

CAMBRIAN BRACHIOPODA: ACROTRETA: LINNARSSON-  
ELLA; OBOLUS; WITH DESCRIPTIONS OF NEW  
SPECIES.

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I had hoped to complete the monograph on the Cambrian Brachiopoda before this time, but owing to the large accessions of new material and to increased administrative duties this has been impracticable. The following additional<sup>1</sup> notes are therefore published, in the hope that they may be of service to students prior to the appearance of the monograph.

Genus ACROTRETA Kutorga.

1848. *Acrotreta* KUTORGA, Verhandl. der russisch-Kais. Min. Gesellsch., St. Petersburg, p. 275.  
1853. *Acrotreta* DAVIDSON, Introduction British Fossil Brachiopoda, p. 133.  
1865. *Acrotreta* VON SEEBACH, Feitschr. deutsch. geol. Gesellsch., XVII, p. 341.  
1865. *Acrotreta* BILLINGS, Paleozoic Fossils, I, p. 216.  
1871. *Acrotreta*? DAVIDSON, British Sil. Brachiopoda, p. 343.  
1872. *Acrotreta* MEEK, Sixth Ann. Rept. U. S. Geol. Sur. Terr., p. 462.  
1874. *Acrotreta* WHITE, Geog. Sur. W. 100th Merid., IV, Pt. 1, p. 53.  
1876. *Acrotreta* LINNARSSON, Bihang till K. Svenska vet. Acad. Handl., III, No. 12, Brachiopoda Paradoxides Beds of Sweden, p. 16.  
1883. *Acrotreta* DAVIDSON, British Sil. Brach. Supl., p. 213.

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<sup>1</sup>Note on the genus *Lingulepis*, Amer. Jour. Sci., 4th ser., III, 1897, pp. 404, 405.  
Cambrian Brachiopoda: Genera *Iphidea* and *Yorkia*, with descriptions of new species of each, and of the genus *Acrothele*, Proc. U. S. Nat. Mus., XIX, 1897, pp. 707-718.

Note on the brachiopod fauna of the quartzitic pebbles of the Carboniferous conglomerates of the Narragansett Basin, Rhode Island, Am. Jour. Sci., 4th ser., VI, 1898, pp. 327, 328.

Cambrian Brachiopoda: *Obolus* and *Lingulella*, with description of new species, Proc. U. S. Nat. Mus., XXI, 1898, pp. 385-420.

Cambrian Brachiopoda: *Obolella*, subgenus *Glyptias*; *Bicia*; *Obolus*, subgenus *Westonia*; with descriptions of new species, Proc. U. S. Nat. Mus., XXIII, 1901, pp. 669-695.

1884. *Acrotreta* WALCOTT, Mong. U. S. Geol. Sur., VIII, p. 16.  
 1886. *Acrotreta* MATTHEW, Trans. Roy. Soc. Canada, III, p. 36.  
 1886. *Acrotreta* WALCOTT, Bull. U. S. Geol. Sur., No. 30, p. 98.  
 1891. *Acrotreta* WALCOTT, Tenth Ann. Rept. U. S. Geol. Sur., p. 608.  
 1892. *Acrotreta* HALL and CLARKE, Pal. New York, VIII, Pt. 1, p. 101; Eleventh Ann. Rept. State Geologist, p. 250.  
 1885. *Limmarssonia* WALCOTT, Amer. Jour. Sci., 3d ser., XXIX, p. 115.  
 1886. *Limmarssonia* MATTHEW, Trans. Roy. Soc. Canada, III, p. 35.  
 1889. *Limmarssonia* DAWSON, Trans. Roy. Soc. Canada, VII, p. 55, fig. 26.  
 1892. *Limmarssonia* HALL and CLARKE, Pal. New York, VIII, Pt. 1, 1892, p. 107; Eleventh Ann. Rept. N. Y. State Geologist, 1891, p. 251.  
 1892. *Limmarssonia* MATTHEW, Trans. Roy. Soc. Canada, II, p. 42.  
 1902. *Acrotreta* MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, Pt. 5, pp. 390, 394.

*Original description.*—Dorsal valve highly conical; the hinge surface of this cone flat, in the form of a high triangle, similar to an area, with a shallow gutter-shaped depression running from the tip as far as the middle point, which [depression] here appears as an indication of a deltidium. At the upper end of this furrow, turned consequently to the hinge side, is found the obtusely oval external siphonal opening (I).

Ventral valve flat, with a distinct marginate apex. On the surface of the shell are seen only delicate growth wrinkles concentric to the apex of the cone, which curves crescentically into the longitudinal furrow of the surface of the shell; no tubercles and no spines; hinge border rectilinear.

*Revised generic description.*—Ventral (pedicle) valve conical, with the posterior face more or less flattened, and usually marked by a shallow groove. Foraminal opening at the apex of the cone and directed slightly backward. Area narrow, divided midway by the path of advance of a small false deltidium. Dorsal (brachial) valve slightly convex, with very small beak; area short and divided as in the pedicle valve by a small false deltidium. Surface marked by fine concentric striæ and lines of growth which cross the posterior face and the median groove. The shell in all species where it is preserved is calcareo-corneous, and built up of several thin layers of lamellæ that are arranged more or less obliquely to the outer surface toward the outer margin of the valves.

The cast of the pedicle valve shows that the interior of the shell had a rather strong callosity or apical swelling penetrated by the foraminal tube, and on each side of and back of the callosity near the posterior margin a small projecting boss or cardinal tubercle, which corresponds to a depression in the shell, on which the transmedian and middle lateral muscle were probably attached. In front of the apical callosity in *A. argenta* there are two trapezoidal areas corresponding to similar areas in *Obotella* and *Obolus*, in which the central, outside, and middle lateral muscles were attached. The position and size of the areas are shown by several specimens. The grooves of the main vascular sinuses pass around the apical swelling and extend forward, diverging toward the antero-lateral margins of the shell. The interior

of the brachial valve is almost invariably marked by a long, well-defined median ridge and a pair of strong cardinal tubercles near the margin of the area, corresponding in position to the cardinal tubercles of the pedicle valve. Smaller tubercles occur in advance of the posterior tubercles, one on each side of the median ridge. They are often replaced by elongate oval scars that correspond to the central scars of the dorsal valve of *Obolus*. The cardinal tubercles of both valves often have scars on them, indicating the attachment of the muscles.

*Observations.*—Of the type of the genus, *A. subconica*, only the external shell is known. In 1884 I illustrated the interior of the two valves of *A. gemma*,<sup>1</sup> showing the area of the median ridge, the "cardinal tubercles" and the central muscle tubercles of the dorsal valve, and the apical swelling and cast of the main vascular canals of the ventral valve. In 1886 Mr. G. F. Matthew illustrated the interior of *A. baileyi*,<sup>2</sup> showing the cast of a small tubercle on each side of the apical swelling. Messrs. Hall and Clarke write that they could not see the cast of these tubercles on the original specimen,<sup>3</sup> and I have been unable to find them on the specimens that Dr. Matthew very kindly sent me as the types. The intimate relations existing between *Acrotreta* and *Linnarssonina* became more and more apparent as better material was obtained of the two species referred to the two genera. Dr. G. H. Girty, when selecting specimens for illustration, called my attention to the strong resemblance between them, and suggested that *Linnarssonina* was a synonym of *Acrotreta*. In all essential characters this is true, and *Linnarssonina*, if retained at all, must be as a subgenus to include the depressed forms of *Acrotreta* intermediate between the typical elevated species *A. subconica*, *A. gemma*, and the nearly flattened shells of *Acrothele*. In view, however, of the close similarity of the interiors of the valves of *Acrotreta schmalensei*, *A. curvata*, *A. kutorgai*, and *Linnarssonina transversa*, *L. sagittalis*, and *L. misera*, there remains only the external form of the pedicle valve to distinguish the two genera; this latter character is not of sufficient importance to base a subgenus on, in the presence of the series of gradation of elevation and outline between *A. subconica* and *A. transversa* shown by *A. idahoensis*, *A. schmalensei*, *A. microscopica*, *A. pyridicula*, *A. sagittalis*, and *A. transversa*.

When studying the specimens of *Acrotreta* at hand in 1884 I believed that *A. gemma* of Newfoundland included the western forms described by Messrs. Meek and White. This conclusion was retained until the study of a large series from each of the typical localities convinced me

<sup>1</sup>Mong. U. S. Geol. Sur., VIII, pl. 1, figs. 1b, 1d.

<sup>2</sup>Trans. Roy. Soc. Canada, III, pl. v, figs. 13, 13c.

<sup>3</sup>Pal. New York, VIII, Pt. 1, p. 102.

that there were a number of species and varieties grouped under *A. gemma*. The species referred to the genus at present are:

*Species at present referred to Acrotreta.*

	Cambrian.			Ord.	Locality.
	L.	M.	U.		
<i>Acrotreta</i>					
<i>argenta</i> , new species.....			✓		Nevada.
<i>attenuata</i> Meek.....					Montana, Wyoming.
<i>babeli</i> Barrande.....				×	Bohemia.
<i>baillyi</i> Matthew.....		×			New Brunswick.
<i>belti</i> Davidson.....				×	Wales.
<i>bisecta</i> Matthew.....			×		Nova Scotia.
<i>claytoni</i> , new species.....	×				Nevada.
<i>concentrica</i> , new species.....		×			Georgia.
<i>conula</i> , new species.....			×		Sweden.
<i>convexa</i> , new species.....			×		Nova Scotia.
<i>curvata</i> , new species.....			×		Nevada.
<i>definita</i> , new species.....		×			Do.
<i>depressa</i> Walcott.....					British Columbia.
<i>gemma</i> Billings.....				×	Newfoundland.
<i>gemma</i> Matthew.....					New Brunswick.
<i>gracia</i> , new species.....					Do.
<i>idahoensis</i> , new species.....		×			Idaho, South Dakota, Wyoming.
<i>idahoensis alta</i> , new variety.....					Nevada.
<i>idahoensis sulcata</i> , new variety.....					Idaho.
<i>inflata</i> Matthew.....			×		New Brunswick.
<i>kutorgai</i> , new species.....					Alabama.
<i>microscopica</i> Shumard.....					Texas, Nevada.
<i>microscopica missouriensis</i> , new variety.....					Missouri.
<i>microscopica tetonensis</i> , new variety.....		×			Wyoming.
<i>minimus</i> Barrande.....					Bohemia.
<i>miser</i> Billings.....			×		Newfoundland, New Brunswick.
<i>nicholsoni</i> Davidson.....				×	Scotland.
<i>ophirensis</i> , new species.....					Utah.
<i>ophirensis rugosus</i> , new variety.....					
<i>oralis</i> , new species.....					Quebec.
<i>pareula</i> Wallerius.....			×		Sweden.
<i>primæva</i> , new species.....		×			Nevada.
<i>pygidicola</i> White.....				×	Idaho, Montana, Nevada.
<i>subline</i> Calloway.....				×	England.
<i>sagittalis</i> Salter.....					North and South Wales, Sweden, Denmark, Newfoundland, Quebec.
<i>sagittalis magna</i> Matthew.....			×		New Brunswick.
<i>sagittalis taconica</i> Walcott.....		×			New York.
<i>sagittalis transversa</i> Hartt.....			×		New Brunswick and Newfoundland.
<i>schaulenski</i> , new species.....			×		Sweden, Denmark.
<i>seebachi</i> , new species.....				×	Norway.
<i>signalis</i> , new species.....			×		Wisconsin.
<i>socialis</i> v. Seebach.....			×		Sweden.
<i>subconica</i> Kutorga.....					

