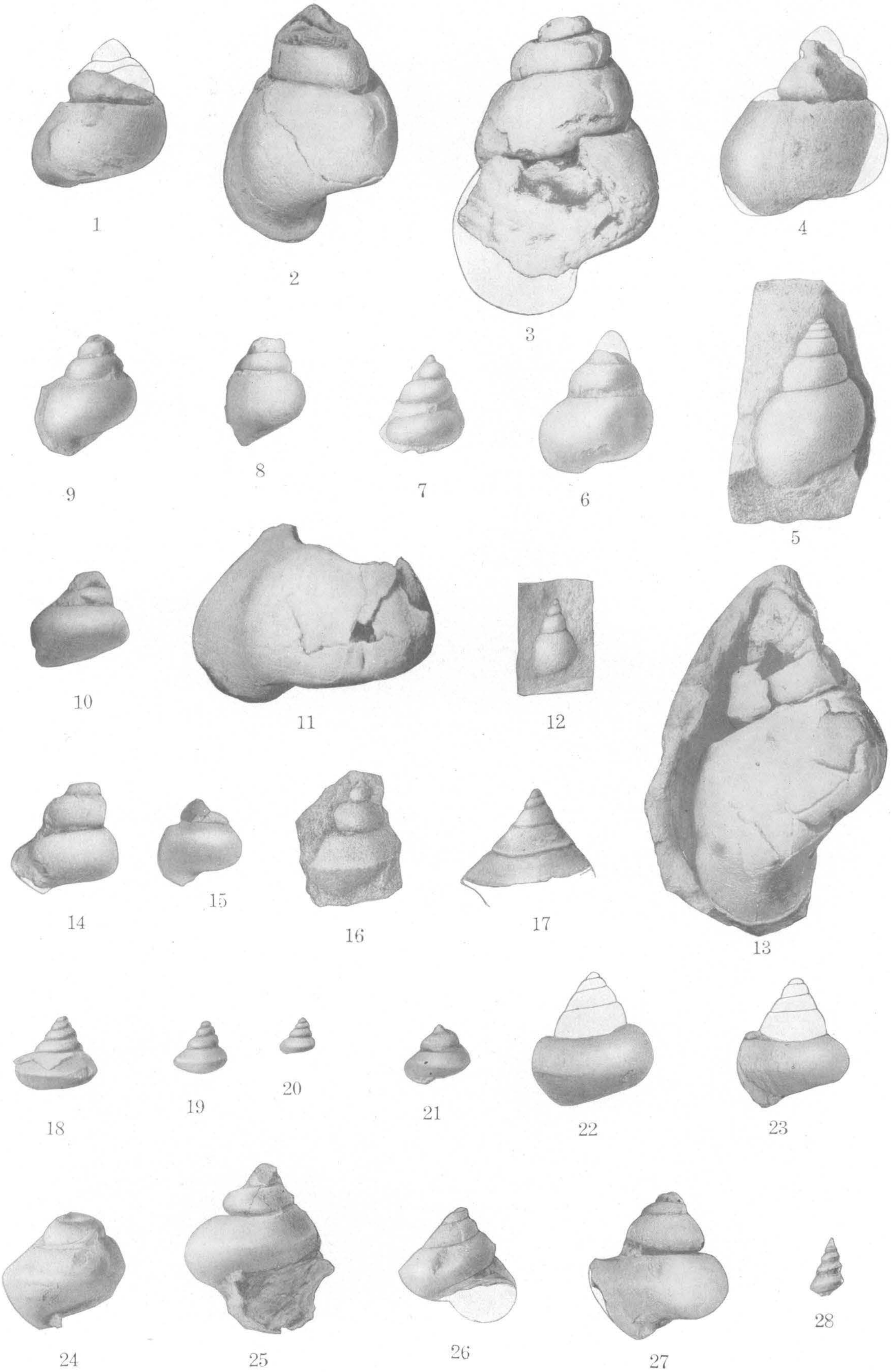
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PLATE XII.

[All the figures on this plate are of natural size, except figures 2, 3, 11, and 13, which are magnified 2 diameters.]

Figures 1–15, *Holopea (Auriptygma) beushauseni* Clarke (p. 281).
Figure 16, *Pseudotectus?* sp. indet. (p. 279).
Figure 17, *Pseudotectus hitchcocki* (Clarke) (p. 278).
Figures 18–27, *Pseudotectus? deciduus* sp. nov. (p. 278).
Figure 28, *Goniostropha chapmani* sp. nov. (p. 276).

1. *Holopea (Auriptygma) beushauseni* Clarke. Interior mold, showing outer whorl. Presque Isle Stream, Chapman Township, Aroostook County, Maine.
2. *Holopea (Auriptygma) beushauseni* Clarke. Interior mold, showing two whorls and flaring lip of the body whorl. × 2. Presque Isle Stream, at end of Tweedy road, Chapman Township, Aroostook County, Maine.
3. *Holopea (Auriptygma) beushauseni* Clarke. Interior mold, showing four whorls. × 2. Two miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
4. *Holopea (Auriptygma) beushauseni* Clarke. Body whorl. Same locality as figure 3.
5. *Holopea (Auriptygma) beushauseni* Clarke. A sandstone mold, possibly of exterior, showing six whorls, probably of this species. Same locality as figure 3.

6–9. *Holopea (Auriptygma) beushauseni* Clarke. Interior molds, showing various expressions of form, partly due to different degrees of removal of matrix. Same locality as figure 3.

10. *Holopea (Auriptygma) beushauseni* Clarke. Internal mold, showing bluntly carinated form of the outer whorl. Same locality as figure 2.
11. *Holopea (Auriptygma) beushauseni* Clarke. Outer whorl, showing flaring lip. × 2. Edmunds Hill, Chapman Township, Aroostook County, Maine.
12. *Holopea (Auriptygma) beushauseni* Clarke. A faint impression of a small shell in sandstone, presenting some resemblance to the mold shown in figure 5, and probably this species. The outlines and divisions between whorls are stronger in the figures than in the specimens. Same locality as figure 3.
13. *Holopea (Auriptygma) beushauseni* Clarke. A somewhat crushed interior mold, showing the flaring lip of outer whorl. × 2. Same locality as figure 3.
14. *Holopea (Auriptygma) beushauseni* Clarke. A specimen in which the outer portion of the body whorl appears to be slightly contracted in diameter. Same locality as figure 3.
15. *Holopea (Auriptygma) beushauseni* Clarke. Outer whorl of a medium-sized specimen, mold of interior. West side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
16. *Pseudotectus ?* sp. indet. A faint mold in sandstone, representing three whorls, the outer one of which is sharply angulated. The outlines are too deeply drawn in the figure; the specific characters are indistinct. Same locality as figure 3.
17. *Pseudotectus hitchcocki* (Clarke). Gutta-percha impression of the exterior of a complete shell, showing the four whorls, the carinated outer edge of the whorl filling in the suture and the rapidly expanding form of the spire. The impression does not show the outer edge of the body whorl. Same locality as figure 3.
18. *Pseudotectus? deciduus* sp. nov. A medium-sized specimen, mainly mold of the interior, but showing a part of exterior of the outer whorl and the carination of the interior of the body whorl. Same locality as figure 3.

19–21. *Pseudotectus? deciduus* sp. nov. Molds of the interior of small specimens, showing the distinct carination of the body whorl, the earlier whorls not showing carination on the interior. Same locality as figure 3.

22. *Pseudotectus? deciduus* sp. nov. Internal mold, showing the carination only upon the outer part of the body whorl. Same locality as figure 3.
23. *Pseudotectus? deciduus* sp. nov. Internal mold of body whorl, showing the carination only in outer part of whorl. Two and one-half miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

24–27. *Pseudotectus? deciduus* sp. nov. Interior molds, showing various degrees of expression of the carination upon the interior surface of the shell and the shape of the mouth aperture. Same locality as figure 3.

28. *Goniostropha chapmani* sp. nov. Interior mold, showing four whorls. Same locality as figure 3.

All from the Chapman sandstone.

PLATE XIII.

[All the figures on this plate are of natural size.]

Figures 1, 4, *Loxonema jerseyense* Weller (p. 280).
Figure 1a, Cœlidium cf. *Loxonema planogyrata* Hall (p. 275).
Figures 2, 3, 5, *Loxonema welleriana* sp. nov. (p. 279).
Figures 6–11, *Mesocœlia tenuella* sp. nov. (p. 273).
Figures 12, 16, *Platyceras chapmani* sp. nov. (p. 259).
Figure 13, Strophostylus cf. *S. globosus* Hall (p. 263).
Figure 14, *Platyceras (Orthonychia) hebes* var. β (p. 261).
Figures 15, 18, *Platyostoma ventricosum* Conrad (p. 262).
Figure 17, *Orthoceras princiana* sp. nov. (p. 282).
Figure 19, *Platyceras edmundi* sp. nov. (p. 260).
Figure 20, *Platyceras (Orthonychia) hebes* Clarke (p. 260).
Figure 21, Orthoceras cf. *O. parlinense* sp. nov. (p. 283).
Figures 22, 23, *Platyceras (Orthonychia) aroostooki* sp. nov. (p. 261).
Figure 24, *Platyceras (Orthonychia) compressa* sp. nov. (p. 262).
Figure 25, *Orthoceras parlinense* sp. nov. (p. 283).
Figure 26, *Platyceras (Orthonychia) hebes* var. α (p. 260).

1. *Loxonema jerseyense* Weller. Mold of interior, showing four whorls. Moose River sandstone, Detroit, Somerset County, Maine.

1a. Cœlidium cf. *Loxonema planogyrata* Hall. Mold of interior, showing the angular character of the whorls. Chapman sandstone. Presque Isle Stream, near end of Tweedy road, Chapman Township, Aroostook County, Maine.

2. *Loxonema welleriana* sp. nov. Exterior of a nearly complete specimen, showing the surface markings. Moose River sandstone, same locality as figure 1.

3. *Loxonema welleriana* sp. nov. Exterior of small specimen, showing external markings. Moose River sandstone, same locality as figure 1.

4. *Loxonema jerseyense* Weller. Exterior of specimen, showing surface markings. Same locality as figure 1.

5. *Loxonema welleriana* sp. nov. Impression of the exterior in sandstone matrix, showing the initial portion of the spire of a nearly complete specimen with 12 whorls. Moose River sandstone, same locality as figure 1.

6–11. *Mesocœlia tenuella* sp. nov. Molds of the interior of several specimens, showing slight difference in size. Figures 9 and 10 show more distinctly than the others the slight angularity of the inner surface of the whorls. Chapman sandstone; figs. 6, 9, 10, and 11 from locality 2 miles west of Presque Isle Stream, 7 and 8 from Presque Isle Stream, Chapman Township, Aroostook County, Maine.

12. *Platyceras chapmani* sp. nov. Internal mold, showing the broad sulcus on the outer side of the body whorl. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

13. Strophostylus cf. S. *globosus* Hall. Side view of the specimen, showing depressed whorls and trace of columellar twisting characteristic of Strophostylus. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

14. *Platyceras (Orthonychia) hebes* var. β. A young specimen not exhibiting the specific characters of the adult form, but referred to the same species on account of its similarity to the early stages of growth of the type. Chapman sandstone, same locality as figure 13.

15. *Platyostoma ventricosum* Conrad. A small specimen viewed at right angles to the axis of the shell, apparently representing the younger portion of the same species as the form shown in figure 18. Moose River sandstone, same locality as figure 1.

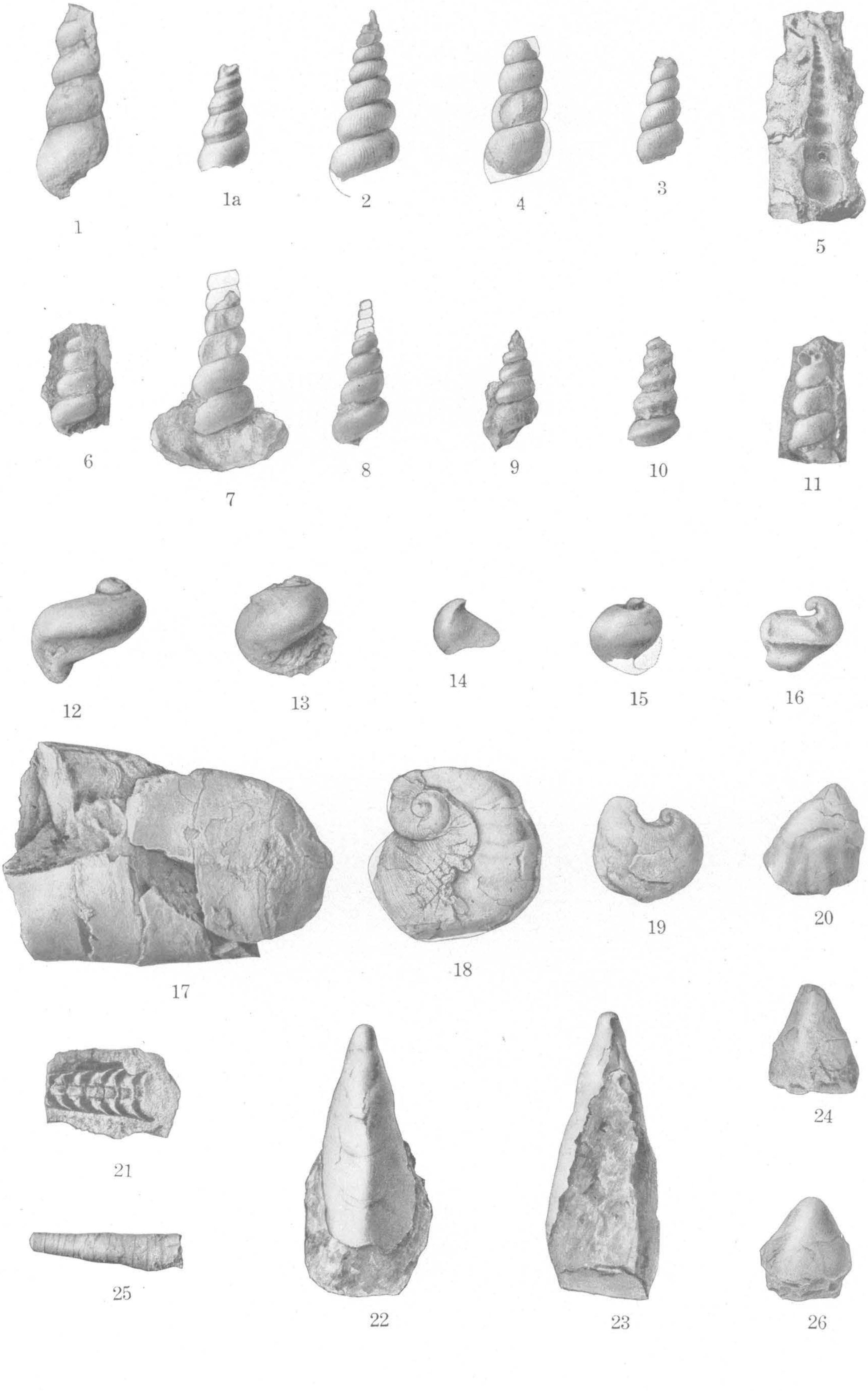
16. *Platyceras chapmani* sp. nov. Interior mold of a smaller specimen than that of figure 12, showing sulcus over part of the inner half of the body whorl as well as on the outer side, suggesting the explanation as a local thickening of the shell. Chapman sandstone, same locality as figure 12.