**ACROTRETA ARGENTA**, new species.

The material representing this species is more or less crushed and broken in the shaly sandstone and limestone, but a few specimens show its general form and characters. It belongs to the *A. idahoensis* group in having a wide false area, strongly marked apical callosity, and foraminal tube. The thickening in the posterior portion of the brachial valve is also characteristic of the two species.

The cast of an interior of the pedicle valve reveals what I have searched for unsuccessfully in hundreds, if not thousands, of specimens of this genus. I refer to the visceral area with the position of the point of attachment of the central and lateral muscles on each side of it, essentially as in *Obolella* and *Obolus*.

*Formation and locality.*—Upper Cambrian, 2 miles southeast and 1 mile southwest of summit of Benders Pass, Silver Peak Range, Nevada. F. B. Weeks, collector, 1900.

**ACROTRETA BAILEYI** Matthew.

*Acrotreta baileyi* MATTHEW, Trans. Roy. Soc. Canada, III, 1886, p. 36, pl. v, fig. 13.—HALL and CLARKE, Pal. New York, VIII, 1892, Pt. 1, p. 102, pl. III, figs. 32-34.—MATTHEW?, Trans. Roy. Soc. Canada, IX, 1892, p. 43, pl. XII, fig. 7d. Referred to *A. bisecta*.

*Acrotreta bisecta* MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, 1902, Pt. 5, p. 395, pl. XVI, figs. 1, 1a-d.

General outline transversely oval, with the posterior margin more or less straight for less than one-half the transverse diameter of the shell. On the pedicle valve the posterior margin is rounded in at the median furrow of the false area, and on the brachial valve it curves gently from the cardinal slopes to the beak.

The pedicle valve is strongly convex, with the apex about one-fourth the length of the valve from the posterior margin. The crushed condition of the shells does not permit of decision as to whether the umbo or the apex is the most elevated part of the valve. False area defined by the incurving of the cardinal slopes so as to form a somewhat flattened triangular space that is divided midway by a rather strong vertical furrow. Foraminal aperture rather large and opening obliquely backward. The brachial valve is gently convex, with a minute marginal beak.

Surface of shell marked by fine concentric striae and lines of growth, and possibly by fine radiating striae. I fail to find any traces of the radiating striae on specimens that have not been distorted by pressure, and it looks as though all radiating striae and lines are the result of lateral compression of the shell. The average length is about 3.5 mm. and the width 4 mm. Distorted shells give a length of 4 mm. and a width of 3 mm.

The cast of the interior of the pedicle valve shows a strong apical callosity, a fair-sized foraminal tube, large cardinal scars, and a small visceral area in front of the apical callosity. Dr. G. F. Matthew describes and shows on his illustration two "minute muscular scars" close to the "umbonal tubercle" and on each side of the parallel striae.<sup>1</sup> I find on one specimen what may have led Dr. Matthew to believe there were such scars, but on many others quite as well preserved there were none such, and they are not known in any other species of the genus. Messrs. Hall and Clarke examined Dr. Matthew's type material, and say that with the original material before them they were unable "to distinguish anything more than the central callosity."<sup>2</sup>

<sup>1</sup>Trans. Roy. Soc. Canada, III, p. 36, pl. v, fig. 13c.

<sup>2</sup>Pal. New York, VIII, Pt. 1, 1892, p. 102.

The cast of the interior of the brachial valve shows a strong median ridge of variable length and size, large cardinal scars, and well-defined central scars.

*Observations.*—This species belongs with the series represented by *A. sagittalis* and its varieties, and if uncompressed, nondistorted, well-preserved specimens could be obtained, it is quite possible that it would prove to be identical with *A. sagittalis transversa*. Dr. Matthew thinks it had a thinner shell; but that is not probable, as the apical callosity and cardinal scars of the pedicle valve, and the median ridge, cardinal and central scars of the brachial valve all indicate a shell quite as thick as that of *A. sagittalis* and varieties.

Dr. G. F. Matthew kindly sent me the type and study material of this species from his private collection.

*Formation and locality.*—Middle Cambrian, Long Reach, Kings County, New Brunswick.

#### ACROTRETA BISECTA Matthew.

*Acrotreta baileyi* MATTHEW?, Trans. Roy. Soc. Canada, IX, 1892, p. 43, pl. XII, fig. 7d.

*Acrotreta bisecta* MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, 1900, p. 275, pl. v, figs. 5a-g; IV, Pt. 5, 1902, p. 394, pl. XVI, figs. 2, 2a-g.

Nearly all the pedicle valves of this species are more or less compressed in the shale, thus decreasing the true elevation. Mr. Matthew illustrates a pointed high pedicle valve, but does not say whether the figure is diagrammatic. Some of the casts in the shale indicate a sharply conical pedicle valve. When the apex is broken off, the cast of a medium apical callosity is seen, with the base of the cast of a medium-sized pyramidal tube; the cardinal scars are small and nearly concealed by the cast of the strong main vascular sinuses. There is considerable range of variation in the size and length of the median ridge of the brachial valve. One specimen shows a strong median ridge, cardinal and central scars, and deeply excavated false deltidium.

Surface marked by fine concentric striae and lines of growth and very fine undulating striae that give the concentric striae a fretted appearance when examined with a strong lens.

The most nearly related species appears to be *A. sabrinæ* of the Shineton shales.

*Formation and locality.*—Upper Cambrian, Barrachois Glen, 4 miles south of Little Bras D'Or Lake. Mr. Matthew's types came from McLeod Brook, Cape Breton, Nova Scotia, and he also identifies it from Div. C, 3c, at Navy Island, St. John Harbor, New Brunswick. Mr. S. Ward Loper found many specimens of several horizons in the shales on both sides of Barrachois River, near the Boisdale road, and for some distance north; also on the east branch of the Barrachois River, Cape Breton, Nova Scotia.

## ACROTRETA CLAYTONI, new species.

The material representing this species does not give sufficient data to prepare a detailed description. The only pedicle valve is depressed by compression in the shale; it is transversely broad oval in outline, with the posterior margin nearly straight for a distance of two-fifths of the diameter of the valve; the false area fairly well defined by the abrupt incurving of the cardinal slopes; its median furrow is distinctly outlined, and it slopes forward to the apex, which is situated about two-fifths the distance from the posterior margin to the front margin. Foraminal aperture minute and directed upward from the extreme apex of the valve. Brachial valve gently convex. Surface of shell marked by fine concentric striae and lines of growth, and very fine, irregular, undulating striae that can be seen only by the aid of a strong lens.

A partial cast of a brachial valve from the same faunal horizon, about 30 miles distant, shows a well-defined median ridge and cardinal scars.

This species is most nearly related to *A. primæra* of the upper *Olenellus* fauna, at Pioche, Nevada. It differs in having a less elevated pedicle valve and the most advanced position of the apex and foraminal aperture. All the five specimens known are also smaller than the average of *A. primæra*, the largest being 3 mm. in width and 2.5 mm. in length.

*Formation and locality.*—Lower Cambrian shales, with *Olenellus*, on the divide between Clayton and Fish Lake valleys, north of Red Mountain, Silver Peak Range; also, 2 to 5 miles south of Barrel Spring and one-half mile east of road as shown on the map of the Silver Peak quadrangle, Nevada.

## ACROTRETA CONCENTRICA, new species.

Shell small, outline subcircular to transversely broad oval; apex of pedicle valve nearly concentric; false area indicated by a slight flattening of the valve on the posterior side and a distinctly marked but very narrow median furrow. The elevation of the valve is about one-half its diameter. The brachial valve is slightly convex, and its cast is marked by small cardinal scars and a narrow median ridge that extends to the anterior third of the shell. A pedicle valve is 1.25 mm. in diameter, and one brachial valve is 2 mm. in length.

This species occurs at about the horizon of *A. kutorgai*, but is distinguished from that species and all others by the concentric position of the apex of the pedicle valve.

*Formation and locality.*—Middle Cambrian, shaly limestones on roadside between Dalton and Lafayette, Georgia.

**ACROTRETA CONULA**, new species.

Shell small. Pedicle valve excentrically cone-shaped, with a broadly ovate transverse aperture. The apex is situated at the posterior fourth of the distance between the front margin and the posterior edge of the slightly indicated false area. A minute pedicle aperture occurs at the summit of the apex. Brachial valve convex with the minute beak at the posterior margin. The cast shows a well-defined median ridge with the central muscle scars well back on the valve.

Surface marked by fine concentric striae and lines of growth.

*Formation and locality.*—Upper Cambrian, *Olenus truncatus* zone, Oland, Sweden.

**ACROTRETA CONVEXA**, new species.

Shell small, subcircular, valves convex. Pedicle valve most elevated at the low apex which is above the slightly transverse posterior margin. Brachial valve somewhat less convex than the pedicle valve, with its greatest elevation at the posterior third beak, minute, marginal. Length and width of shell 1 mm. Shell substance very thin but not proportionally thinner than other larger forms. Surface marked by fine concentric striae and lines of growth.

Casts of the interior of the pedicle valve show a minute apical callosity and cardinal scars. The cast of the brachial valve has a long median furrow and minute cardinal scars.

This minute shell occurs in a fine-grained sandstone interbedded in the shales of the Upper Cambrian. It is characterized mainly by the convexity of the brachial valve and the low pedicle valve.

*Formation and locality.*—Upper Cambrian, Gillis Hill, Salmon River, 13 miles south of Marion Bridge, Cape Breton, Nova Scotia. Collected by Mr. S. Ward Loper.

**ACROTRETA CURVATA**, new species.

This is one of the so clearly defined species that it is possible to illustrate all that is known of it with the exception of the very fine concentric surface striae. It belongs with *A. idahoensis* and other species with a broad false area. It differs from described species in the incurved apex of the pedicle valve and the general aspect of the two valves.

*Formation and locality.*—Upper Cambrian, passage beds between Cambrian and Ordovician near base of Pogonip limestone, Hamburgh Ridge, Eureka District, Nevada.

**ACROTRETA DEFINITA**, new species.

The false pedicle groove is very distinct and also broader than that of *A. attenuata*. The interior of the pedicle valve is beautifully shown by casts. One of these shows the strong vascular sinuses, cardinal



sears, east of apical callosity, and just in front of the latter two slight tubercles which may be the east of depressions corresponding to the foraminal pits of *Acrothole*. The east of the brachial valve is also very instructive in showing the area, cardinal sears, median ridge, and central sears.

*Observations.*—This large fine species differs from its nearest ally, *A. idahoensis*, in the false area and the details of the arrangement of the vascular markings and muscle sears of the interior of the valves. The Idaho shells occur in a dark argillaceous shale and were collected by Mr. Spence, of Paris, Idaho. The Eureka, Nevada, specimens are from a shaly limestone.

*Formation and locality.*—Middle Cambrian, near Montpelier, Idaho; summit of Prospect Mountain limestone, Prospect Mountain, Eureka District, Nevada.

#### ACROTRETA GEMMA Billings.

*Acrotreta gemma* BILLINGS, Pal. Foss., I. 1865, p. 216, figs. 201a-f.

*Original description.*—Shell very small, about 1 line in diameter; one valve nearly flat and the other acutely conical. Dorsal valve very gently convex, nearly circular; sides and front margin uniformly rounded; posterior margin very obtusely angulated at the beak, on each side of which a portion of the cardinal edge, equal to one-fourth of the whole width of the shell, is nearly straight; umbo very small; beak apparently depressed to the hinge line and not projecting beyond it; cardinal angles compressed, broadly rounded; a wide, shallow, mesial sinus extends from the front margin about halfway to the beak; elsewhere the valve is gently convex or nearly flat.

Ventral valve acutely conical, with a flat triangular area which is perpendicular to the plane of the lateral margin, its base half the width of the whole shell. In the apex of this valve there is a minute circular aperture, and in one specimen a dark line extends from it down the middle of the area, which appears to represent the foraminal groove of this genus; but in two other specimens of the ventral valve, with the area well preserved, there is no indication of a groove. Surface with very fine concentric striae.

Width of dorsal valve, about 1 line; length, about seven-eighths of a line. The height of the ventral valve is about 1 line.

The form of this species is very like that of *A. subconica* (Kutorga), but that species is twice the size of this and has the area distinctly grooved.

*Observations.*—By the courtesy of Prof. J. F. Whiteaves, of the Geological Survey of Canada, I have had the opportunity of studying the type material of this species. Nine specimens of the pedicle valve were received, but none of the brachial valve, as they could not be found. One specimen in a dove-colored limestone appears to belong to a distinct species, which I have named *Acrotreta ovalis*. The remaining specimens show some variation in the angle of slope of the sides of the pedicle valve, but four of them are similar to the form illustrated by Billings.

The broad false area with a scarcely perceptible impression of the path of advance of the pseudodeltidium is clearly shown in one of the

specimens, and faintly in others. Two shells have the apex broken off so as to expose the cast of a minute apical callosity and a small portion of the side of the cast of the main vascular sinus.

*A. gemma* belongs to the *A. subconica* group of the genus, having a high pedicle valve and distinct and broad false area. It differs from *A. subconica* in having a less elevated pedicle valve and in the apex being in front of the posterior margin instead of extending over it. With the forms from the Rocky Mountains that I identified with it there are no strong specific relations. *A. attenuata* has a high pedicle valve, but the false area is practically absent, a narrow deep sulcus taking its place. *A. idahoensis alta* has the elevation and false area, but differs in the details of the area and the outline of the cross section of the pedicle valve. It was this form that led me to consider that *A. gemma* occurred in Nevada, and with the slight knowledge that I then had of the genus and species a wide range of form was given to *A. gemma*. As far as now known to me, the species is restricted to the type locality.

*Formation and locality.*—Lower Ordovician, limestone, North Table Head and Pistolet Bay; limestone point 4 miles northeast of Portland Creek, Newfoundland.

#### ACROTRETA GRACIA, new species.

Shell small, slightly transverse; apex of pedicle valve about one-third the length of the shell from the posterior margin; height about two-thirds the length of the shell; false area defined by the sharp rounding of the cardinal slopes and the transverse posterior margin, which is indented by the strong, broad, median groove extending from the margin to the apex, where it almost comes in contact with the minute apical foramen. Brachial valve moderately convex, with a nearly straight or gently curved posterior margin; beak minute, marginal. Surface of shell marked by fine concentric striae and lines of growth. Shell strong, and built up of thin layers or lamellae that over the central and anterior portions are more or less oblique to the outer surface layer.

The cast of the pedicle valve indicates a small but very clearly marked apical callosity; rather small cardinal scars and main vascular sinuses. The cast of the interior of the brachial valve shows a broad, low, median ridge extending to about the anterior third of the length of the valve; small cardinal scars and small main vascular sinuses that arch inward after passing the central scars, and then outward. The area is very narrow, and broken midway by a rather wide, slightly arching false deltidium.

This species is distinguished by the strong shell, broad median ridge of the brachial valve, and deep median groove of the false area of the pedicle valve. The light color of the shell may be owing to the char-

acter of the limestone in which it is preserved, or it may be that it is a little more calcareous than other species of the genus.

Dr. G. F. Matthew describes and illustrates an *Acrotreta* from Hastings Cove as *Linnarssonia belti magna* that is characterized by a narrow median ridge in the brachial valve and other characters not present in *A. gracia*. I found on Hanford Brook in the *Paradoxides* zone numerous examples of a species of *Acrotreta* that appear to be identical with the form described by Mr. Matthew, and have referred it as a variety of *Acrotreta sagittalis*.

*Formation and locality*.—Middle Cambrian, *Paradoxides* zone, Hastings Cove, Kennebecasis River, St. John County, New Brunswick.

#### ACROTRETA IDAHOENSIS, new species.

*Acrotreta subconica* MEEK, Sixth Ann. Rept. U. S. Geol. Sur. Terr., 1873, p. 463.  
Not Kutorga, 1847.

The general outline, form, and convexity of the two valves are so fully shown by the illustrations for the monograph that detailed descriptions will not be given. The material for illustrating the interior of the pedicle valve is limited, but one cast shows the position of the base of the cast of the foraminal tube and the large main vascular sinuses. An interior of abrachial valve presents characters rarely seen in this genus. The vascular canals arch out around the central muscle scars and then bend in toward the median ridge, and again obliquely outward to form the outer limit of a smooth, polished, lanceolate-shaped surface that extends obliquely outward from the median ridge. The line that extends from in front of the cardinal scars forward subparallel to the margin of the shell and then bends abruptly in and forward is apparently the outer boundary of a very broad, shallow, vascular sinus. Something of this same character occurs in the brachial valve of *Obolus* (*Lingulobolus*) *spissus*. The cardinal scars are small and situated close to the narrow area. A cast of the interior shows the central scars distinctly; also the presence of a thickening of the shell in the vicinity of the cardinal scars.

*Observations*.—The external characters of this species suggest *Acrotreta curvata*, but the elevation and curvature of the pedicle valve are not the same and the interior of the brachial valve is very distinct in its specific characters. There are no interiors of the form from the Black Hills, but the external characters appear to be the same. These include the broad false area, with its slightly marked groove, the position of the apex, and the curvature of the false area.

*Formation and locality*.—Middle Cambrian. Five miles southeast of Malad City, Idaho. Northwest suburb of Deadwood, Black Hills, South Dakota. South side of Gallatin Valley, in several sections of Flathead and Gallatin terranes; also Crowfoot section, Gallatin Range, Yellowstone National Park, Wyoming.

## ACROTRETA IDAHOENSIS ALTA, new variety.

This is one of the forms that I included with *Acrotreta gemma* in the report on the paleontology of the Eureka District, Nevada. It has the broad false area of *A. idahoensis*, but the pedicle valve is more elevated and the apex does not overhang the false area. From *A. attenuata* it differs in having a broad false area.

*Formation and locality.*—Middle Cambrian, upper portion of Secret Canyon shales, Secret and New York canyons, Eureka District, Nevada.

## ACROTRETA IDAHOENSIS SULCATA, new variety.

This strongly marked pedicle valve is associated with typical forms of the species, but in its rounded posterior side and strong median groove it is quite distinct. The apex is broken off so as to show the cast of a small apical callosity and the base of a minute foraminal tube.

*Formation and locality.*—Middle Cambrian, near Paris, Idaho. Collected by Mr. Spence.

## ACROTRETA INFLATA Matthew.

*Lingulella? inflata* MATTHEW, Trans. Roy. Soc. Canada, III, 1886, p. 33, pl. v, figs. 7, 7a; Trans. N. Y. Acad. Sci., XIV, 1895, p. 127, pl. v, fig. 3.

*Lingulella? inflata* var. *oralis* MATTHEW, Trans. N. Y. Acad. Sci., XIV, 1895, p. 127, pl. v, fig. 4.

*Acrothyra? inflata* MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, 1901, p. 303.

*Lingulella (Acrothyra?) inflata* MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, 1902, Pt. 5, p. 390.

Shell subcircular to transversely broad oval. Pedicle valve subconical, with the apex directed backward and usually on a line with the posterior margin, or extending beyond it, but it may be anterior to it; false area slightly defined by the abrupt curvature of the cardinal slopes; median line depressed, narrow, the two sides of the false area incurving to form to it; foraminal aperture longitudinally oval and slightly truncating the apex. Brachial valve gently convex, with a minute marginal beak. Surface of shell marked by concentric striae and growth lines, and fine, irregular, wavy striae that inosculate more or less, giving the surface a fretted appearance under a strong lens. The inner surface is marked by concentric lines, also rather strong radiating lines. The shell is built up of the thin, outer, ornamented surface and several thin inner layers or lamellæ. The average length of the pedicle valve is 4 mm. and the width 3 to 3.5 mm. The brachial valves are usually wider than long.

Casts of the interior of the pedicle valve show strong cardinal scars, a strong apical callosity, and rather weakly developed main vascular sinuses. The apical callosity varies in size and in form from elongate oval to subcircular. The cast of the interior of the brachial valve

shows a broad, short median ridge posteriorly that extends beyond the center of the valve.

*Observations.*—This species appears to be a true *Acrotreta* with the apical callosity elongated by the elongation of the pedicle valve. The brachial valve is more convex than in most species of *Acrotreta*, which gives a stronger relief to the ridges on the cast between the cardinal scars and the median ridge. The posterior view should be compared with the same view of the brachial valve of *Acrotreta sagittalis* and its varieties. The fretted surface is of the same type as that of several other species of the genus.

Dr. G. F. Matthew had very little material when he described the species; subsequently he created the variety *oralis*, from a more elongated pedicle valve. In the collection made for the U. S. National Museum by Mr. S. Ward Loper there are a number of pedicle and brachial valves. The range of variation in outline appears to cover the variety *oralis*. Some are more transverse than the original type of the species, and others nearly as elongate as the variety *oralis*. I have therefore considered the variety as within the original species. Some of the shells show elongation, and others are broadened by distortion.