17. *Orthoceras princiana* sp. nov. Specimens showing four chambers in the midpart of the shell. Moose River sandstone, same locality as figure 1.

18. *Platyostoma ventricosum* Conrad. A large specimen viewed from the apical end, showing the body whorl rapidly expanding, the surface markings, and the revolving undulations affecting the outer part of the body while the early stages of growth are not undulate. Moose River sandstone, same locality as figure 1.

19. *Platyceras edmundi* sp. nov. A specimen showing the low spire and the sulcation on inner side of the body whorl. Chapman sandstone, same locality as figure 12.

20. *Platyceras (Orthonychia) hebes* Clarke. A specimen presenting the characters of Clarke's species from the same locality, figured from a slightly different angle from that of his figures. Chapman sandstone, same locality as figure 13.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21. Orthoceras cf. *O. parlinense* sp. nov. Specimens showing mold of interior of six chambers. Moose River sandstone, same locality as figure 1.
22. *Platyceras* (*Orthonychia*) *aroostooki* sp. nov. A specimen showing the outer side of the shell opposite the aperture, the almost straight growth, and the angular expression of the body part of the shell. Chapman sandstone, same locality as figure 12.
23. *Platyceras* (*Orthonychia*) *aroostooki* sp. nov. Opposite side of the specimen shown in figure 22, showing the slight coiling of the initial portion of the shell, and the oval, elongate aperture. Chapman sandstone, same locality as figure 12.
24. *Platyceras* (*Orthonychia*) *compressa* sp. nov. A short specimen, with the same almost straight conical form as *P.* (*O.*) *aroostooki*, but with more compressed aperture. Chapman sandstone, same locality as figure 13.
25. *Orthoceras parlinense* sp. nov. A small specimen, showing eleven chambers; the type specimen of the species. Moose River sandstone, Somerset County, Maine, probably from the ledge along the side of Parlin Pond.
26. *Platyceras* (*Orthonychia*) *hebes* var. α. A specimen corresponding to the apical portion of the type species. Chapman sandstone, same locality as figure 13.

PLATE XIV.

[All the figures on this plate are of natural size except as otherwise indicated.]

Figures 1, 1a, 1b, 12, 13, 17–19, 28, *Bellerophon (Plectonotus) trilobatus* Sowerby (p. 266).
Figures 2, 11, *Tropidodiscus minimus* var. *americanus* var. nov. (p. 272).
Figures 3–10, 16, 21, *Tropidodiscus obex* Clarke (p. 270).
Figures 14, 15, 20, 27, *Bellerophon (Patellostium) revolvens* sp. nov. (p. 265).
Figure 22, *Tropidodiscus (Temnodiscus) somerseti* sp. nov. (p. 271).
Figures 23, 24, *Tentaculites schlotheimi* Koken (p. 283).
Figure 25, *Cornulites serpularius* Schlotheim (p. 15).
Figure 26, Tentaculites cf. *T. elongatus* Hall (p. 284).
Figure 29, *Cornulites (Ortonia) mainensis* sp. nov. (p. 16).

1. *Bellerophon (Plectonotus) trilobatus* Sowerby. A large specimen showing the shape of the outer whorl and the sinus cutting into the middle of the outer lip of the median lobe. Moose River sandstone, Somerset County, Maine.

1a. *Bellerophon (Plectonotus) trilobatus* Sowerby. Opposite view of the specimen shown in figure 1, showing the inner part of the outer whorl. Moose River sandstone, same locality as figure 1.

1b. *Bellerophon (Plectonotus) trilobatus* Sowerby. A mold of the exterior of the outer whorl of a mature specimen, showing the slit band in center of the middle lobe. Moose River sandstone, same locality as figure 1.

2. *Tropidodiscus minimus* var. *americanus* var. nov. A view of the front of a small specimen, showing the shape of the body whorl at the mouth. × 2. The same specimen is represented in figure 11. Chapman sandstone, 2 miles west of Presque Isle stream, Chapman Township, Aroostook County, Maine.

3. *Tropidodiscus obex* Clarke. Cancellation of the external surface, showing the ornamentation of a very well preserved specimen. × 5. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

4. *Tropidodiscus obex* Clarke. A lateral view of a complete shell. Chapman sandstone, same locality as figure 3.

5. *Tropidodiscus obex* Clarke. Mold of the umbilicus. × 2. Chapman sandstone, same locality as figure 3.

6. *Tropidodiscus obex* Clarke. Mold of the inner face of the outer whorl, showing the groove formed by the inner coil. Chapman sandstone, same locality as figure 3.

7. *Tropidodiscus obex* Clarke. Dorsal view of a small specimen. Chapman sandstone, same locality as figure 3.

8, 9. *Tropidodiscus obex* Clarke. Dorsal and lateral views of another nearly perfect specimen. Chapman sandstone, same locality as figure 3.

10. *Tropidodiscus obex* Clarke. Dorsal view of the specimen shown in figure 4. Chapman sandstone, same locality as figure 4.

11. *Tropidodiscus minimus* var. *americanus* var. nov. A lateral view of the coiled shell. Chapman sandstone, same locality as figure 2.

12. *Bellerophon (Plectonotus) trilobatus* Sowerby. A small specimen, lateral view, showing the lateral lobe separated by regular impressed groove from the outer lobe. Chapman sandstone, same locality as figure 2.

13. *Bellerophon (Plectonotus) trilobatus* Sowerby. A somewhat larger specimen showing the median lobe and the expansion at the open end of the shell. Chapman sandstone, same locality as figure 2.

14, 15, 20, 27. *Bellerophon (Patellostium) revolvens* sp. nov. Specimens of varying size exhibiting the characteristics of the species. Figures 15 and 20 show the inner and exterior molds of the same (the type) specimen, showing the evenly rounded body whorl and the broadly flaring mouth, with sulcus in the outer lip. Moose River sandstone, Detroit, Somerset County, Maine.

16. *Tropidodiscus obex* Clarke. A specimen of the same outline as the typical Chapman form but with groove above the bulging umbilical ridge. Compare with figure 4. Moose River sandstone, same locality as figure 14.

17. *Bellerophon (Plectonotus) trilobatus* Sowerby. Another specimen, lateral view. Chapman sandstone, same locality as figure 2.

18. *Bellerophon (Plectonotus) trilobatus* Sowerby. Another specimen of about the same size as that shown in figure 12, showing the flattened median lobe and narrow lateral lobes. Chapman sandstone, same locality as figure 2.

19. *Bellerophon (Plectonotus) trilobatus* Sowerby. A specimen of the same size and form as that shown in figure 13. Moose River sandstone, same locality as figure 14.

20. See figure 14.

21. *Tropidodiscus obex* Clarke. A small specimen showing the shape of the umbilicus and smaller whorls of the shell. Chapman sandstone, same locality as figure 3.

22. *Tropidodiscus (Temnodiscus) somerseti* sp. nov. A large specimen showing part of the outer whorl and umbilical cavity but broken at the front. Moose River sandstone, same locality as figure 14.

23, 24. *Tentaculites schlotheimi* Koken. Two specimens in sandstone, showing the shape and size of the cone and the rings of the surface, but not the surface markings. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.


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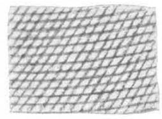
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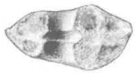
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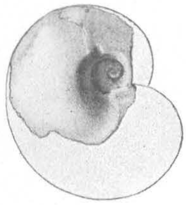
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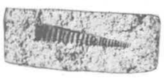
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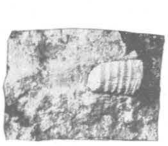
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25. *Cornulites serpularius* Schlotheim. A fragment showing the characteristics of the species, partly embedded in sandstone. Chapman sandstone, same locality as figure 3.
26. Tentaculites cf. *T. elongatus* Hall. A slab of sandstone showing several specimens, some of them larger than the Chapman specimens; and smaller than *Tentaculites elongatus*, which they also closely resemble. Moose River sandstone, same locality as figure 14.
27. See figure 14.
28. *Bellerophon* (*Plectonotus*) *trilobatus* Sowerby. A small, narrow specimen showing the shape of the shell in young stage of growth. Chapman sandstone, same locality as figure 2.
29. *Cornulites* (*Ortonia*) *mainensis* sp. nov. A specimen showing the small conical shells attached to the surface of a Chonetes. Moose River sandstone, same locality as figure 14.

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PLATE XV.

[All the figures on this plate are of natural size.]

Figures 1–17, *Actinopterella radialis* (Clarke) (p. 184).
Figures 18–23, *Actinopterella aroostooki* (Clarke) (p. 187).

1. *Actinopterella radialis* (Clarke). Mold of interior of a right valve, showing the hinge area and teeth and anterior muscular impression. Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County Maine.

2. *Actinopterella radialis* (Clarke). Exterior of a left valve, showing hinge area, hinge teeth and anterior muscular scar, and surface markings. Chapman sandstone, same locality as figure 1.

3–7. *Actinopterella radialis* (Clarke). Exterior of left valves, showing considerable difference in shape, size, and proportions. Chapman sandstone, same locality as figure 1.

8–10. *Actinopterella radialis* (Clarke). Different views of a single specimen of a mold of interior of both valves. Figure 8 shows view from front, both valves convex, though left valve more convex than right; figure 9, view from apical end, showing similarity of the two valves; figure 10, mold of interior of right valve. Chapman sandstone, same locality as figure 1.

11. *Actinopterella radialis* (Clarke). Left valve, showing anterior teeth and muscular scar. Chapman sandstone, same locality as figure 1.

12. *Actinopterella radialis* (Clarke). Left valve, showing broad umbonal region and rather small posterior wing, Chapman sandstone, same locality as figure 1.

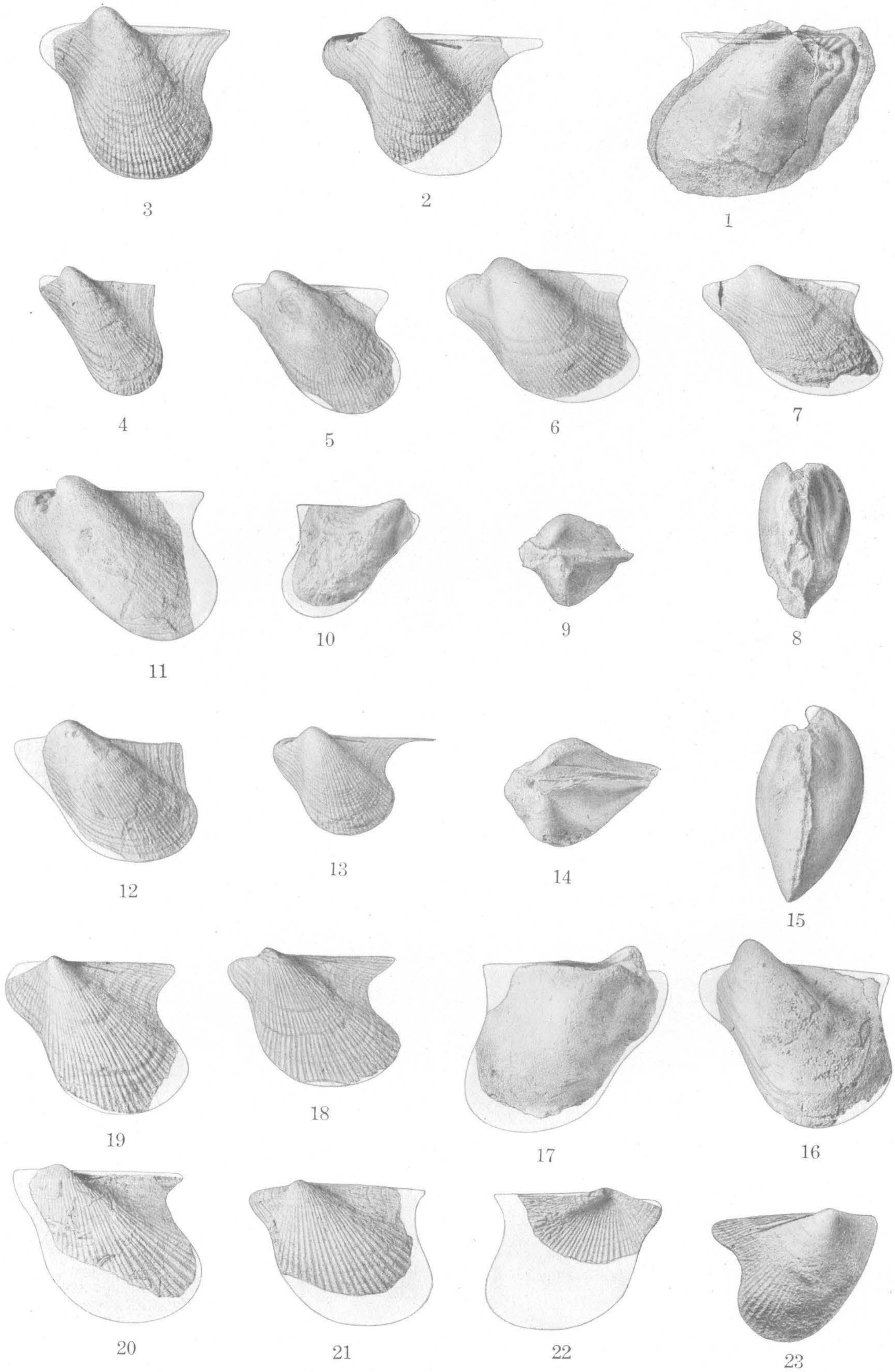
13. *Actinopterella radialis* (Clarke). Left valve, showing both concentric and radial surface markings, mucronate extension of posterior wing, and posterior tooth. Chapman sandstone, same locality as figure 1.