Dr. G. F. Matthew called attention to the resemblance of this species to *Linnaarssonina* and *Acrotreta*, and when describing the genus *Acrothyra* suggested that it might belong to that genus. It appears, however, to be a true *Acrotreta*. A series of specimens supplemented by the types and a number of pedicle valves received from Dr. Matthew, which he had provisionally identified as "*Acrotreta gemma* Bill<sup>1</sup>," show a rather remarkable variation in outline and position of the apex of the pedicle valve. The narrow forms, var. *oralis* Matthew, have the apex extended beyond the posterior margin, and in the broad forms the apex is above or in advance of the posterior margin, but if the shells are compressed vertically the apex may be pushed out over the false area whether the shell be narrow or broad. I think that in the normal form the false area is vertical or slightly inclined backward.

*Formation and locality.*—Middle Cambrian, division 1b of Matthew's section, Hanford Brook, New Brunswick.

#### ACROTRETA KUTORGAI, new species.

The external characters of the pedicle valve are clearly exhibited, and what is known of the interior, by a unique specimen, as it is the only one known to me that clearly shows the true area and pseudo-deltidium of the pedicle valve. The corresponding portion of the brachial valve is well defined in the casts. The median ridge is as long proportionally as that of *A. bisecta*, and, like it, varies in length and size in different shells.

<sup>1</sup>Trans. N. Y. Acad. Sci., XIV, 1895, p. 126.

The outer surface is marked by fine concentric striae and lines of growth.

*Observations.*—This pretty species occurs attached to the surface of siliceous nodules in association with *Olenoides curticei*, *Crepicephalus teranus*, *Acrothele bellula*, and casts of *Medusa*. The outline of the convexity of the valves and the posterior view of the pedicle valve is most like that of *A. attenuata*, but the interior markings are quite unlike.

*Formation and locality.*—Middle Cambrian. Siliceous nodules in Coosa shales, Coosa Valley, 3 miles south of Gadsden, and near Che-pultepec on road near Wades Gap, Alabama. Rogersville shale, Rogersville, and north and south of the town, Tennessee.

**ACROTRETA MICROSCOPICA MISSOURIENSIS, new variety.**

The shell is uniformly larger than the Texas shells and the vertical median line of the false area is more depressed and distinct. Some of the specimens of the pedicle valves beautifully illustrate the effects of compression. One shell is like that of *Acrotreta attenuata*, and another resembles the low form of *A. ophirensis* with the apex overhanging the false area. The surface of the shells embedded in a very fine-grained sandstone has a papillose surface resulting from the indenting of the shell by the grains of sand, while those from limestone are marked only by fine concentric striae.

*Formation and locality.*—Middle Cambrian, in sandstones of the conglomerate series, St. Francois County, and in thin-bedded limestones south-southwest of Potosi, Missouri.

**ACROTRETA MICROSCOPICA TETONENSIS, new variety.**

This neat little shell possesses the characters of *A. microscopica* and *A. idahoensis*, but differs from both by the projection of the apex of the pedicle valve over the false area. All that is known of it is represented by the illustrations for the monograph.

*Formation and locality.*—Middle Cambrian, divide at head of Sheep Creek, north end of Teton Range, Wyoming.

**ACROTRETA MISER Billings.**

*Obolella ? miser* BILLINGS, Can. Nat. and Geol., new ser., VI, 1872, p. 470; Pal. Foss., II, 1874, Pt. 1, p. 69.

*Linnarssonia misera* MATTHEW, Trans. Roy. Soc. Can., III, 1886, p. 35, fig. 12.—HALL and CLARKE, Pal. N. Y., VIII, 1892, Pt. 1, p. 108, pl. VIII, figs. 35–37.

The abundant material that I collected of this species in Newfoundland gives illustrations that present its characters with such fullness and detail that minute description is unnecessary. Numerous figures of the pedicle valve show variation in outline, also of the cast of the apical callosity, cardinal scars, and base of main vascular sinuses. Others well illustrate the interior of the brachial valve.

The outer surface is marked by fine concentric striae and growth lines, and the inner layers or lamellae by very fine radiating striae. The minute foraminal aperture is on the back side of the apex, opening almost posteriorly in some examples.

This is a small species averaging from 1.5 to 2.5 mm. in length. It occurs in immense numbers in limestone lentiles of the *Paradoxides darisi* zone of Newfoundland. It is also very abundant at Hastings Cove.

*Formation and locality.*—Middle Cambrian, paradoxides zone, Chapel Arm, Trinity Bay; Manuels Brook, Avalon Peninsula, Newfoundland; Hastings Cove, Kennebecasis River, and Dr. G. F. Matthew identified it at Porters Brook, St. Martins, St. John County, New Brunswick.

ACROTRETA OPHIRENSIS, new species.

General outline transversely broad oval, sometimes nearly circular, with the posterior margin slightly indented midway on the pedicle valve by incurving to the false pedicle furrow. The pedicle valve is convex and moderately elevated, the highest point being in front of the foraminal aperture at about one-third the diameter of the shell. Foraminal aperture large for the size of the shell and opening either directly or obliquely backward. One specimen shows a short, narrow area, with a triangular false pedicle furrow crossing it; false area scarcely defined by the cardinal slopes, which incurve very gently; median furrow well defined, rather strong, and nearly flat on the bottom, the margins being sharply outlined in many specimens. The shell sometimes curves over the false area so that the depressed apex extends slightly beyond the posterior margin, but usually it is directly on the line of the posterior margin or a little in front of it. Longitudinal diameter of average size pedicle valve 3 mm., with a length of 2 mm. to 2.5 mm.; elevation 1.5 mm. A few shells have nearly the same length and width. The convexity of the brachial valve averages 0.75 mm. The minute beak of the brachial valve curves down to the posterior margin from the somewhat elevated posterior third of the valve.

Surface marked by fine concentric striae and marked lines of growth which occasionally form concentric ridges. The shell is built up of a thin outer layer and numerous thin inner layers or lamellae that are oblique to the outer layer over the central and outer portions, the obliquity increasing toward the outer anterior and lateral margins.

The interior of the pedicle valve shows a rather strong apical callosity that extends nearly to the posterior inner margin of the shell; distinct but relatively small cardinal scars, and narrow main vascular sinuses that may be traced nearly to the antero-lateral margins of the valve; the outlines of the visceral cavity are indicated on one well-

preserved east of the interior of the valve. The interior of the brachial valve shows great variation in the size and length of the median ridge, and cardinal and central scars. These characters are fully shown in the numerous illustrations of the interior and casts of the interior of the brachial valve.

*Observations.*—This species is most closely related to *Acrotreta curcata*. It differs in the pedicle valve being larger, in the apex being less extended over the false area, and in the form of the median furrow, which is like that of *A. alternata*. Although the shells occur in a compact, unaltered limestone, there is more or less distortion in the outline of both valves. This, taken in connection with the variations in form and size of the vascular markings, muscle scars, and median ridge of the brachial valve, might serve to discriminate several so-called varieties, but I do not think that any good purpose would be subserved thereby.

*Formation and locality.*—Middle Cambrian, in limestone above the basal quartzite, Ophir City, Utah.

#### ACROTRETA OPHIRENSIS RUGOSUS, new variety.

This form is associated with *A. ophirensis* in considerable numbers. It is characterized by strong, rugose growth lines and thicker shell.

#### ACROTRETA OVALIS, new species.

In the material representing *A. gemma* received from the Geological Survey of Canada there was one pedicle valve embedded in a smooth, dove-colored limestone from Point Levis. In the oval outline of the rim of the shell, less elevated apex, and less well-defined false area this specimen differs materially from *A. gemma*. It is more of the *A. socialis* type than any of the Atlantic province forms, and of *A. microscopica* of the interior continental species.

*Formation and locality.*—Lower Ordovician, Limestone No. 1 of Mr. Billings's Point Levis section, Province of Quebec, Canada.

#### ACROTRETA PARVULA Wallerius.

*Obolella parvula* WALLERIUS, 1895. Undersökningar öfver zonen med *Agnostus levigatus*. Vestergötland. Akad. Afhandl. Lund., p. 65, pl., fig. 9.

Shell minute, subcircular. Pedicle valve relatively depressed, the highest point being at the umbo, from which there is a slight downward curvature to the apex. False area low and about vertical, the apex being on a line with the posterior margin. Brachial valve slightly convex; beak marginal. Surface marked by fine concentric striae.

This minute species occurs with *Agnostus levigatus* in the upper portion of the Middle Cambrian. It is of the *Acrotreta sagittalis* type, but does not appear to be identical with the young of that species.

*Formation and locality.*—Middle Cambrian. Dark-brown limestone at Borgholm, Oland, Sweden, as collected by M. Schmalensee. Dr. Wallerius gives Gudhem and Djupadal, Vestergötland, Sweden.



## ACROTRETA PRIMAÆA, new species.

*Acrotreta gemma* WALCOTT, Bull. U. S. Geol. Sur., No. 39, 1886, pp. 98, 99, pl. VIII, figs. 1, 1a, b.; Tenth Ann. Rept. U. S. Geol. Sur., 1891, p. 608, pl. LXVII, figs. 5c, 5d, 5e.

Outline of valves transversely oval to subcircular. Pedicle valve subconical, with the apex at the summit of the false area near to or just above the posterior margin. The elevation varies from one-half to two-thirds the diameter of the shell. The false area is quite clearly defined in most specimens; it varies in width at the posterior margin from one-third to nearly one-half of the diameter of the shell; the path of advance of the pseudodeltidium is marked usually by a narrow incised line similar to that of *A. attenuata*. Foraminal aperture minute and situated at the apex of the cone. Brachial valve slightly convex, with a minute beak slightly incurved over the posterior margin. A broad, slightly defined median sinus flattens the front and central portion of the valve, but it is not perceptible toward the umbo and beak. Surface of the shell marked by fine concentric striæ and occasional ridges of growth, and on some shells there is a very fine, almost microscopic irregular concentric striation that gives a fretted surface somewhat similar to that of *Obolus* (*Westonia*) *ella*. The inner lamellæ of the shell and the interior surface have traces of fine radiating striæ, that with the irregular concentric striæ give a broken, sub-imbriated, fretted effect to the surface. The shell is formed of a thin outer layer and several thin inner layers or lamellæ, the outer ones of which are slightly oblique to the outer surface layer. The largest shells have a transverse diameter of 5.5 mm., and a longitudinal diameter of 5 mm.; height of pedicle valve 3 mm.; brachial valve 1 mm. The interior of a slightly crushed pedicle valve shows the cast of an apical callosity, strong vascular canals, and faint outlines of the visceral cavity. The cast of an interior of a brachial valve has a long, well-defined median ridge, cardinal scars, and faintly defined central scars.

*Observations.*—This, the oldest species of the genus known to me, has all the essential characters of the type species, as far as the available information permits of comparison. It is one of the largest shells of the genus, and is a striking feature of the fauna of the higher portion of the *Olenellus* zone of Central Nevada. The nearest species appears to be *A. attenuata* var.