14–17. *Actinopterella radialis* (Clarke). Four views of the same specimen, showing convexity of both valves but some difference in relative size, especially at early stage of growth. Chapman sandstone, same locality as figure 1.

18–21. *Actinopterella aroostooki* (Clarke). Exterior views of left valves, showing the coarse surface marking, extending over the wings as well as the body of the shell. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

22. *Actinopterella aroostooki* (Clarke). Mold of exterior of left valve. Chapman sandstone, same locality as figure 18.

23. *Actinopterella aroostooki* (Clarke). Mold of interior of right valve, in which the posterior hinge tooth and the exterior surface markings are impressed. Chapman sandstone, same locality as figure 18.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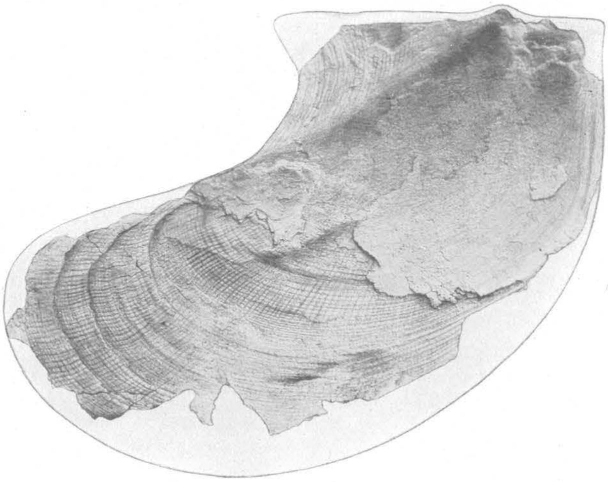

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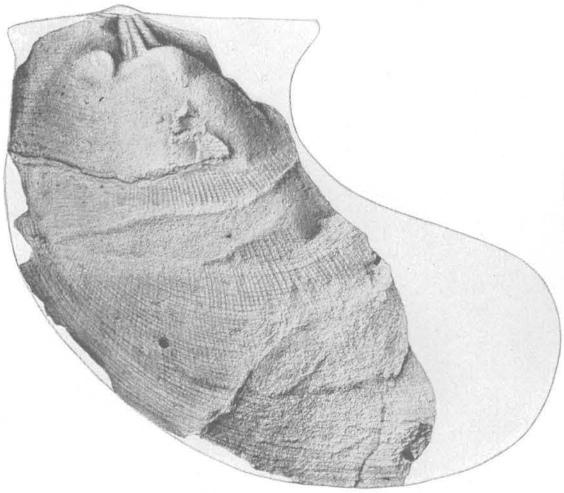

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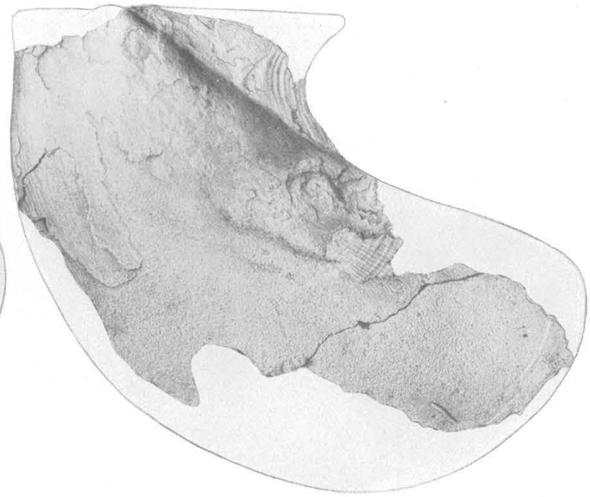

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PLATE XVI.

[All the figures on this plate are of natural size.]

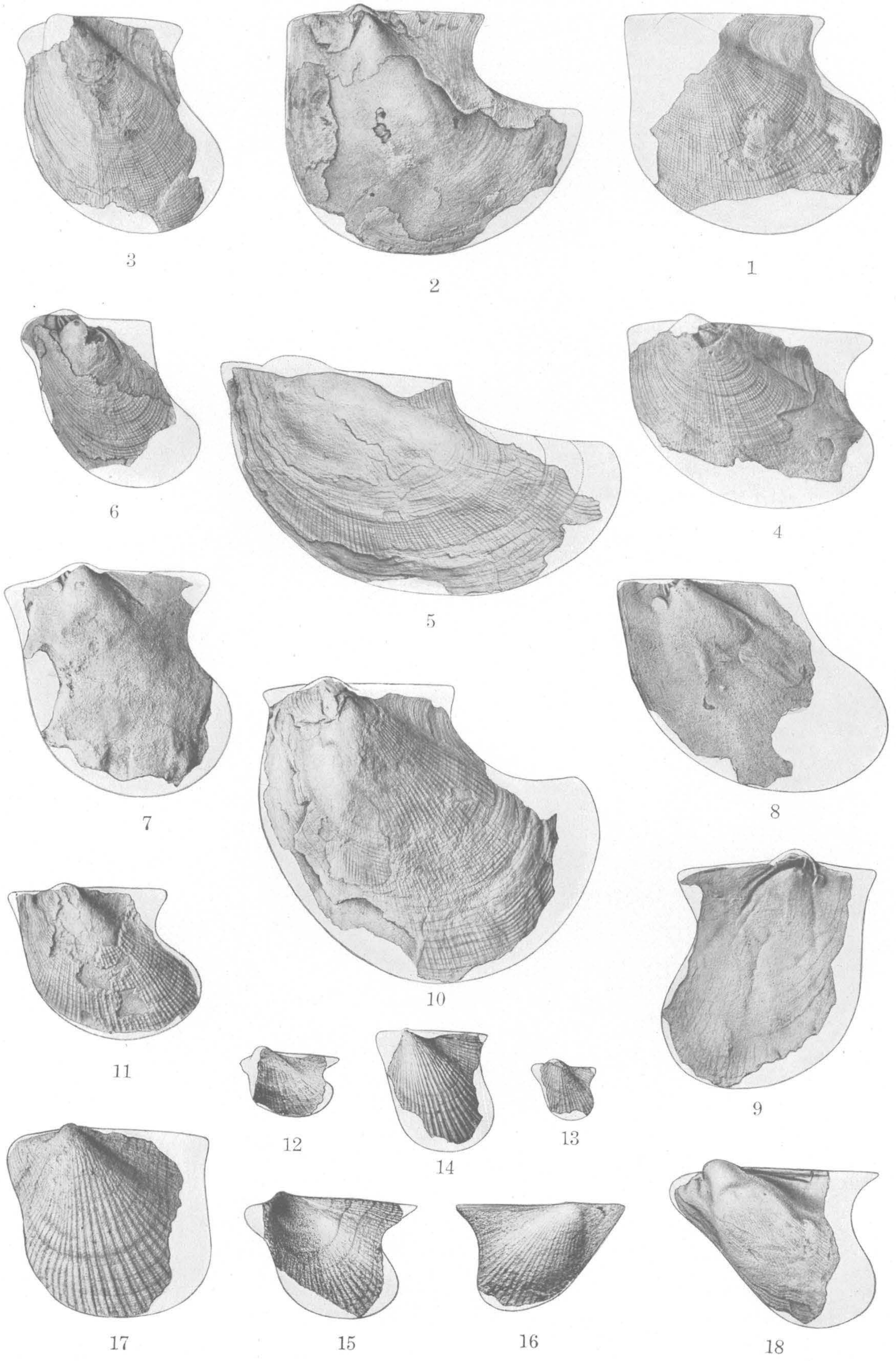
Figures 1-6, *Follmannella mainensis* (Clarke) (p. 179).

1. *Follmannella mainensis* (Clarke). Interior of a left valve in which the exterior markings are shown through the outer layer of the shell but do not affect the inner layers. The mature form of the shell is shown in this specimen. Moose River sandstone, Detroit, Somerset County, Maine.
2. *Follmannella mainensis* (Clarke). An immature left valve, showing the characteristic surface markings over the body and on the wing. Moose River sandstone, same locality as figure 1.
3. *Follmannella mainensis* (Clarke). Mold of interior of left valve, showing the hinge teeth and anterior muscular scar. Moose River sandstone, same locality as figure 1.
4. *Follmannella mainensis* (Clarke). Exterior of a left valve, similar to that shown in figure 3. Moose River sandstone, same locality as figure 1.
5. *Follmannella mainensis* (Clarke). An exfoliated left valve of a mature massive specimen. Varietally differing from the typical specimens shown in figures 1 to 4, but presenting the same characters of general form. The concentric lines are too strongly represented in the figure; only the innermost layers of the shell are present and only on a part of the original specimen. Moose River sandstone, same locality as figure 1.
6. *Follmannella mainensis* (Clarke). An exfoliated and crushed specimen of a mature left valve, showing the inner layers of shell without the characteristic surface markings of the outer layers. Moose River sandstone, same locality as figure 1.

PLATE XVII.

[All the figures on this plate are of natural size.]

1. *Follmannella mainensis* (Clarke). A medium-sized left valve, showing the characteristic surface markings over the body and the contour of the posterior part of an immature shell and the posterior wing. Moose River sandstone, Detroit, Somerset County, Maine.
2. *Follmannella mainensis* (Clarke). An exfoliated left valve, showing the outline and the beginning of retral extension of the basal part of the shell. Moose River sandstone, same locality as figure 1.
3. *Follmannella mainensis* (Clarke). A small left valve of narrow, elongate form, exhibiting surface markings but not the retral extension of the base, characteristic of adult shells. Moose River sandstone, same locality as figure 1.
4. *Follmannella mainensis* (Clarke). A small broad form, exhibiting the characteristic surface markings but not the characteristic form of mature shells. Moose River sandstone, same locality as figure 1.
5. *Follmannella mainensis* (Clarke). A medium-sized left valve in which the mature characteristics of form have been assumed early in growth and are expressed in extreme development. Moose River sandstone, same locality as figure 1.
6. *Follmannella mainensis* (Clarke). A small erect form, showing surface markings on the front part of the shell, and by removal of shell over the umbonal region exhibiting the hinge teeth and anterior muscular scar. Moose River sandstone, same locality as figure 1.
7. *Follmannella mainensis* (Clarke). Mold of interior of left valve, showing the hinge teeth and anterior muscular scar. Moose River sandstone, same locality as figure 1.
8. *Follmannella mainensis* (Clarke). Mold of interior of left valve, showing hinge teeth and both muscular scars. Moose River sandstone, same locality as figure 1.
9. *Follmannella mainensis* (Clarke). Mold of interior of right valve, showing the hinge teeth, anterior muscular scar, concave form of that valve, and faint impressions of radial markings on the interior of the basal part of the shell. These markings are very faint on the original, and their strength and regularity are exaggerated in the figure. No specimens showing the exterior of the right valve have been seen. Moose River sandstone, same locality as figure 1.
10. *Follmannella mainensis* (Clarke). A partly exfoliated left valve. In the central part of the shell the superficial radial lineation is conspicuous. Near the basal margin the concentric lines dominate, showing the deeper layers of the shell, the surface having been removed. Moose River sandstone, same locality as figure 1.
11. *Follmannella mainensis* (Clarke). A small specimen. The slightly greater coarseness of the radial lineation is due to removal of the outer layer of the shell, on which the finer intercalated radial lines are better exhibited. Moose River sandstone, same locality as figure 1.
12. *Actinopterella concentrica* sp. nov. An imperfect specimen of a left valve, showing the posterior part of the shell and its characteristic surface sculpture. The high arching of the umbonal and central part of the shell are not correctly reproduced by the figure. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
13. *Actinopterella aroostooki* var. *planicosta* var. nov. An imperfect specimen of a left valve, showing the form and surface character of the variety. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
14. *Actinopterella aroostooki* (Clarke). An erect specimen, showing the characteristic markings of the species. Chapman sandstone, same locality as figure 12. (See also Pl. XV, figs. 18–23.)
15. *Actinopterella aroostooki* (Clarke). A specimen showing the lineation on the posterior wing. Same locality as figure 14.
16. *Actinopterella aroostooki* (Clarke). A right valve, showing both wings, the posterior hinge tooth, the anterior muscular scar, and the characteristic convexity. Chapman sandstone, same locality as figure 12.
17. *Actinopterella aroostooki* var. *erecta* var. nov. The type specimen of the variety, a left valve in which the broad and depressed convex umbonal region and coarser radial lineation are exhibited. Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
18. *Actinopterella tenuiradiata* sp. nov. Mold of interior of left valve, showing the highly arched cylindrical body portion of the shell, the strong posterior hinge teeth, and the faintly impressed radial lineation, implying a distinct lineation on the exterior of the shell, although no exterior of this species has been seen. Moose River sandstone, Detroit, Somerset County, Maine.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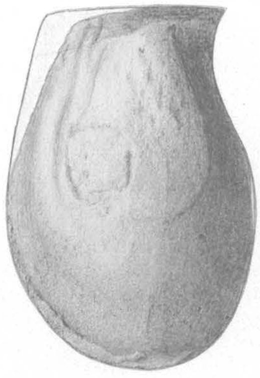

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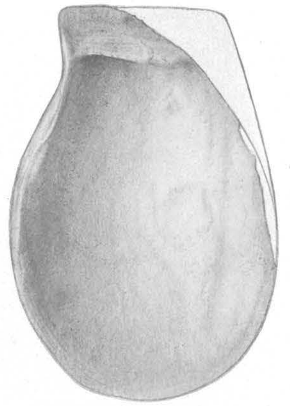

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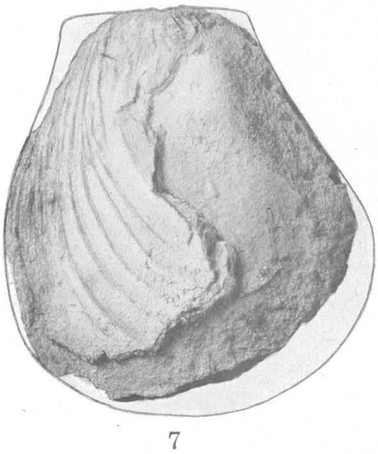

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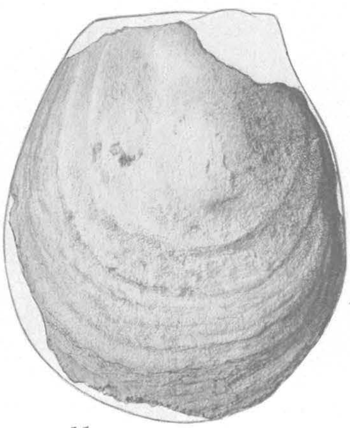

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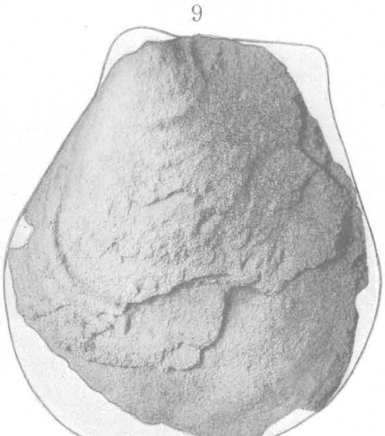

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PLATE XVIII.