*Formation and locality.*—Lower Cambrian, upper portion of *Olenellus* zone, associated with fragments of *Olenellus gilberti* in thin layers of limestone interbedded in shales on east side of anticline just above quartzite, Pioche, Nevada.

## ACROTRETA SAGITTALIS Salter.

- Obolella sagittalis* SALTER, Rep. Brit. Assn. Adv. Sci., for 1865, 1866, p. 285.  
*Discina labiosa* SALTER, Rep. Brit. Assn. Adv. Sci., for 1865, 1866, p. 285.  
*Obolella sagittalis* DAVIDSON, Geol. Mag., V, 1868, p. 309, pl. xv, figs. 17-24; Brit. Foss. Brach., III, 1871, p. 339, pl. L, figs. 1-14; V, 1883, Pt. 2, p. 211, pl. XVI, figs. 25, 26.  
*Obolella sagittalis* LINNARSSON, Brach. Paradoxides Beds of Sweden. Bihang till k. Svenska vet. Akad. Handl., III, 1876, No. 12, p. 19, pl. III, figs. 36-41.  
*Linnarssonia sagittalis* WALCOTT, Amer. Jour. Sci., 3d ser., XXIX, 1885, pp. 115, 116; Tenth Ann. Rept. U. S. Geol. Sur., 1891, p. 610, pl. LXVIII, figs. 2, 2a-d.  
*Obolella (Linnarssonia) pretiosa* DAWSON, Trans. Roy. Soc. Canada, VII, 1889, p. 53, figs. 26, a, b, c.  
*Linnarssonia enf. pretiosa* HALL, Trans. Roy. Soc. Canada, VII, 1889, p. 55.  
*Linnarssonia pretiosa* HALL and CLARKE, Pal. N. Y., VIII, 1892, Pt. 1, p. 109, pl. III, figs. 43, 44.

Although I have examined a large collection of this species, both from Wales and from Sweden, good exteriors of the valves have not been observed. The apex of the pedicle valve almost invariably remains in the matrix or the shell has been removed by solution. The convexity of the two valves is approximately the same, except that the pedicle valve is more elevated near the apex. The apex is situated a little in front of the posterior margin at the edge of the slightly defined false area which slopes forward at an angle of from  $70^{\circ}$  to  $80^{\circ}$ . The surface of the shell is marked by rather coarse concentric striae and often strong ridges of growth and very fine radiating striae on the interior layers. The shell is built up of thin layers or lamellae of a calcareo-conchoidal nature. The average size of specimens from St. Davids, Wales, is 2.5 mm.

The interior of the pedicle valve is shown by numerous casts. The apical callosity is usually large, as are also the cardinal scars. The visceral cavity is sometimes outlined in front of the callosity and between the clearly marked main vascular sinuses. Casts of the interior of the brachial valve show a remarkable range of variation in the length and size of the median ridge. Within the extremes of variation specific characters could be established.

The representatives of the species from Andrarum, Sweden, are usually smaller than the St. Davids shells, but otherwise appear to be identical. This species has had a varied experience at the hands of paleontologists. Dr. Davidson elaborately illustrated the casts of the interiors of the valves, and I copied some of his figures when preparing the description of the genus *Linnarssonia*. When in Wales in 1888, I collected a quantity of material at St. Davids, and recently Mr. Schmalensee collected a good series at Andrarum for the U. S. National Museum. From these collections a series of figures have been drawn that illustrate the appearance of the shells as they occur both in shale and in limestone.

The varieties *taconica* and *transversa* are strongly marked, but I think are not entitled to full specific valuation.

A direct comparison of specimens from the black shales of Little Metis with those from the black shales of the type locality of *A. sagittalis* at St. Davids fails to disclose any specific differences between them, as far as the material at hand permits of comparison. The Little Metis shell was identified with "*Obolella-Acrothele*" *pretiosa* by Prof. James Hall, and this identification was accepted by Sir William Dawson. "*Obolella*" *pretiosa* is a true *Acrothele*, and no species of *Acrotreta* is known to occur at the type locality on the Chaudiere River. The stratigraphic horizon of the Little Metis beds has not been definitely determined. Sir William Dawson says, "At Metis the evidence of the pebbles in the conglomerates indicates that they are newer than the Lower Cambrian, and the few fossils found in the sandstones and shales would tend to place them at or near the base of the Lewis division, or approximately on the horizon of the Chazy.<sup>1</sup> I personally examined the section at Little Metis in 1899, and am not at all certain of the horizon of the shales carrying *Acrotreta sagittalis* and the beautiful fossil sponges described by Sir William Dawson. It is a region of strong folding and thrust faults. The *Acrotreta* is a Middle Cambrian type, and nothing similar to it is known from the Upper Cambrian. As far as this shell can locate the horizon it is Cambrian, and probably low down in the Upper Cambrian.

*Formation and localities.*—Middle Cambrian, *Paradoxides* zone, Menevian, St. Davids, South Wales; near Dolgelly, North Wales. See Davidson for local distribution in the Menevian. Limestones of *Paradoxides forchhammeri* beds, Andrarum, Lovened Djupadalen Vestergotland, Sweden. Borregard Bornholm, Denmark. Limestone with *Paradoxides davisi*, Seal Point Cove, near Long Point, Trinity Bay, Newfoundland. Black shales of Little Metis, Province of Quebec, Canada, in association with fossil sponges described by Sir William Dawson. Probable horizon between the Middle and Upper Cambrian.

#### ACROTRETA SAGITTALIS MAGNA Matthew.

*Linnarssonia belli* DAVIDSON mut. *magna* MATTHEW, Trans. Roy. Soc. Canada, 2d ser., III, 1897, p. 169, pl. 1, figs. 1a, 1b.

In addition to the material collected by Dr. G. F. Matthew I have a number of specimens collected by me at the typical locality. A comparison with a series of specimens of *A. sagittalis* from St. Davids, Wales, and of *A. sagittalis transversa*, shows at once that the form Dr. Matthew named is very closely related to both. The length and size of the median ridge, the position of the central scars of the brachial valve, and the size and position of the cardinal scars of the pedicle valve are the internal characters that Dr. Matthew depends upon to

<sup>1</sup> Trans. Roy. Soc. Canada, VII, 1889, p. 32.

distinguish the variety *magna*. All of the characters are fully covered by the variations in the same characters in *A. sagittalis* and its variety *transversa*. The nearly circular form of variety *magna* is about the only character that can be considered of value, and that is very closely approached by some specimens of *A. sagittalis*.

Dr. Matthew's making his shell a variety of the variety *belti* (*Acrotreta sagittalis beltii*) is not altogether desirable, and it is not probable that the Lower Tremadoc shell *beltii* is a variety of *A. sagittalis*, and still less so that the New Brunswick shell is a variety of *Acrotreta beltii*. In order to have all the data possible for the student, I have illustrated Dr. Matthew's types, which he kindly sent me for the purpose; also specimens I found at Hastings Cove.

*Formation and locality*.—Middle Cambrian, *Paradoxides* zone, Hastings Cove, Kennebecasis River, St. John County, New Brunswick.

#### ACROTRETA SAGITTALIS TRANSVERSA Hartt.

- Obolella transversa* HARTT, Dawson, 1868; *Acadian Geology*, 2d ed., p. 614.—WALCOTT, Bull. U. S. Geol. Sur., No. 10, p. 16, 1884, pl. i, fig. 5.  
*Limmarssonia transversa* WALCOTT, Am. Journ. Sci., 3d ser., XXIX, 1885, p. 116, figs. 3, 46.—MATTHEW, Trans. Roy. Soc. Can., III, 1886, p. 35, pl. v, fig. 11.—HALL and CLARKE, Pal. N. Y., VIII, 1892, Pt. 1, p. 108, pl. III, figs. 38-42.—MATTHEW, Trans. N. Y. Acad. Sci., XIV, 1895, p. 125, pl. v, figs. 1, 2.  
*Limmarssonia sagittalis* var. *transversa* WALCOTT, Tenth Ann. Rept., U. S. Geol. Sur., 1891, description of pl. LXVIII, fig. 2a.

This is the representative of *A. sagittalis* in the *Paradoxides* zone of New Brunswick. Many shells are more transverse in outline than the average of *A. sagittalis*, but examples of the latter are nearly as much so, and the interior casts show a striking similarity in the Welsh and Acadian forms. The range of variation in each form is nearly if not quite as great as the variation between the two. In view of this, I think it best to characterize *transversa* as a variety of *A. sagittalis*.

*Formation and locality*.—Middle Cambrian, *Paradoxides* zone, division b, c<sup>2</sup>, and d, St. John, Hanford Brook, New Brunswick; *Paradoxides darvisi* zone, Mannels Brook section, Avalon Peninsula, Newfoundland.

#### ACROTRETA SAGITTALIS TACONICA Walcott.

- Limmarssonia taconica* WALCOTT, Am. Jour. Sci., 3d ser., XXXIV, 1887, p. 189, pl. i, figs. 18, 18a-d.  
*Limmarssonia sagittalis* var. *taconica* WALCOTT, Am. Jour. Sci., 3d ser., XXXVIII, 1889, p. 36; 1891; Tenth Ann. Rept. U. S. Geol. Sur., p. 610, pl. LXVIII, 1, 1a-d.

This variety is characterized by the uniformly shorter median ridge of the dorsal valve. The pedicle valves appear to be identical with those of *A. sagittalis* from Andrarum, which are embedded in the same character of matrix as the variety *taconica*.

This is the second species found in association with *Olenellus*. *A.*

*primæva* occurs in the upper zone of the *Olenellus* fauna in Nevada, and this is in the upper portion of the same fauna in the Appalachian region. Its association with *Microdiscus connexus*, a representative of *Microdiscus punctatus*, of the *Paradoxides* zone of New Brunswick, also serves to connect it with *Acrotreta sagittalis*. It appears to be one of the few forms that serve to connect the Cambrian fauna of the Atlantic province with that of the Appalachian province.

*Formation and localities.*—Upper portion of Lower Cambrian. Limestone interbedded in shaly slates. Rock Hill schoolhouse, near North Greenwich;  $1\frac{1}{2}$  miles east, also west of North Greenwich; west summit of Bald Mountain, in the town of Greenwich; 2 miles south of North Granville; on the roadside just west of Low Hampton crossing of the Poultney River; one mile south of Shushan, one mile east of Salem, northeast section of Whitehall Township on SSW. road from Low Hampton—all in Washington County; Schodack Landing, Kinderhook Creek below paper mill at Stockport, Rensselaer County; near Valatie Creek near line of Nassau and Schodack townships, Columbia County, New York.

#### ACROTRETA SCHMALENSEI, new species.

*Acrotreta socialis* LINNÆARSSON, Brach. Paradoxides Beds of Sweden. Bihang till K. Svenska vet akad. Handl., III, 1876, No. 12, p. 16, pl. III, figs. 32-35.—WALLERUS, Undersökningar öfver zonen med *Agnostus levigatus* i Västergötland. Akad. Afhandl. Lund, 1895, p. 66.