[All the figures on this plate are of natural size.]

Figures 1-6, 8, 11, *Myalina maureriana* sp. nov. (p. 213).
Figures 7, 9, 10, 12, *Myalina maureriana* var. *lata* var. nov. (p. 215).

1. *Myalina maureriana* sp. nov. Mold of the interior of a right valve, with part of the shell preserved across the middle part of the valve. The flat striated hinge, the small deep pit of the anterior muscular scar, and a little of the pallial line are visible. Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.
2. *Myalina maureriana* sp. nov. Gutta-percha impression of the mold of the exterior of a left valve, showing the surface character and the beak projected slightly beyond the edge of the hinge. Chapman sandstone, same locality as figure 1.
3. *Myalina maureriana* sp. nov. A specimen of a right valve showing the posterior muscular scar and mantle. Chapman sandstone, same locality as figure 1.
4. *Myalina maureriana* sp. nov. Mold of the interior of a right valve, showing part of the hinge area, the outline of the edge of the mantle and the posterior muscular scar near the middle and the anterior muscular scar at the hinge margin. Chapman sandstone, same locality as figure 1.
5. *Myalina maureriana* sp. nov. A specimen similar to that shown in figure 4, but somewhat more slender and elongate, in which only the posterior scar is visible. Chapman sandstone, same locality as figure 1.
6. *Myalina maureriana* sp. nov. Mold of the interior of a right valve.
7. *Myalina maureriana* var. *lata* var. nov. A partly exfoliated right valve, showing the characteristic widening of the front part of the shell and the surface sculpture (on the left). Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.
8. *Myalina maureriana* sp. nov. A small left valve, which apparently from thinness of the shell has left the impression of the surface sculpture on the matrix. In the specimen the shell substance is entirely removed. Chapman sandstone, same locality as figure 1.
9. *Myalina maureriana* var. *lata* var. nov. Mold of interior of left valve, showing outline of mantle but no distinct evidence of muscular attachments. Chapman sandstone, same locality as figure 7.
10. *Myalina maureriana* var. *lata* var. nov. Mold of interior of a small right valve in which the pallial margin is evident but no distinct impression of muscular scar. Chapman sandstone, same locality as figure 7.
11. *Myalina maureriana* sp. nov. Exterior surface of a right valve, somewhat exfoliated but exhibiting the rough surface of a mature shell. Chapman sandstone, same locality as figure 1.
12. *Myalina maureriana* var. *lata* var. nov. Exterior of a left valve, showing the characteristic broadening of the anterior part of the shell of this variety as contrasted with the slightly broadened form of the typical species shown in figure 11. Chapman sandstone, same locality as figure 7.

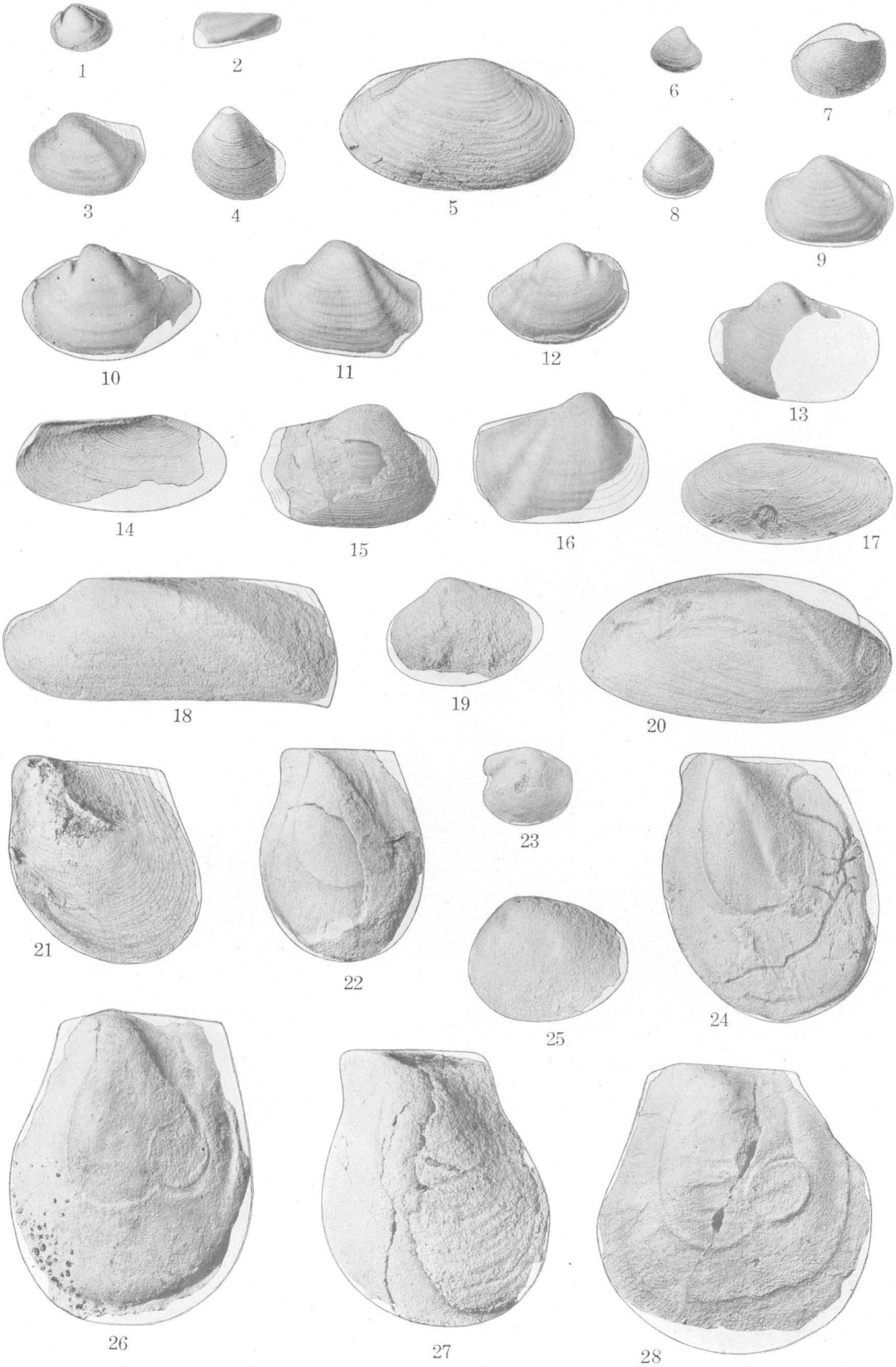
PLATE XIX.

[All the figures on this plate are of natural size except figures 4, 7, and 8, which are enlarged $1\frac{1}{2}$ diameters.]

Figure 1, *Cleidophorus curtus* sp. nov. (p. 160).
Figure 2, *Orthodesma carinifera* sp. nov. (p. 126).
Figures 3, 9, 11, 13, 15, 16, *Tellinites gibbosa* var. *kayseri* Beushausen (p. 165).
Figure 4, *Nuculoidea bellatula* sp. nov. (p. 174).
Figure 5, *Tellinites chapmani* sp. nov. (p. 163).
Figure 6, *Nuculoidea cordata* sp. nov. (p. 175).
Figure 7, cf. *Nuculoidea aquisgranensis* Beushausen (p. 176).
Figure 8, *Nuculoidea trigonale* sp. nov. (p. 176).
Figures 10, 12, 19, *Paleoneilo (Ditichia) mainensis* Clarke (p. 168).
Figures 14, 17, *Glossites barrandii* sp. nov. (p. 144).
Figure 18, *Goniophora kayseri* sp. nov. (p. 230).
Figure 20, *Glossites amnigenoides* sp. nov. (p. 145).
Figure 21, *Leiopteria reisiana* sp. nov. (p. 211).
Figures 22, 26, *Myalina maureriana* sp. nov. (p. 213).
Figure 23, *Megambonia cardiiformis* var. *parviuscula* var. nov. (p. 201).
Figures 24, 27, *Myalina maureriana* var. *pterinæoides* var. nov. (p. 215).
Figure 25, cf. *Cypricardella rotundata* sp. nov. (p. 246).
Figure 28, *Myalina maureriana* var. *lata* var. nov. (p. 215).

1. *Cleidophorus curtus* sp. nov. Mold of interior of left valve, showing the strong ridge on interior separating anterior muscular scar from umbone, and slight ridge on posterior side. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
2. *Orthodesma carinifera* sp. nov. Interior mold of a left valve, the supposed outline of the posterior and front margin is expressed by added line. Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
3. *Tellinites gibbosa* var. *kayseri* Beushausen. Mold of interior of a small left valve, in which the anterior and front are preserved, but the beak and hinge portion are absent. Chapman sandstone, same locality as figure 2.
4. *Nuculoidea bellatula* sp. nov. Exterior of a right valve, showing the narrow erect form and surface markings. $\times 1\frac{1}{2}$. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
5. *Tellinites chapmani* sp. nov. Mold of interior of right valve, near the upper posterior margin of which a part of the shell is preserved, showing the surface lineation. The coarser concentric undulations seen on the body of the shell evidently belong to the inner surface of the shell and are not expressed on the exterior. Chapman sandstone, same locality as figure 2.
6. *Nuculoidea cordata* sp. nov. Exterior of a right valve, showing size, form, and surface markings. Chapman sandstone, same locality as figure 1.
7. cf. *Nuculoidea aquisgranensis* Beushausen. An imperfect specimen showing the left valve without the umbonal portion. The form of the body of the shell, surface markings, pallial line, and anterior muscular scar are seen in the figure. Chapman sandstone, same locality as figure 4.
8. *Nuculoidea trigonale* sp. nov. A small right valve, showing the thick umbonal portion of the shell and well-rounded front, with a single strong growth lamella. $\times 1\frac{1}{2}$. Chapman sandstone, same locality as figure 4.
9. *Tellinites gibbosa* var. *kayseri* Beushausen. Mold of interior of a small left valve, showing the concentric folds and the faint radiating lineation, which do not appear on the outer surface of the shell. Chapman sandstone, same locality as figure 2.
10. *Paleoneilo* (*Ditichia*) *mainensis* Clarke. Interior mold of left valve, showing the strong ridge on the inner side of both the anterior and posterior muscular scars and a low umbonal fold from beak to front on inner side of the internal ridge. The hinge margin is lacking. Chapman sandstone, same locality as figure 2.
11. *Tellinites gibbosa* var. *kayseri* Beushausen. Mold of interior of left valve, showing almost complete outline of the shell and the characteristic undulations on the posterior slope and radial lines over the body of the shell on the interior surface. Chapman sandstone, same locality as figure 2.
12. *Paleoneilo* (*Ditichia*) *mainensis* Clarke. Interior mold of right valve, showing the strong ridges inside the muscular scars, the anterior much deeper and broader than the posterior, indication of two of the cardinal teeth in front of the beak, and the slight undulations along the posterior slope. Chapman sandstone, same locality as figure 2.
13. *Tellinites gibbosa* var. *kayseri* Beushausen. A specimen showing the form of the beak and front end of a left valve. Chapman sandstone, same locality as figure 2.

14, 17. *Glossites barrandii* sp. nov. Mold of exterior and matrix of same specimen showing the form and surface markings of a left valve. Chapman sandstone, same locality as figure 4.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15. *Tellinites gibbosa* var. *kayseri* Beushausen. A right valve, partly a mold of interior but showing on the front and anterior the outer surface with fine sharp concentric lines. The posterior slope is crushed, so that evidence of the undulations is destroyed. Chapman sandstone, same locality as figure 2.
16. *Tellinites gibbosa* var. *kayseri* Beushausen. Mold of interior of right valve, showing strong surface undulations on posterior slope, faint radiating lines over the body of the shell and distinct concentric lines of growth over the whole. Chapman sandstone, same locality as figure 2.
17. See figure 14.
18. *Goniophora kayseri* sp. nov. A sandstone mold of a left valve, showing form, but devoid of either internal or external markings. Chapman sandstone, same locality as figure 4.
19. *Paleoneilo* (*Ditichia*) *mainensis* Clarke. An imperfect sandstone mold of a left valve. Chapman sandstone, same locality as figure 1.
20. *Glossites amnigenoides* sp. nov. A right valve, the umbonal and cardinal part absent and theoretically reproduced by lines. Shows the surface markings and the anterior muscular scar. Chapman sandstone, same locality as figure 1.
21. *Leiopteria reisiana* sp. nov. Exterior of a left valve showing concentric surface sculpture and the form and outline of the shell. Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.
22. *Myalina maureriana* sp. nov. A small specimen, mainly an interior mold, of a left valve. Chapman sandstone, same locality as figure 21.
23. Megambonia cf. *M.cardiiformis* var. *parviuscula* var. nov. Specimen showing the exterior form and markings of a left valve. Moose River sandstone, Detroit, Somerset County, Maine.
24. *Myalina maureriana* var. *pterinæoides* (Clarke). Interior mold of left valve, showing pallial line and (faintly) the posterior scar. Chapman sandstone, same locality as figure 21.
25. cf. *Cypricardella rotundata* sp. nov. A sandstone mold of a left valve, showing very little upon which to identify it, but referred with doubt to the species named. Chapman sandstone, same locality as figure 1. (See also Pl. XXI, figs. 14, 15.)
26. *Myalina maureriana* sp. nov. Internal mold of left valve, showing distinctly the two muscular scars and the pallial margin. Chapman sandstone, same locality as figure 21.
27. *Myalina maureriana* var. *pterinæoides* (Clarke). Mold of a nearly perfect left valve, showing shell over right side of body and internal mold on left. Chapman sandstone, same locality as figure 21.
28. *Myalina maureriana* var. *lata* var. nov. Mold of interior of left valve, showing pallial line and the posterior muscular scar; the anterior scar not visible. Chapman sandstone, same locality as figure 21. (See also Pl. XVIII, figs. 7, 9, 10, 12.)