As in the case of many other species of this genus, the student is referred to the series of figures illustrating it for information as to the external outline, form, and convexity of the two valves and the range of known variation. The collections of the U. S. National Museum contain a large series of specimens, from which the shells illustrated were selected.

The broad false area has a shallow, faint median groove on some specimens, and on others no traces of it have been seen. The foraminiferal aperture, which is exceedingly minute, is situated at the extreme apex of the pedicle valve; the cast of the base of the foraminiferal tube is clearly shown in interior casts of the valve. One of the distinguishing characters is the cast of the large main vascular sinuses on each side of the visceral area. The casts of the interior of the brachial valve are interesting and instructive in showing the considerable variation in the size and length of the median ridge and the size of the cardinal and central scars.

The shell is small and is built up of a thin outer layer and several inner layers as lamellæ more or less oblique to the outer layer. The outer surface is marked by fine concentric striæ and lines of growth, and the inner surfaces of the lamellæ by concentric striæ and fine radiating striæ. The average length of the opening of the valves is 1.5 to 2 mm., and the width is usually a little more.

All of the specimens illustrated are from the *Paradoxides forchhammeri* zone. They appear to be identical with the figures of *A. socialis* of Dr. Linnarsson, but not of Dr. v. Seebach. Those of the latter represent a shell with strong concentric striae and median groove on the false area, characters that Dr. Linnarsson says he did not find on his specimens. Among the collections made for me by Mr. G. Schmalensee, collector of the Geological Survey of Sweden, I find a larger *Aerotrete* than the one described by Professor Linnarsson, which agrees with the description of *A. socialis* of Dr. v. Seebach and with his figures. Dr. Linnarsson writes that he thinks Professor v. Seebach had representatives of several species before him when he wrote his notes on *A. socialis*. With this I am in full agreement, but with the collections now before me from Bornholm and Öland, I think the specific name *A. socialis* should be given to the larger shell illustrated by Professor v. Seebach, and a new name to the smaller and very distinct shell illustrated by Dr. Linnarsson. In recognition of the faithful and intelligent work of Mr. Schmalensee I take pleasure in naming the species in his honor.

*A. schmalensei* is of the type of *A. subconica* Kutorga, but is much less elevated. It may be compared with *A. microscopica* and *A. gemma* among American species.

*Formation and locality.*—Middle Cambrian, *Paradoxides forchhammeri* zone, Island of Bornholm, Andrarum and Markarten and Lovened, Djupadalen, Vestergothana, Sweden; Borregaard, Bornholm, Denmark. *Paradoxides olandicus* zone, Windjuelandet, Ringsaker, Norway.

#### ACROTRETA SEEBACHI, new species.

Among the fragments of trilobites in the *Ceratopyge* limestone collected by Mr. Schmalensee there are a few specimens of a species of *Aerotrete* distinct from *A. schmalensei* and *A. socialis*. The pedicle valve is relatively low, with the false area nearly vertical. A cast of this valve shows the cardinal scars on each side high up toward the apex, small main vascular sinuses, and apical callosity. False area rather large and marked by a slight indication of a median depression that is recognized by a slight undulation in the transverse striae. Surface marked by fine thread-like concentric striae and lines of growth. A broken brachial valve has a broad median sulcus and a small, distinct beak at the posterior margin. The valves are slightly transverse. A large pedicle valve measures 3 mm. in width by 2.5 mm. in length.

The surface striae and the cardinal scars serve to distinguish this species from others known to me. *Aerothera ceratopygonum* Brögger is from the *Ceratopyge* shales, but it has a low pedicle valve, with the false area sloping forward.

*Formation and locality.*—*Ceratopyge* limestone, Slemmestad, etage

3 aj of Brögger, at Kristiania, Vestfonus, Eugervik, and doubtfully at Vakkerø near Kristiania, all in collection of University of Kristiania, collected by Dr. W. C. Brögger, Norway.

ACROTRETA SIGNALIS, new species.

Pedicle valve transverse, broadly ovate; height about one-third the length; apex directed backward on a line with the posterior margin, which is transverse and slightly undulated at the center by the median furrow of the slightly defined false area; apex with a minute apical foramen directed backward. Surface marked by fine concentric striae and lines of growth that at the median furrow of the false area curve toward the posterior margin. Shell small, 1.5 mm. long by about 1.75 mm. in width. Shell is built up of several very thin layers or lamellae.

In all of the great collections made from the Cambrian sandstones of the Upper Mississippi Valley, only two pedicle valves of any species of *Acrotreta* have been found, as far as known to me. These occur in association with *Obolus (Lingulepis) acuminatus*, and the shells have the color and appearance of those of that species. Shiny, light gray to white, the original coloring matter having been leached out. Only the exterior of the pedicle valve is known. This compared with *A. microscopica* shows a less elevated pedicle valve and less distinct false area. It also has a marked median groove on the false area. It recalls *A. idahoensis*, but differs in being more depressed and in having a stronger groove on a narrower false area.

*Formation and locality.*—Middle Cambrian, St. Croix sandstone, St. Croix Falls, Wisconsin.

ACROTRETA SOCIALIS v. Seebach.

*Acrotreta socialis* v. SEEBACH, Zeitsch. deutschen geol. Gesellsch., XVII. 1865, p. 341, pl. VIII, figs. 1-4.

The species described and illustrated by Professor v. Seebach as *Acrotreta socialis* is characterized by a well-marked concentrically striated surface and a strong median groove in the false area. In the collections made for me by Mr. Schmalensee at Oland, Borgholm, I find associated with *Paradoxides olandicus* an *Acrotreta* that has these characters. All the specimens from the *Paradoxides forchhammeri* zone belong to a distinct species which I have named *A. schmalensei*. Professor v. Seebach evidently had specimens of the latter species, also of a species of *Acrotreta* from the *Ceratopyge* limestone, as he mentions the occurrence of *A. socialis* at both horizons. As now restricted *A. socialis* occurs at Oland in the *Paradoxides olandicus* zone.

The external form, as far as known to me, is shown by the figures. There is some variation in the height of the pedicle valve and in the outline of the margins of the valves. The false area is clearly defined and marked by a strong, rather broad median groove. The foraminal

aperture is at the apex of the pedicle valve and quite readily seen in several specimens, a character in strong contrast with the minute aperture at the apex of *A. schmalensei*. Shell formed of several thin layers or lamellæ that show very plainly where the thin outer layer is exfoliated. Surface marked by striæ and lines of growth that are very distinct on some shells and less so on others; the concentric striæ occur on all the lamellæ of the shell and on the inner surface; fine radiating striæ are to be found on the inner surface. The cast of the interior of the pedicle valve shows the presence of a large apical callosity and unusually large foraminal tube and main vascular sinuses on each side of the visceral cavity. The cardinal scars are well defined in both the pedicle and brachial valves. Casts of the interior of the brachial valve show a strong median ridge, central scars, and fairly well-defined main vascular sinuses. Professor v. Seebach describes the surface as having minute warts on it. I find numerous fragments of the shell of *Acrotreta granulata* associated with *Acrotreta socialis*, and it may be that it was the surface of this shell that he mistook for that of the species he was describing. No known species of *Acrotreta* has such a surface.

A large pedicle valve has a diameter of 5 mm. and a height of 2.5 mm. The average size is about 3 mm. in diameter.

This species belongs to the *A. subconica* group of species, with a broad false area and well-defined median groove. Its surface is more strongly marked by concentric striæ than any other species of the genus, and the shell is also thicker.

*Formation and locality.*—Middle Cambrian. *Paradoxides olandicus* zone, Oland, Island of Borgholm, Sweden.

#### ACROTRETA SUBCONICA Kutorga.

*Acrotreta subconica* KUTORGA, Über die Siphonotretæ Verhandl., Russisch-Kaiserl., mineralogischen Gesell., 1848, p. 275, pl. vii, figs. 7a, b, c, b<sup>1</sup>, c<sup>1</sup>.

*Original description.*—Strongly conical; the deltidium-like furrow narrow and plainly impressed. Innumerable growth-wrinkles run on the whole surface of the shell horizontally, and make deflections only in the furrow, the convexity of which is turned toward the base of the cone.

Height of the cone, 0.014?; length of the base or of the ventral valve, 0.012?; breadth of the same, 0.015?.

Four specimens, of which one is complete and three are without ventral valve. From the collection of Herr v. Volborth.

On the specimen with the apex broken off I investigated the surface of the fracture, under the microscope with a magnification of 45 times, and found on it two cruriform, shallow impressions similar to those on the casts of the Siphonotretes. Their surface was polished and with impressions of growth folds; and between the extremities of the crura in the neighborhood of the area-like hinge surface, a columniform fragment of the mold of the siphon. From this it proceeds that the broken-off tip, just as the beak of the Siphonotretes, was solid and contained a cylindrical siphon.

*Observations.*—Through the courtesy and permission of Dr. F. Schmidt, Dr. F. Huene kindly sent me the types of this species, which he had been studying. One of them preserves the outer shell at the



apex. It shows a minute foraminal aperture on the back side of the apex and a strong median groove on the false area. The outlines of the pedicle valve vary from the somewhat diagrammatic drawings of Dr. Kutorga, and there is some variation among the five specimens representing the types.

*Formation and locality.*—Upper Cambrian, Popovke, near St. Petersburg, Russia.

LINNARSSONELLA, new genus.

Ventral (pedicle) valve convex with a slightly incurved beak projecting over a low false area. Foraminal opening just in front of the beak. A very slight trace of a pseudodeltidium occurs beneath the beak, dividing the area midway, as in the genus *Iphidea*; the false area arches slightly upward and backward in some specimens, while in others of the same species its edge is nearly coincident with the plane of the edge of the shell. The dorsal (brachial) valve is slightly convex, with a minute beak at the posterior margin. Surface marked by very fine concentric striae and undulations of growth. Shell strong, thick, and built up of a thin outer layer and numerous inner layers or lamellae that are arranged more or less obliquely to the outer layer. All the known species are small, not exceeding  $2\frac{1}{2}$  mm. in diameter.

The cast of the interior of the pedicle valve shows the presence of two well-marked cardinal scars, one on each side of the main vascular canals, well toward the posterior border of the valves. The main vascular canals of the pedicle valve were large, extending nearly to the frontal margin, and including between them back of the center of the valve a small visceral area. The cast of the foraminal opening occurs just in front of the union of the main vascular sinuses. The cast of the interior of the brachial valve shows two large cardinal scars; two central scars, and traces of a minute antero-lateral scar; strong vascular canals; a well-defined false area and pseudodeltidium and a narrow median ridge extending in some shells to the anterior third of the valve.

Type, *Linnarssonella girtyi*. Second species, *L. minuta*. Third species, *L. broadheadi*. Fourth species, *L. tennesseensis*.