PLATE XX.

the figures on this plate are of natural size.]

Figures 1–7, *Modiomorpha chapmani* sp. nov. (p. 221).
Figure 8, *Grammysia (Grammysioidea) princiana* sp. nov. (p. 136).
Figure 9, *Schizodus? prunum* sp. nov. (p. 238).

1. *Modiomorpha chapmani* sp. nov. Sandstone mold of a right valve. The shell substance is entirely removed and the concentric lineation, though it represents the surface markings, is probably less sharp than on the actual surface of the shell. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
2. *Modiomorpha chapmani* sp. nov. A somewhat weathered mold of a left valve on which the concentric markings are nearly obliterated. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
3. *Modiomorpha chapmani* sp. nov. Mold of right valve on which the concentric lines on the posterior slope of the cardinal border of the shell and the coarser surface folding on the anterior end are distinctly preserved. Chapman sandstone, same locality as figure 2.
4. *Modiomorpha chapmani* sp. nov. A left valve in which the margin is lacking except at the posterior end, but the body form is represented. Chapman sandstone, same locality as figure 1.
5. *Modiomorpha chapmani* sp. nov. An imperfect left valve, the outlines of which are reconstructed. Chapman sandstone, same locality as figure 2.
6. *Modiomorpha chapmani* sp. nov. Stone mold of a left valve, much weathered, but still preserving the strong concentric growth lines of the shell. Chapman sandstone, same locality as figure 1.
7. *Modiomorpha chapmani* sp. nov. Posterior part of a left valve showing the broad sulcus on the median part of the shell. Chapman sandstone, same locality as figure 2.
8. *Grammysia (Grammysioidea) princiana* sp. nov. Mold of the exterior of a large right valve, the surface considerably weathered but still showing the concentric growth varices, the posterior umbonal angular ridge, and the posterior muscular scar. Moose River sandstone, Detroit, Somerset County, Maine.
9. *Schizodus? prunum* sp. nov. An imperfect stone mold, showing little of definite value but resembling in form the genus Schizodus. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

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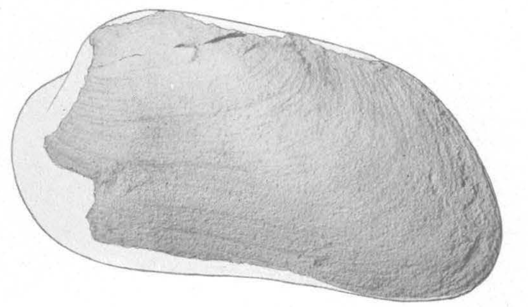

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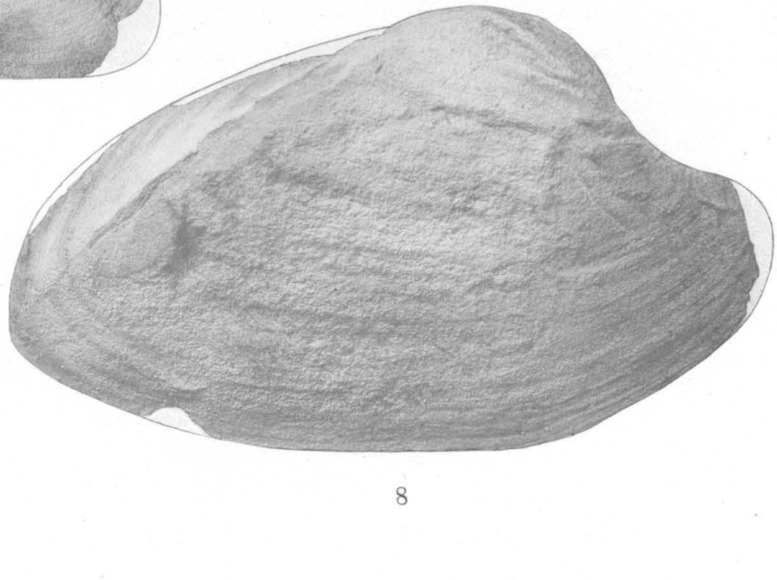

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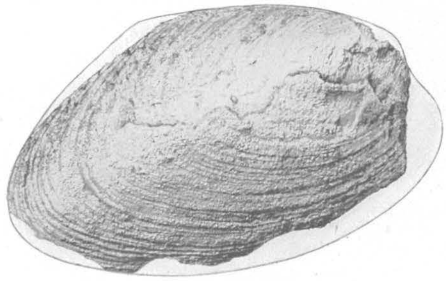
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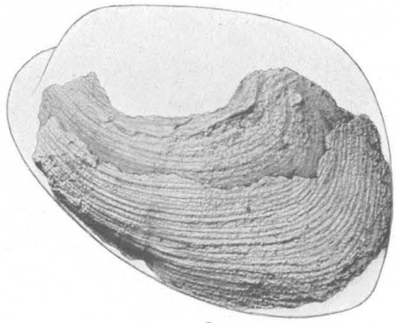
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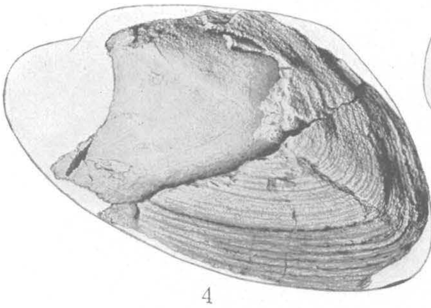
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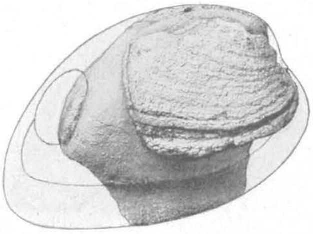
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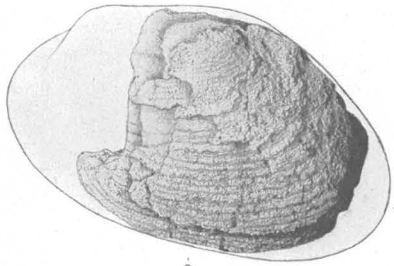
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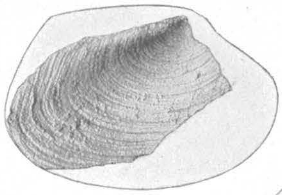
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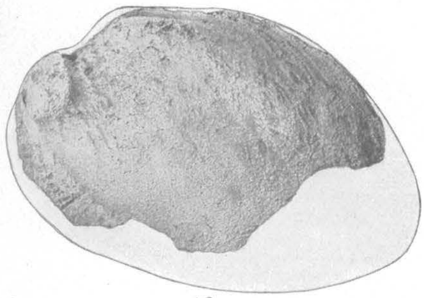
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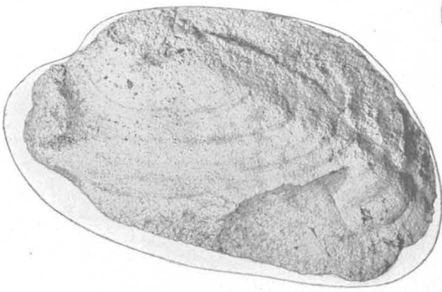
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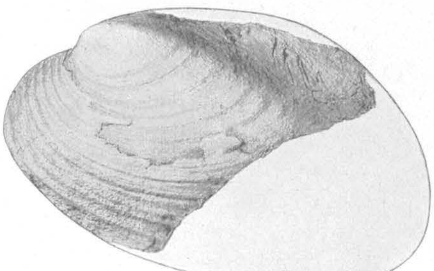
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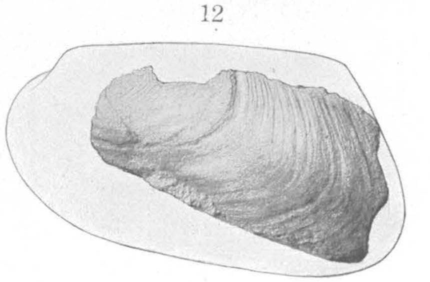
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PLATE XXI.

[All the figures on this plate are of natural size except figure 1, which is magnified 2 diameters.]

Figure 1, *Cypricardella bellatula* sp. nov. (p. 244).
Figures 2–7, 10–13, *Modiomorpha aroostooki* sp. nov. (p. 219).
Figure 8, *Cypricardella transversa* sp. nov. (p. 247).
Figure 9, Cypricardella cf. *C. bicostula* Krantz (p. 248).
Figures 14–15, *Cypricardella rotundata* sp. nov. (p. 246).
Figure 16, Modiomorpha cf. *M. protea* Clarke (p. 219).

1. *Cypricardella bellatula* sp. nov. A well-preserved mold of this small species, showing well the form and surface characters × 2. Chapman sandstone, Presque Isle Stream, at end of Tweedy road, Chapman Township, Aroostook County, Maine.
2. *Modiomorpha aroostooki* sp. nov. Exterior of right valve, somewhat worn, the edges imperfect, but showing the form and surface markings. Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.
3. *Modiomorpha aroostooki* sp. nov. Ventral part of left valve, showing the concentric lineation of the surface. Chapman sandstone, same locality as figure 2.
4. *Modiomorpha aroostooki* sp. nov. Another imperfect left valve, in which the form is more elongate in the direction of the umbonal ridge. Chapman sandstone, same locality as figure 2.
5. *Modiomorpha aroostooki* sp. nov. Fragment of a right valve, showing a piece of the shell and the mold of the interior, the pallial margin, and the inner edge of the posterior muscular scar. Chapman sandstone, same locality as figure 2.
6. *Modiomorpha aroostooki* sp. nov. Weathered fragment of left valve. Chapman sandstone, same locality as figure 2.
7. *Modiomorpha aroostooki* sp. nov. A nearly complete left valve, showing the form and surface markings. Chapman sandstone, same locality as figure 2.
8. *Cypricardella transversa* sp. nov. A sandstone mold showing form but very little of surface character, referred with doubt to the genus Cypricardella. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
9. Cypricardella cf. *C. bicostula* Krantz. A finely preserved fragment of the mold of the exterior of a left valve. The specimen is concave. Chapman sandstone, same locality as figure 8.
10. *Modiomorpha aroostooki* sp. nov. Mold of interior of left valve, showing the anterior muscular scar. Chapman sandstone, same locality as figure 2.
11. *Modiomorpha aroostooki* sp. nov. Mold of interior of left valve, showing umbonal ridge and anterior muscular scar. Chapman sandstone, same locality as figure 2.
12. *Modiomorpha aroostooki* sp. nov. Mold of interior of left valve, somewhat crushed, showing anterior and posterior (?) muscular scars. Chapman sandstone, same locality as figure 2.
13. *Modiomorpha aroostooki* sp. nov. A left valve in which the surface of the front part and the form of the umbo and umbonal ridge are well preserved. Chapman sandstone, same locality as figure 2.

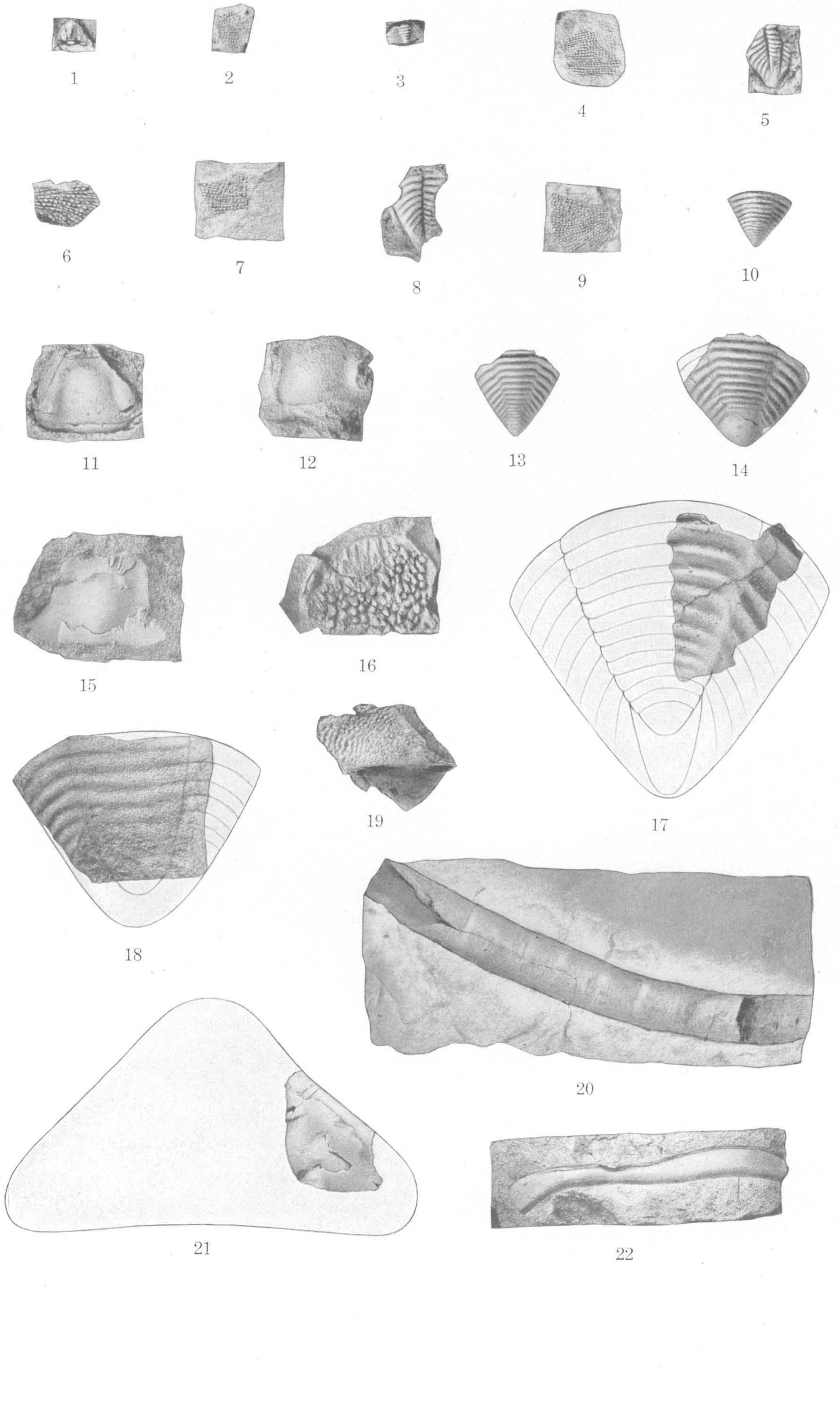
14–15. *Cypricardella rotundata* sp. nov. Stone molds of left valves; weathered specimens; the surface markings being removed. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.

16. *Modiomorpha protea* Clarke. Fragment of left valve, showing the form of Clarke's species. Chapman sandstone, same locality as figure 8.

PLATE XXII.

[All the figures on this plate are of natural size.]

1. *Phacopidella chapmani* sp. nov. Cephalon, showing small size, elongate glabella, with only the third pair of furrows showing. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
2, 4, 7, 9, *Polypora lilæa* Hall. Stone molds of incomplete fronds, showing the arrangement and size of the fenestrules. Chapman sandstone, same locality as figure 1.
3. *Phacopidella chapmani* sp. nov. Fragment of a small pygidium, showing resemblance to Proetus and Phacops. Chapman sandstone, same locality as figure 1.
4. See figure 2.
5. Dalmanites (Synphoria?) sp. β. Fragment of a pygidium of a small specimen, too imperfect for satisfactory specific definition. Chapman sandstone, same locality as figure 1.
6. *Polypora psyche* Billings. Stone mold of incomplete frond, showing fenestrules of larger size than in *P. lilæa*. Chapman sandstone, same locality as figure 2.
7. See figure 2.
8. Dalmanites (Synphoria?) sp. α. Fragment of a pygidium, too imperfect for satisfactory specific definition. Chapman sandstone, Edmunds Hill, Chapman Plantation, Aroostook County, Maine.
9. See figure 2.
10. *Homalonotus vanuxemi* Hall. A small terminal part of a pygidium. Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
11. *Homalonotus laticaudatus* sp. nov. A small, nearly complete glabella, showing the eye lobes and occipital ring. Chapman sandstone, same locality as figure 8.
12. *Homalonotus vanuxemi* Hall. Portion of the right side of a glabella, showing part of the right eye lobe. Chapman sandstone, same locality as figure 10.
13. *Homalonotus vanuxemi* Hall. A nearly complete pygidium of a small specimen. Chapman sandstone, same locality as figure 10.
14. *Homalonotus laticaudatus* sp. nov. Posterior of a medium-sized pygidium, showing the wide axis and broad form. Compare with figure 13. Chapman sandstone, same locality as figure 1.
15. *Homalonotus vanuxemi* Hall. A hypostoma preserving a portion of the shell substance. Chapman sandstone, same locality as figure 10.
16. Favosites sp. indet. Mold of surface of mass of coral, showing the filling of the mouths of the coralites. Chapman sandstone, same locality as figure 1.
17. *Homalonotus laticaudatus* sp. nov. A fragment of a large pygidium. Chapman sandstone, same locality as figure 1.
18. *Homalonotus laticaudatus* sp. nov. Stone mold of a fragment of a large pygidium, showing the broad axis. Chapman sandstone, same locality as figure 8.
19. *Asterolepsis clarkei* Eastman. A dorso-median plate, showing the closely crowded stellate tubercles and the angular median ridge, with rapidly sloping sides characteristic of the genus. Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
20. *Trachyderma (?Gyrichnites) speciosa* sp. nov. A piece of the tubular skin molded in the sandstone block, showing the shape of the flattened tubular form and the broad wrinkles of the surface. Chapman sandstone, same locality as figure 8.
21. *Homalonotus vanuxemi* Hall. A fragment of the right free cheek. Chapman sandstone, same locality as figure 10.
22. *Homalonotus laticaudatus* sp. nov. Mold of a segment of the thorax. Chapman sandstone, same locality as figure 1.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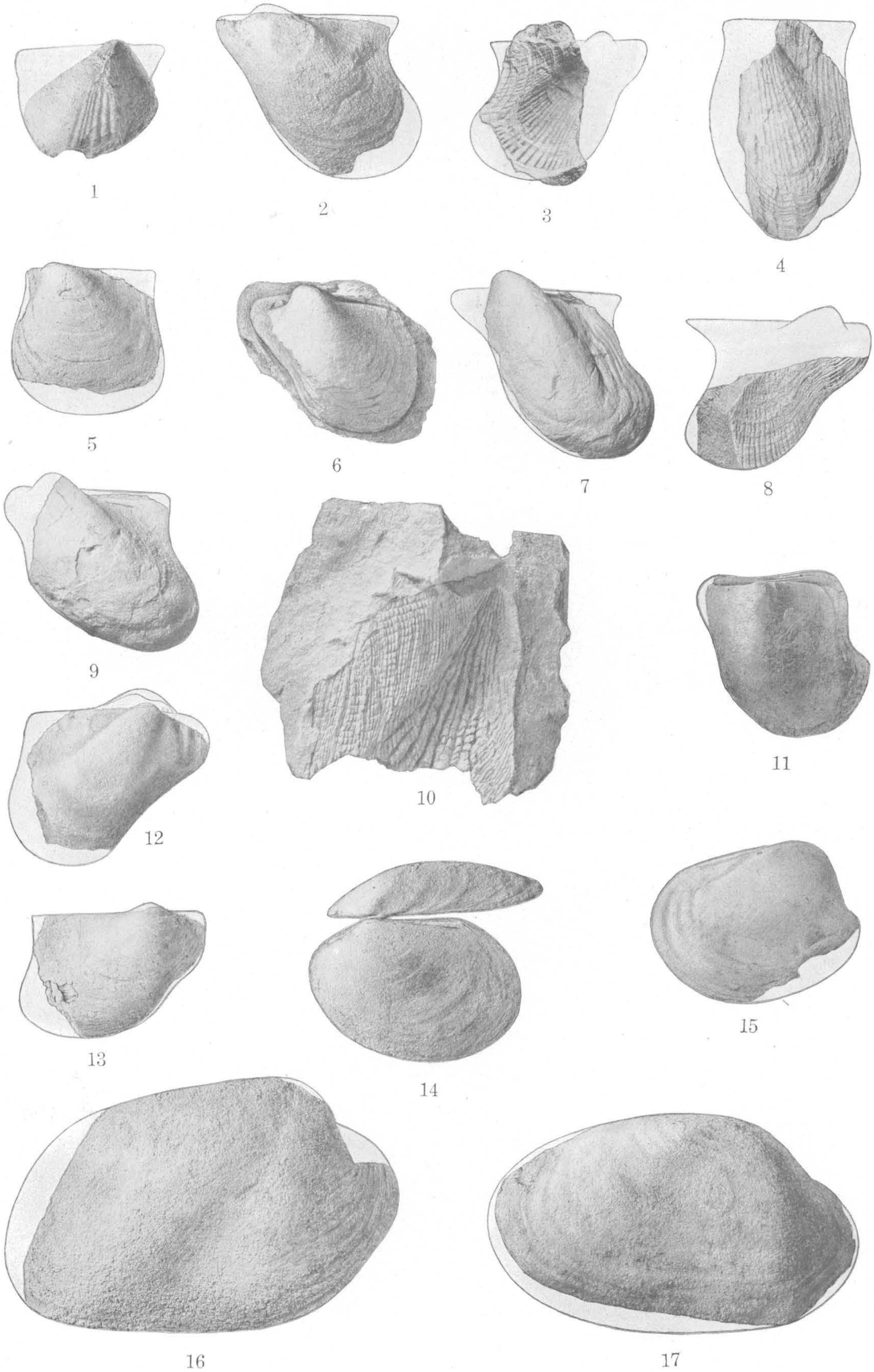
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PLATE XXIII.

[All the figures on this plate are of natural size except figure 10, which is magnified 2 diameters.]

Figure 1, ??*Conocardium dubia* sp. nov. (p. 201).
Figure 2, Actinopterella sp. δ (p. 192).
Figures 3, 7, Actinopterella sp. γ (p. 192).
Figures 4, 10, *Limoptera pauciradiata* Hall var. *chapmani* var. nov. (p. 204).
Figure 5, *Pteronitella quadrata* sp. nov. (p. 196).
Figures 6, 8, 9, 11-13, *Actinopterella radialis* (Clarke) (p. 184).
Figures 14, 15, *Cypricardites detroitense* sp. nov. (p. 155).
Figures 16, 17, *Grammysia modiomorphæ* Clarke (p. 138).

1. ??*Conocardium dubia* sp. nov. This fragment is supposed to represent the inflated middle portion of a right valve of a Conocardium, showing the longitudinal furrows over the body part of the shell. Chapman sandstone, Presque Isle Stream, Chapman Township, Aroostook County, Maine.
2. Actinopterella sp. δ. Left valve, with imperfect surface. The figure does not exhibit the highly arched form of the shell which is characteristic of the original. Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
3. Actinopterella sp. γ. Fragment of a left valve showing in mold the exterior markings. Chapman sandstone, Presque Isle Stream, at end of Tweedy road, Chapman Township, Aroostook County, Maine.
4, 10. *Limoptera pauciradiata* Hall var. *chapmani* var. nov. Molds of the interior and exterior of a single left valve. In figure 4 the outline is somewhat distorted by crushing, but the relation of body and wing is well seen; in figure 10 (which is enlarged 2 diameters) the nature of the surface sculpture is seen. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.
5. *Pteronitella quadrata* sp. nov. Stone mold of the left valve, of which the contour, wing, and surface markings are exhibited. Chapman sandstone, same locality as figure 1.
6. *Actinopterella radialis* (Clarke). Mold of interior of left valve, showing the posterior cardinal tooth and the anterior cardinal of this valve with cavity for articulation with its opposite tooth. Chapman sandstone, same locality as figure 1.
7. Actinopterella sp. γ. Mold of interior of left valve, showing the narrow, highly arched body of the shell. Chapman sandstone, same locality as figure 3.
8. *Actinopterella radialis* (Clarke). Fragment of mold of exterior of left valve, showing part of the anterior wing and the surface sculpture. Chapman sandstone, same locality as figure 1.
9. *Actinopterella radialis* (Clarke). Mold of interior of left valve, showing wing and posterior tooth. Chapman sandstone, same locality as figure 1.
10. See figure 4.
11. *Actinopterella radialis* (Clarke). Interior mold of a left valve, the beak of which is abruptly cut off, showing the striated hinge area and the posterior hinge tooth. Chapman sandstone, same locality as figure 1.
12. *Actinopterella radialis* (Clarke). Direct view of mold of right valve, showing the anterior teeth and the overarching beak of the left valve. Chapman sandstone, same locality as figure 1.
13. *Actinopterella radialis* (Clarke). Mold of interior of another right valve of more regular form than the specimen shown in figure 12. Chapman sandstone, same locality as figure 1.
14. *Cypricardites detroitense* sp. nov. Mold of interior of two valves still joined at the hinge line. The left valve, showing hinge teeth, is in its natural form, but the right valve is crushed. Moose River sandstone, Detroit, Somerset County, Maine.
15. *Cypricardites detroitense* sp. nov. Mold of interior of right valve, showing the form and exhibiting the posterior hinge teeth. Moose River sandstone, same locality as figure 14.
16. *Grammysia modiomorphæ* Clarke. A worn, imperfect specimen of a right valve, showing the anterior end and oblique sulcus across center of shell. Chapman sandstone, same locality as figure 4.
17. *Grammysia modiomorphæ* Clarke. A worn specimen, showing faintly the concentric varices and the general form of a right valve. Chapman sandstone, same locality as figure 4.

PLATE XXIV.

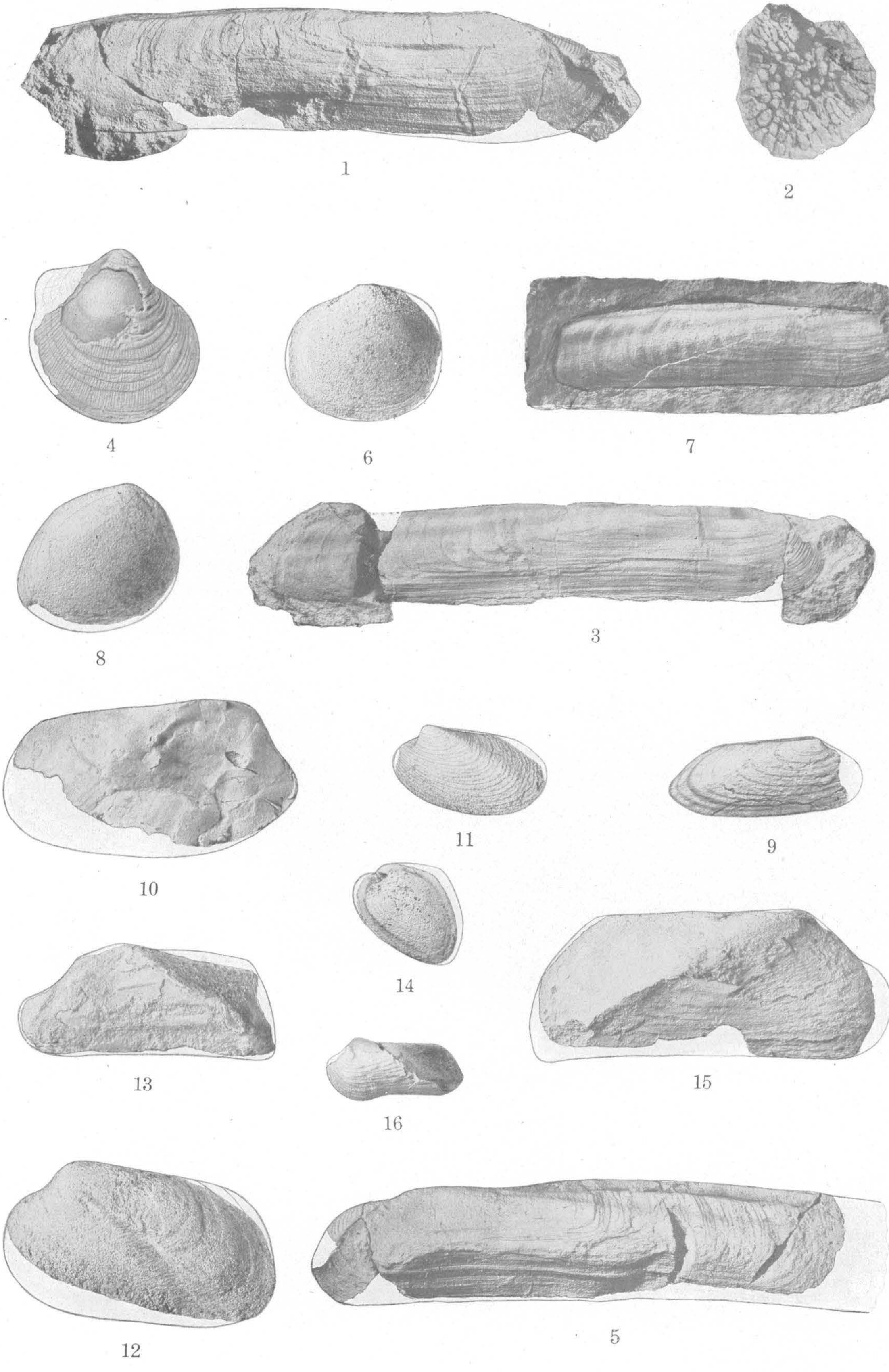
[All the figures on this plate are of natural size except figs. 1, 2, 3, 5, and 7, which are magnified 2 diameters.]