This is a most interesting type, combining characters of *Iphidea* and *Acrotreta*. *Bicia*, of the *Olenellus* fauna, has a strikingly similar dorsal valve, and the ventral is not unlike it if the narrow pedicle furrow of *Bicia* is closed, so as to provide a foraminal aperture.

*L. girtyi* occurs in great abundance in a single layer in the Middle Cambrian of the Black Hills, North Dakota, and also at two localities in Oklahoma Territory, northwest of Fort Sill. The valves of *L. minuta* almost cover a fragment of sandy shale from the Eureka District, Nevada. *L. broadheadi* is numerous in the Middle Cambrian limestones of Missouri. *L. tennesseensis* occurs quite abundantly in

sandy shales and thin-bedded sandstones, also in argillaceous shales above the Knox sandstone.

Failing to establish a satisfactory genus in honor of Dr. Linnarsson in the first instance, I make another attempt with this rare and interesting form.

LINNARSSONELLA GIRTYI, new species.

Shell minute. General form broad ovate to subcircular. Ventral (pedicle) valve convex; beak small and slightly incurved over the false area; false area short and varying from vertical to a backward inclination of  $45^{\circ}$  to  $50^{\circ}$  with the plane of the edge of the valve. In some examples the margin of the false area arches, while in others it appears to be straight. A very slightly indicated pseudodeltidium occurs beneath the beak, that gradually widens to the margin, very much as in *Iphidea pedici*. Foraminal opening minute exteriorly, but the tube increases in size toward the inner surface of the shell. In one very perfect shell the aperture appears to open into a narrow elongate depression just in front of the beak, but it usually is seen as a minute circular perforation in front of the beak. Dorsal (brachial) valve gently convex, with a minute beak at the posterior margin. Surface of the shell glossy and smooth to the unaided eye, but a strong magnifier shows very fine concentric striae and lines of growth. The inner surface is marked outside of the visceral area by very fine radiating striae. The shell is formed of several layers or lamellae, and, judging from the depth of the impressions of the muscle scars and vascular markings, is rather thick over the central and posterior portions. The average length of the ventral valve is 1.5 to 1.75 mm. The dorsal valve is slightly shorter.

The cast of the interior of the pedicle valve shows the presence of a large cardinal sear on each side of the visceral area and outside of the very strong vascular canal; they are oval in outline and probably the point of attachment of strong muscle or muscles. The visceral area is small, but is well defined. Of the vascular canals, only the main trunks are shown by strong ridges in the casts; in one specimen they extend almost in a direct line from the beak to the antero-lateral margins of the valve. The cast of the interior of the foramen is usually broken off. The interior of the brachial valve is beautifully shown by one specimen; the narrow area with its well-defined pseudodeltidium, the large oval cardinal scars immediately in front of the area, and the strong vascular canals are as clearly defined as in the large shells of *Obolus*. The cardinal scars are divided into three parts by two transverse lines crossing the outer slope more or less obliquely, but the divisions on the two sides are unequal; the inner slopes of the scars are finely polished and afford no evidence of the attachment of muscles. Traces of the central scars occur on the outer slope of the cast of a

rather strong median ridge; they are elongate oval in outline, the major axis inclining posteriorly toward the median ridge. What may be the impression of an antero-lateral scar occurs on the median ridge a little in advance of the central scars.

*Observations.*—I collected a large number of this little shell in a layer of gray limestone about 100 feet above the quartzitic sandstone at the base of the Cambrian in the Black Hills. The associated trilobites and brachiopods belong to the Middle Cambrian fauna of the Upper Mississippi Valley and eastern Rocky Mountain region. This species differs from *L. minuta* in the greater convexity of the pedicle valve and the median ridge of the dorsal valve. The specific name is given in recognition of the paleontologic work of Dr. George H. Girty.

Mr. E. O. Ulrich found this species in 1901 in great abundance in gray limestones interbedded in the lower portion of the Middle Cambrian section of the Wichita Mountains, and Mr. R. Greger collected it in the Middle Cambrian limestones near Potosi, Missouri.

*Formation and locality.*—Middle Cambrian limestone in north suburb of Deadwood, Black Hills, South Dakota. Also at the same relative horizon in Oklahoma Territory in calcareous layers of the Regan greensand; one locality is 15 miles northwest of Fort Sill, one-half mile east of Canyon Creek, Wichita Mountains, and another is about 4 miles east of Canyon Creek in the southwest quarter section 17, T. 4 N., R. 12 W.

**LINNARSSONELLA MINUTA** Hall and Whitfield (sp.).

*Lingulepis* (?) *minuta* HALL and WHITFIELD, Geol. Expl. Fortieth Parallel, IV, 1877, p. 206, pl. 1, figs. 3 and 4.

*Lingulepis* (?) *minuta* WALCOTT, Mong. U. S. Geol. Sur., VIII, 1884, p. 13

*Lingulella minuta* SCHUCHERT, Bull. U. S. Geol. Sur., No. 87, 1897, p. 257.

Shell small; general form broad ovate, with the pedicle valve slightly subacuminate. The convexity of the two valves is nearly the same and in each the minute beak is at the posterior margin. The false area of the pedicle valve is small and divided midway by a faint, narrow, pseudodeltidium; it is on the plane of the margin of the valve. Foraminal opening minute, elongate, and situated on the slope just in front of the beak. Brachial valve a trifle less convex than the pedicle.

The outer surface of the shell is marked by fine concentric striae and lines of growth and the inner lamellæ and inner surface by fine radiating striae. The shell is formed of several thin layers or lamellæ, those of the anterior and lateral portions being more or less oblique to the outer surface layer; the shell is also thickened in the visceral region by irregular additions on the inside. The average length of the pedicle valve is 2 to 2.5 millimeters; the dorsal is a little shorter.

The interior of the pedicle valve shows a cardinal scar on each side, well out toward the lateral margin, which corresponds to the position of the transmedian and antero-lateral scars in *Obolus apollinis*. The visceral area is small and compressed between the sinuses occupied by the large, main vascular canals. The opening of the foraminal tube is oval and situated at the posterior portion of the visceral depression at the margin of the area. The main vascular canals start near the beak and gradually diverge toward the antero-lateral margins of the valve. The interiors of the brachial valve associated with the two pedicle valves illustrated are all so imperfect that only a median ridge like that in *Acrotreta* can be clearly determined. This ridge varies greatly in size and length in different specimens.

*Observations.*—In a hasty examination of this species in 1884, I confused the dorsal valve with that of *Acrotreta* and considered the ventral valve as the type, placing it under *Lingulepis*, stating that it had “nearly the same vertical range and geographic distribution as *L. maera*.” As now known, it is confined to the one locality discovered by the geologists of the Fortieth Parallel Survey, and to a single slab of reddish-brown sandy shale on which a large number of the separated valves occur.

The generic reference is somewhat doubtful on account of the difference in what is known of the interior of the dorsal valve and the position of the area of the ventral valve.

*Formation and locality.*—Upper Cambrian, Hamburg Ridge, Eureka district, Nevada.

#### LINNARSSONELLA TENNESSEENSIS, new species.

General form of pedicle valve rounded subtriangular, moderately convex, with the beak curving gently over a very low false area nearly to the posterior margin. Foraminal opening minute and situated a little in front of the beak. Brachial valve moderately convex, with the beak marginal.

Surface of shell marked by fine concentric striae and lines of growth. The interior surface shows a few fine radiating striae. Shell rather thick and built up of several thin layers or lamellae.

The cast of the interior of the pedicle valve shows small cardinal scars and a minute foraminal tube directed backward very much as in *Obolus atlantica*. The main vascular canals of the pedicle valve are outlined nearly to the antero-lateral margins and include between them a narrow visceral area. The cast of the brachial valve indicates relatively strong cardinal scars, distinct central scars, and a narrow median ridge. None of the specimens show the main vascular canals except at their base.

*Observations.*—This shell has the general outline of *L. girtyi*, but it differs in having the pedicle valve more acuminate, less convex, and

in the apex curving over nearly to the posterior margin. It has the outline of *L. minuta*, but not the strong vascular sinuses and small cardinal scars of the pedicle valve of that species. From *L. broadheadi* it varies in outline and convexity.

*Formation and locality.*—Middle Cambrian, in shales and sandstones above the Knox sandstones, Bull Run, Copper Ridge, 11 miles west of Knoxville; 6 miles northeast of Knoxville; 1½ miles east of Post Oak Springs, Roane County, all in Tennessee.

**OBOLUS (LINGULELLA) SCHMALENSEI**, new species.

This is the European representative of the American *Obolus* (*L. rotundatus*). Its outline is slightly elongate to subcircular. When the shell is exfoliated the cast indicates that it was strong over the visceral area and thin toward the margins.

The specific name is given in honor of M. Schmalensee, who collected the material for me.

*Formation and locality.*—Middle Cambrian limestones of *Paradoxides forchhammeri* zone, Skane, Andrarum, Sweden.

**BRÖGGERIA**, new subgenus.

Type, *Obolus* (*Bröggeria*) *salteri*.

This subgenus differs from the typical forms of *Obolus* in having a very deep visceral depression in both valves and a minutely papillose interior surface. A series of shells showing the effect of compression on the appearance of the interior casts of the valves will be illustrated in the monograph.

**OBOLUS (BRÖGGERIA) SALTERI** Holl.

*Obolella salteri* HOLL, Quar. Jour. Geol. Soc., XXI, 1865, p. 101, fig. 9.

? *Obolella salteri* DAVIDSON, Brit. Foss. Brach., III, 1870; Sil. Brach., p. 61, pl. iv, figs. 28, 29.

*Obolus salteri* BRÖGGER, Die Silurischen Etagen 2 und 3, 1882, p. 44, pl. x, figs. 10, 11, 13.

*Obolus* ? *salteri* MICKWITZ, Mem. Imp. Acad. Sciences, St. Petersburg, VIII, 1896, 4 ser., No. 2, p. 19.

*Original description.*—Compressed, subtriangular to nearly round, rather broader than long; shell thin; surface grooved concentrically by a few inequidistant, strongly marked lines of growth, and by numerous finer lines which are distinct only on the sides of the shell. Length usually about one-third inch; width slightly more.

*Position.*—In the Black Shales. [The Black Shales are referred to Upper Cambrian, the locality being in the eastern portion of the Malvern Hills of England.]

Mr. Davidson copies Holl's description and figure. Dr. W. C. Brögger, however, identifies the species from the Upper Cambrian *Ceratopyge* slate and limestone of Sweden, illustrating a form from the slate, and a very beautiful interior of what appears to be a dorsal valve of this species from the limestone.

Through the courtesy of Dr. Brögger, I studied the material representing this species collected in Norway.