Figures 1, 3, 5, 7, *Paleosolen chapmani* sp. nov. (p. 251).
Figure 2, *Pleurodictyum problematicum* Goldfuss (p. 14).
Figure 4, Megambonia cf. *M. cardiiformis* Hall (p. 199).
Figure 6, cf. Edmondia (sp. indet.).
Figure 8, cf. Schizodus (sp. indet.) (p. 239).
Figure 9, *Sphenotomorpha rigidula* sp. nov. (p. 234).
Figure 10, *Grammysioidea ellymelloides* sp. nov. (p. 138).
Figure 11, *Elymella harrisi* sp. nov. (p. 142).
Figure 12, *Grammysia acadica* Billings var. (p. 135).
Figures 13, 15, *Goniophora omega* sp. nov. (p. 232).
Figure 14, *Anodontopsis maccoyiana* sp. nov. (p. 236).
Figure 16, Cimitaria cf. *C. chapmani* sp. nov. (p. 255).

1. *Paleosolen chapmani* sp. nov. A nearly complete right valve, showing the general form and outline. × 2. Chapman sandstone, Presque Isle Stream, at end of Tweedy road, Chapman Township, Aroostook County, Maine.
2. *Pleurodictyum problematicum* Goldfuss. A specimen showing mold of the interior of the tubules, too poorly preserved for close specific identification. Chapman sandstone, same locality as figure 1.
3. *Paleosolen chapmani* sp. nov. A nearly complete right valve, more slender that the one shown in figure 1 and exhibiting the siphonal plication of the posterior part of the shell. × 2. Chapman sandstone, same locality as figure 1.
4. Megambonia cf. *M. cardiiformis* Hall. An imperfect left valve, which in surface markings and form presents the characters of Hall's species but is smaller. Moose River sandstone, Detroit, Somerset County, Maine.
5. *Paleosolen chapmani* sp. nov. Left valve, showing the anterior end, umbo, surface markings, and siphonal plications. × 2. Chapman sandstone, same locality as figure 1.
6. cf. Edmondia (sp. indet.). Stone mold of right valve, showing the general form and size but no marked specific characters. Chapman sandstone, Edmunds Hill, Aroostook County, Maine.
7. *Paleosolen chapmani* sp. nov. A small right valve, showing the characters of the posterior half of the shell. × 2. Chapman sandstone, same locality as figure 1.
8. cf. Schizodus (sp. indet.). An imperfect stone mold, showing the general form and size but nothing to determine accurately the specific characters. Chapman sandstone, west side of Edmunds Hill, Aroostook County, Maine.
9. *Sphenotomorpha rigidula* sp. nov. An imperfect right valve, showing form and surface markings. Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.
10. *Grammysioidea ellymelloides* sp. nov. A crushed and otherwise imperfect right valve, showing the general form of the shell. Chapman sandstone, same locality as figure 1.
11. *Elymella harrisi* sp. nov. A nearly complete left valve, showing form and surface markings. Chapman sandstone, same locality as figure 6.
12. *Grammysia acadica* Billings var. An imperfect stone mold of a left valve referred to as a variety of Billings's species. Chapman sandstone, same locality as figure 6.

13, 15. *Goniophora omega* sp. nov. Two specimens representing the left and right valves, upon which the outline, the surface form, and (indistinctly) the markings can be seen. Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

14. *Anodontopsis maccoyiana* sp. nov. Mold of interior of left valve, showing the hinge teeth and the flattened margin which may mark the limits of the pallial margin. Chapman sandstone, same locality as figure 9.
15. See figure 13.
16. Cimitaria cf. *C. chapmani* sp. nov. A small specimen, showing the exterior of a left valve. The very abrupt fall from umbonal ridge to the posterior slope of the shell, which is nearly flat, is not well brought out by this figure; the sharp edge of the ridge is shown. Chapman sandstone, same locality as figure 1.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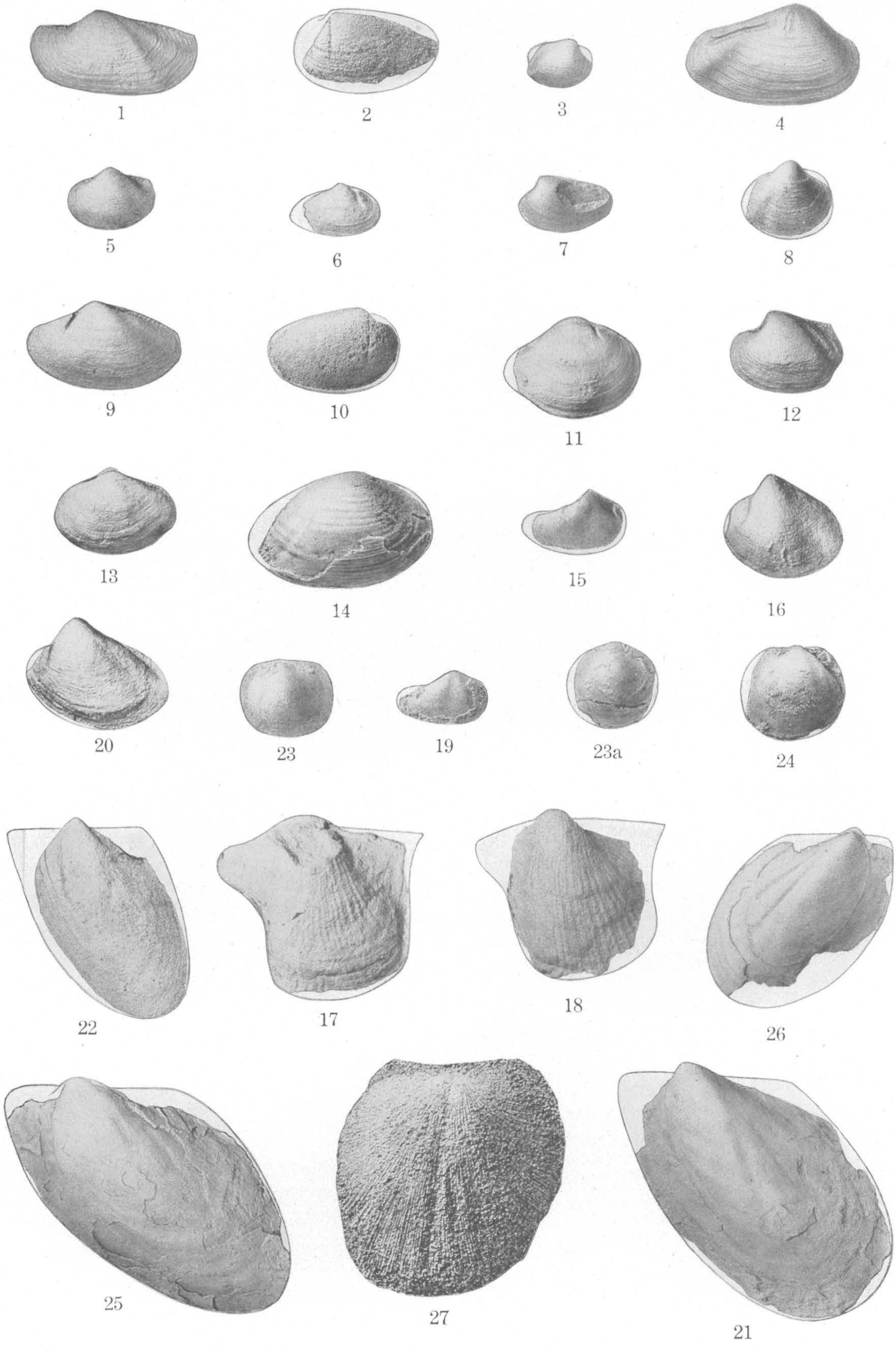
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PLATE XXV.

[All the figures on this plate are of natural size except figures 17 and 18, which are enlarged 2 diameters.]

Figures 1, 3-5, 12, *Tellinites gibbosa* var. *kayseri* Beushausen (p. 165).
Figures 2, 10, *Cleidophorus perovalis* sp. nov. (p. 161).
Figures 6, 9, 11, 13, *Paleoneilo (Ditichia) mainensis* Clarke (p. 168).
Figure 7, *Myoplusia chapmani* sp. nov. (p. 162).
Figure 8, *Tellinites gibbosa* var. *crassa* Beushausen (p. 165).
Figure 14, *Tellinites curta* sp. nov. (p. 165).
Figures 15, 19, *Leda harrisi* sp. nov. (p. 171).
Figures 16, 20, *Paleoneilo (Ditichia) mainensis* var. *umbonata* var. nov. (p. 170).
Figures 17, 18, Actinopterella sp. β (p. 192).
Figures 21, 22, 25, 26, *Preavicula oblonga* Hall (p. 207).
Figures 23, 23a, 24, *Paracyclas bulloides* sp. nov. (p. 258).
Figure 27, *Beachia chapmani* sp. nov. (p. 71).

1. *Tellinites gibbosus* var. *kayseri* Beushausen. A mature elongate left valve, showing the umbonal ridge and sulci strongly developed, also along the posterior hinge the hinge teeth. Chapman sandstone, Presque Isle Stream, at end of Tweedy road, Aroostook County, Maine.
2. *Cleidophorus perovalis* sp. nov. An incomplete mold of interior of left valve, showing the clavicular ridge in front of the umbo. Chapman sandstone, west side of Edmunds Hill, Chapman Township, Aroostook County, Maine.
3. *Tellinites gibbosus* var. *kayseri* Beushausen. A short young shell, showing right valve, the posterior end wanting. Chapman sandstone, same locality as figure 1.
4. *Tellinites gibbosus* var. *kayseri* Beushausen. A mature elongate right valve, showing outlines and surface form. Chapman sandstone, same locality as figure 1.
5. *Tellinites gibbosus* var. *kayseri* Beushausen. A small short left valve, showing teeth on hinge margin. Chapman sandstone, same locality as figure 1.

6, 11. *Paleoneilo* (*Ditichia*) *mainensis* Clarke. A narrow and a broad form of the right valve, showing the anterior ridge. Chapman sandstone, same locality as figure 1.

7. *Myoplusia chapmani* sp. nov. An imperfect left valve, showing the general outline and the form of the anterior half of the shell. Chapman sandstone, same locality as figure 1.
8. *Tellinites gibbosus* var. *crassa* Beushausen. An extremely short, small right valve. Chapman sandstone, same locality as figure 1.

9, 13. *Paleoneilo* (*Ditichia*) *mainensis* Clarke. Two specimens showing different outlines. The anterior ridge is evident in figure 9 but not in figure 13. These specimens and those represented in figures 6 and 11 show extremes of expressions of this variable form. Chapman sandstone, same locality as figure 1.

10. *Cleidophorus perovalis* sp. nov. Right valve, showing clavicular ridge, gently curving surface, and the nearly complete outline of the species. Chapman sandstone, same locality as figure 2.
11. See figure 6.
12. *Tellinites gibbosus* var. *kayseri* Beushausen. A short left valve. Compare with figure 1. Chapman sandstone, same locality as figure 1.
13. See figure 9.
14. *Tellinites curta* sp. nov. Right valve showing the broad, even arching of the body of the shell, the slight, narrow umbonal furrows, and on the anterior front a portion of the surface of the shell. Chapman sandstone, same locality as figure 2.

15, 19. *Leda harrisi* sp. nov. Two right valves, showing the form and size but not the surface characters. Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

16, 20. *Paleoneilo mainensis* var. *umbonata* var. nov. Two left valves, showing the produced narrow umbones, the decided sulcus inside the umbonal ridge, and the anterior ridge; also the extremes of long and short type of shell observed in the series of specimens of the typical species. Chapman sandstone, same locality as figure 1.

17, 18. Actinopterella sp. β. Two imperfect left valves, showing the short quadrate form, the large wing and ear, and the radiating lines over the body and slightly exhibited on the posterior wing, apparently lacking on the anterior ear. $\times$ 2. Chapman sandstone, same locality as figure 1.

19. See figure 15.
20. See figure 16.

21, 22, 25. *Preavicula oblonga* Hall. Partly exfoliated left valves, showing the form, partly restored outlines, and faint radiating plication, which may pertain to the interior rather than exterior of the shell. Chapman sandstone, 2½ miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

23, 23a, 24. *Paracyclas bulloides* sp. nov. Three interior molds of left valves. The anterior muscular scar and pallial line are best seen in figure 23, and the form and particularly the posterior slope are best exhibited by figure 24. Chapman sandstone, same locality as figure 15.

25. See figure 21.
26. *Preavicula oblonga* Hall. Right valve, showing the pallial line and scar of the posterior muscular impression. Chapman sandstone, same locality as figure 21.
27. *Beachia chapmani* sp. nov. Stone cast referred with doubt to this species. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

PLATE XXVI.

[All the figures on this plate are of natural size except figure 1, which is magnified 4 diameters.]

Figure 1, *Leda minuta* sp. nov. (p. 172).
Figures 2, 3, 5–7, 10, 12, 13, *Anodontopsis maccoyiana* sp. nov. (p. 236).
Figure 4, Physetomya sp. indet. (p. 140).
Figures 8, 9, *Preavicula brevis* sp. nov. (p. 208).
Figures 11, 15, 16, *Preavicula oblonga* (Hall) sp. et gen. nov. (p. 207).
Figure 14, Modiomorpha cf. *M. protea* Clarke (p. 219).

1. *Leda minuta* sp. nov. A minute right valve, showing the form of the type specimen. × 4. Chapman sandstone, Presque Isle Stream, at end of Tweedy road, Chapman Township, Aroostook County, Maine.

2, 3. *Anodontopsis maccoyiana* sp. nov. Two small left valves, showing the form and imperfectly the exterior characters of the shell. Chapman sandstone, 2 miles west of Presque Isle Stream, Chapman Township, Aroostook County, Maine.

4. Physetomya sp. indet. An imperfect left valve, showing the surface wrinkles and outline. Chapman sandstone, Edmunds Hill, Chapman Township, Aroostook County, Maine.

5–7, 10. *Anodontopsis maccoyiana* sp. nov. Four medium-sized right valves, partly exfoliated, showing slight differences in outline. Chapman sandstone, same locality as figure 2.

8. *Preavicula brevis* sp. nov. A partly exfoliated specimen, showing the narrow, elongate form and the concentric lines of growth. Chapman sandstone, same locality as figure 2.

9. *Preavicula brevis* sp. nov. A larger specimen with more expanded front and no concentric lines evident on the surface. The two shells shown in figures 8 and 9, though differing in present appearance, are believed to represent a single species, as they come from the same locality. The illustrations exaggerate the differences; figure 9 gives the typical form. Chapman sandstone, same locality as figure 2.

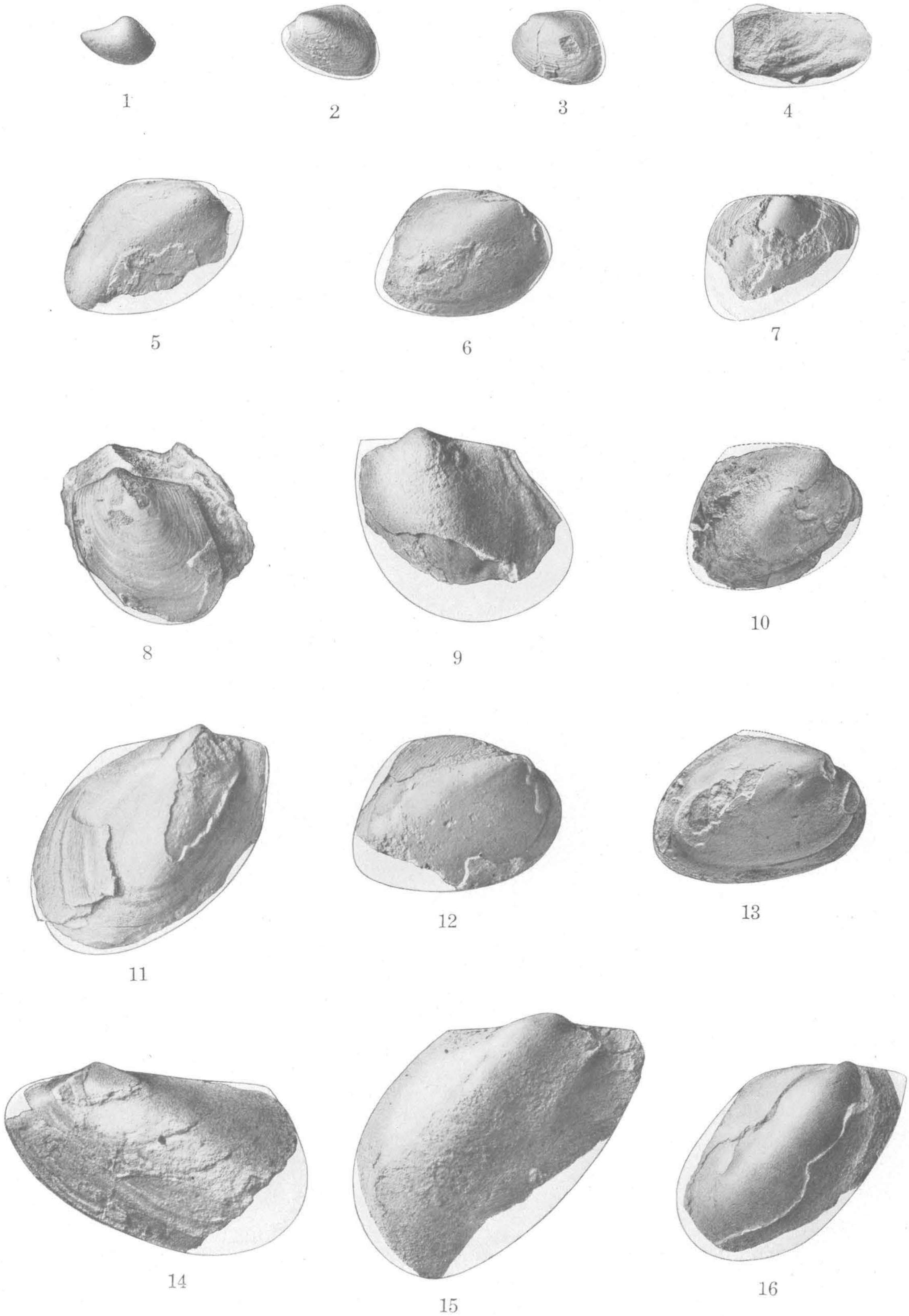
10. See figure 5.

11, 16. *Preavicula oblonga* Hall. Two specimens of right valves showing the ordinary characters of the species. (See also Pl. XXV, figs. 21, 22, 25, 26.) Chapman sandstone, same locality as figure 2.

12, 13. *Anodontopsis maccoyiana*, sp. nov. Two large right valves, partly exfoliated, showing well the surface markings over posterior hinge in figure 12, and the pallial line and muscular scars in both figures. Chapman sandstone, same locality as figure 2.

14. Modiomorpha cf. *M. protea* Clarke. An imperfect left valve resembling in general form the first of the specimens figured by Clarke under the name *M. protea*. (See also Pl. XXI, fig. 16.) Chapman sandstone, same locality as figure 4.

15. *Preavicula oblonga* Hall. Mold of the interior of a large incomplete right valve, in which a ridge from the anterior muscular scar toward the front is particularly conspicuous; a wide furrow separates this ridge from the body of the shell. Referred with doubt to this species. Chapman sandstone, same locality as figure 4.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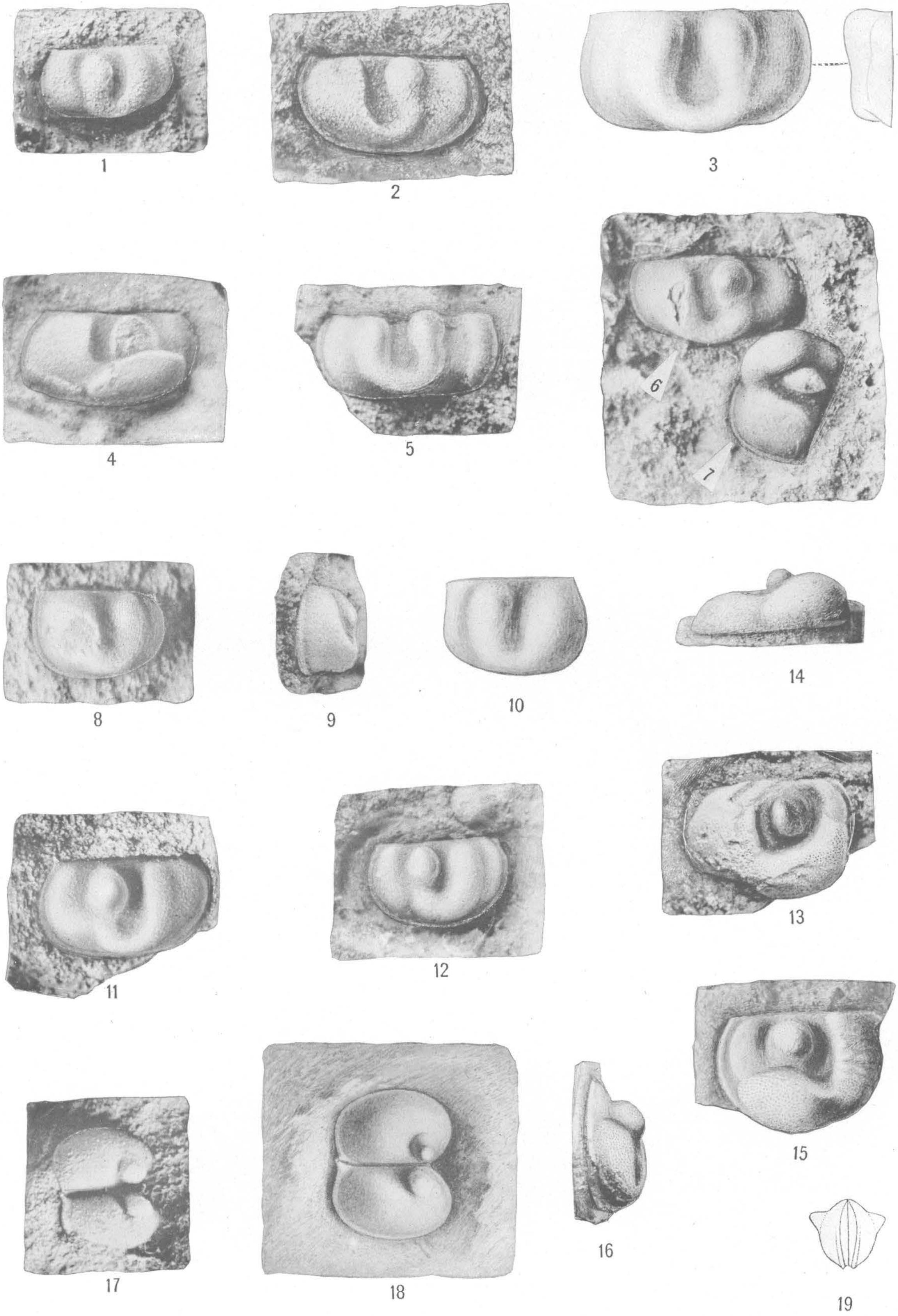
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PLATE XXVII.

[Unless otherwise stated all the figures on this plate are magnified 10 diameters. All the specimens were procured from the Chapman sandstone.]

Figures, 1-6, Zygobeyrichia devonica Jones and Woodward (p. 291).
Figures 7-10, Zygobeyrichia extrema Ulrich (p. 292).
Figures 11-16, Zygobeyrichia apicalis Ulrich (p. 292).
Figures 17-19, Ctenobolbina (?) cornuta Ulrich (p. 289).

1. *Zygobeyrichia devonica* Jones and Woodward. Cast of the interior of a right valve tilted so as to obscure the central part of the ventral edge and cause the swollen upper end of the median lobe to appear as farther removed from the dorsal edge than in a view taken at a right angle to the plane of the edges of the valve. U. S. Nat. Mus. Cat. No. 61359.
2. *Zygobeyrichia devonica* Jones and Woodward. View taken from a clay squeeze of a natural mold of a left valve, × 11. The flattened border is more sharply defined than usual. U. S. Nat. Mus. Cat. No. 61360.
3. *Zygobeyrichia devonica* Jones and Woodward. Drawing of a cast of the interior of a large left valve, × 11, with an outline sketch indicating relief of surface in a view of the posterior end. U. S. Nat. Mus. Cat. No. 61380.
4. *Zygobeyrichia devonica* Jones and Woodward. Cast of the interior of a left valve of the female form of the species, showing the position and elongate form of the ventral pouch. U. S. Nat. Mus. Cat. No. 61381.
5. *Zygobeyrichia devonica* Jones and Woodward. Cast of the interior of a left valve, showing differences in the outline and in the posterior lobe thought to be due chiefly to distortion subsequent to burial. U. S. Nat. Mus. Cat. No. 61382.
6. *Zygobeyrichia devonica* Jones and Woodward. Another slightly distorted cast of the interior of a left valve. U. S. Nat. Mus. Cat. No. 61383.
7. *Zygobeyrichia extrema* Ulrich. Cast of the interior of the right valve of a female example of this species, the ventral pouch and median lobe slightly crushed by rock pressure. U. S. Nat. Mus. Cat. No. 61363.

8, 9. *Zygobeyrichia extrema* Ulrich. Cast of the interior of a left valve and view of anterior end of same. U. S. Nat. Mus. Cat. No. 61376.

10. *Zygobeyrichia extrema* Ulrich. Cast of the interior of a right valve. U. S. Nat Mus. Cat. No. 61377.

11, 12. *Zygobeyrichia apicalis* Ulrich. Casts of the interior of two right valves, showing small differences in outline, probably caused by distortion. The smaller specimen (fig. 12) is believed to be the more normal in form. U. S. Nat. Mus. Cat. Nos. 61361, 61384.

13, 14. *Zygobeyrichia apicalis* Ulrich. Testiferous left valve of the female form, as seen in side and ventral views. Figure 13 shows the pitted ornament on the ventral pouch and adjacent parts of the broad anterior lobe. U. S. Nat. Mus. Cat. Nos. 61362, 61385.

15, 16. *Zygobeyrichia apicalis* Ulrich. Testiferous right valve of the female form. The specimen is perfectly preserved except the anterior margin, which is broken away. The transverse undulations on the anterior lobe seem to be normal. U. S. Nat. Mus Cat. No. 61386.

17. *Ctenobolbina* (?) *cornuta* Ulrich. Gutta-percha squeeze of a natural mold of the exterior of both valves. U. S. Nat. Mus. Cat. No. 61355.
18. *Ctenobolbina* (?) *cornuta* Ulrich. Drawing of same with missing parts restored, × 11.
19. *Ctenobolbina* (?) *cornuta* Ulrich. Diagrammatic outline drawing of the two valves in natural position.

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