In a collection kindly sent me by Dr. G. Lindström I find two ventral valves from the black shale of Skane, but it is in the collection made by Mr. v. Schmalensee that specimens occur showing the casts of the interior of the dorsal valve. These have the imprint of the central visceral area; the large vascular sinuses, and the area. A cast of an uncompressed shell proves that the visceral area was short and relatively small. Comparing the matter, I am led to conclude that the latter is a partially exfoliated specimen preserving the vascular markings on the thin inner layers of the shell.

In Cape Breton this species occurs abundantly in association with *Obolus* (*Lingulella*) *concinus* Matthew, and *Aerotreta bisecta* Matthew. The shells are all compressed in the shale, but a direct comparison of the interiors of the valves of specimens from Cape Breton and from the *Ceratopyge* shales of Sweden shows the two to be identical in all characters except the length of the area and pedicle groove. The Cape Breton shells have a longer area, but whether this is owing to the conditions of preservation or not, I am unable to decide, as the material from Sweden is very imperfect about the area. On one of the Cape Breton shells the fine punctæ of the interior surface are clearly shown.

*Formation and localities.*—Upper Cambrian. Black shale 3 f, *Dictyograptus* series; greenish arenaceous *Ceratopyge* shale 4a, Bornholm. In dark, ferruginous sandstone, associated with fragments of *Olenus tornquisti* Moberg, Skane Fagelsang, Sweden. Étage 3 aj. Vestfossum; Engervik, Asker; Slemmestad Roken, 3 ab, Kristiania, Norway. Argillaceous shale, Barachois 11n, 4 miles south of Little Bras D'or Lake, Cape Breton, Nova Scotia.

#### OBOLUS (LINGULELLA) LENS Matthew.

*Lingula? lens* MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, 1900, p. 274, pl. v, figs. 3a, 3b.

*Obolus* (*Lingulella*) *bellus* WALCOTT, Proc. U. S. Nat. Mus., XXIII, 1901, p. 685.

General form broadly ovate. The ventral valve is subacuminate and the dorsal valve very broadly ovate to subsemicircular. The convexity of the valves is moderate, the ventral valve being most prominent along the center, with the postero-lateral slopes somewhat flattened toward the margin.

Surface of the shell marked by fine, concentric striae and lines of growth, and the inner surface by concentric lines and very fine radiating striae. The shell is thinner than most species of the subgenus, resembling in this respect *Lingula murrayi* and *O. (L.) bellus*. It is formed of several layers or lamellae that are slightly oblique to the outer layer. Dr. Matthew speaks of minute pits on the outer surface. These also appear on the inner layers. I have been unable to deter-

mine whether the thin calcareous crust mentioned by Dr. Matthew is really the true outer layer or simply a thin calcareous deposit.

The largest specimen of a dorsal valve in the collection has a length of 15 mm., with a width of 13 mm. The corresponding ventral valve was probably 1 or 2 mm. longer.

*Observations.*—In the material collected by Mr. S. Ward Loper in 1901 there are some specimens that show the form of the ventral and dorsal valves of this species. The shell is broader and rounder than I supposed when studying the material Dr. G. F. Matthew sent me. It is quite distinct from *O. (L.) bellus* and *O. (L.) concinnus*, with which I placed it. The interior markings are those of *Lingulella*, but it may be that more perfect material would prove it to belong to some other subgenus of *Obolus*.

*Formation and locality.*—Upper Cambrian, thin calcareous layers in the arenaceous shales at McAdams shore, Escasonie, Cape Breton, Nova Scotia.

#### OBOLUS (LINGULELLA) SPATULUS, new species.

General form of the ventral valve spatulate, the sides sloping from the apex forward with a very slight curvature to the anterior fifth of the shell, where they pass into the broadly rounded frontal margin.

Dorsal valve ovate, with the greatest width toward the front. Convexity moderate, and about equal in both valves. A ventral valve 9 mm. in length has a convexity of about 1 mm. A fragment of the outer surface indicates that the surface was relatively smooth, being broken only by fine, scattered striae of growth. The inner layers show concentric lines, also fine, radiating striae. The interior of the shell was marked by scattered postules, concentric striae, and a few radiating lines.

The largest ventral valve has a length of 9 mm. and a width of 6 mm. A dorsal valve 5 mm. in width has a length of 7 mm.

The only traces of the vascular system preserved is the median ridge of the dorsal valve, which extends forward to the anterior fourth of the shell.

*Observations.*—This very pretty little shell occurs in abundance in the chocolate-brown sandstone interbedded in the shales just above the massive Tonto sandstone. It is distinct from all other species known to me from the Cambrian rocks of the Grand Canyon region. *O. (L.) chuarvensis* occurs in a layer of sandstone 50 or 60 feet higher up in the section.

*Formation and locality.*—Middle Cambrian, Tonto sandstone series, just above massive sandstone near mouth of Bass Canyon, on the south side of the Grand Canyon of the Colorado, southeast of Powells Plateau, Arizona.

## OBOLUS (LINGULELLA) WELLERI, new species.

General form elongate ovate, with the ventral valve subacuminate and the dorsal valve subelliptical. Owing to the more or less crushed condition of all the specimens the exact convexity of the entire valve is unknown. Surface of the shell marked by numerous elevated concentric lines of growth and very fine, slightly irregular, interstitial concentric striae.

When the outer surface is exfoliated the inner layers show fine radiating striae and concentric lines of growth. Nothing is known of the interior surface of the shell. The shell appears to have been relatively thin and formed of several layers or lamellae.

A ventral valve 14 mm. in length has a width of 9 mm., and a dorsal valve 10 mm. in length has a width of  $7\frac{1}{2}$  mm. In both valves the width is slightly increased by the flattening of the shell.

*Observations.*—This species occurs in association with *O. (Lingulepis) acuminatus* in an arenaceous magnesian limestone. It differs from described species in the elliptical form of the dorsal valve and the strongly filose concentric striae of the outer surface. The specific name is given in honor of Prof. Stuart Weller, who discovered the locality. The specimens representing the species were collected by Mr. Henry Dickhaut.

*Formation and locality.*—Upper Cambrian, magnesian limestones, O'Donnell & McManiman's quarry, Newton, New Jersey.

## OBOLUS (LINGULELLA) CONCINNUS Matthew.

*Lingulella concinna* MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, 1900, p. 273, pl. v, figs. 2a-b.

*Obolus (Lingulella) bellus* WALCOTT, Proc. U. S. Nat. Mus., XXIII, 1901, p. 685.

General form ovate, with the ventral valve subacuminate and the dorsal valve broadly ovate. There is considerable variation in the outlines of the valves. The convexity of the valves is fairly strong, although they are usually more or less flattened and compressed in the arenaceous shale.

Surface of the shell is marked by fine concentric striae and lines and ridges of growth. When the outer surface is exfoliated numerous fine radiating striae occur in the inner layers or lamellae. The inner surface is marked by concentric lines of growth. In some specimens scattered minute pits occur that are sometimes arranged in the cast like beads along the lines of growth. The shell is of moderate thickness and formed of a thin outer layer and several inner layers or lamellae that are slightly oblique to the outer layer. In the older shells the oblique lamellae form laminated ridges of growth. Some of the larger ventral valves have a length of 10 to 12 mm., but the average length is about 8 mm.



The area of the ventral valve is about one-fifth the length of the shell. It is divided midway by a narrow, strongly marked pedicle furrow, and midway between the pedicle and lateral margins by a sharp flexure line. The striae of growth cross parallel to its base. The area of the dorsal valve is relatively short, but extends well out onto the cardinal margins. Although there is a large series of specimens, and many of them with the surface of the shell exfoliated, nothing is known of the vascular markings or muscle scars.

*Observations.*—When studying *O. (L.) bellus* in 1900, I came to the conclusion that *O. (L.) concinnus* and *O. (L.) lens* from Cape Breton were identical, but with still larger collections obtained by Mr. S. Ward Loper in 1901 from Cape Breton, especially of *O. (L.) lens*, it appears that the outlines of *O. (L.) bellus* are more uniformly subquadrate in the adult specimen of the dorsal valve than the Cape Breton form. *O. (L.) concinnus* and *O. (L.) bellus*, however, are closely related and both occur in the Upper Cambrian beds.

*Formation and locality.*—Upper Cambrian. Arenaceous shale at several localities on McNeils Brook; also, ravine one-half mile north of McMullin's, on crossroad to Boisdale railroad station; in ravine east of railroad, just south of Barachois post-office; Upper Leitches Creek, Cape Breton, Nova Scotia.

#### OBOLUS (LINGULELLA) ATAVUS Matthew.

*Leptobolus atavus* MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, 1899, p. 200, pl. II, figs. 1 a-f.

*Obolus (Lingulepis) gregeva* WALCOTT, Proc. U. S. Nat. Mus., XXIII, 1901, p. 692.

General form elliptical, with the ventral valve subacuminate and the dorsal valve broadly subacuminate in outline. In the shorter form of the valves the sides are almost uniformly rounded from the cardinal slopes to the frontal margin. The convexity of the valves is fairly strong, that of the dorsal valve being broken by a slight longitudinal flattening that extends from the posterior portion to the frontal margin. As shown by the matrix, the outer surface is marked by concentric ridges and fine striae of growth. The interior cast shows concentric lines and traces of rather coarse radiating lines. None of the specimens preserve the shell, but from the strength of the interior surface markings it is inferred that the shell was rather thick.

The longest ventral valve in the collection has a length of 6 mm., width  $3\frac{1}{2}$  mm. The dorsal valves are slightly shorter.

The area of the ventral valve is divided at the center by a strong pedicle furrow, and about midway between the pedicle furrow and the outer margin by clearly marked flexure lines that extend from the apex with a slightly outward curvature to the base of the area. Striae of growth cross the area parallel with its base, being much stronger on the area than in the pedicle furrow. The area of the dorsal valve

is fully as prominent as that of the ventral valve. It curves forward at the center and extends well out on the cardinal slopes. The flexure lines are clearly defined well out toward the lateral margin. The striae of growth cross the area parallel to the base.

The cast of the interior of the ventral valve shows only the outline of the visceral cavity and that the main vascular sinuses extend a considerable distance in advance of the visceral cavity. The cast of the interior of the dorsal valve shows that it had a strong, broad, central ridge divided by a faint longitudinal median sinus. Only traces have been seen of the main vascular sinuses.

*Observations.*—This is a very pretty little species that I confused with the young of *Obolus* (*Lingulepis*) *gregwa* in the absence of well-defined specimens. Material collected by Mr. S. Ward Loper at the type locality proves that the shell differs considerably from the young of *O.* (*L.*) *gregwa*. It also differs, in being regularly oval, from *O.* (*L.*) *collicia* Matthew, with which it is associated, and *O.* (*L.*) *canius* Walcott, from the *Paradoxides* horizon of Cape Breton.

*Formation and locality.*—Middle Cambrian, Matthew's Etcheminian, just above the conglomerate at the base of the section on Dougal Brook, branch of Indian River, Cape Breton, Nova Scotia.

#### OBOLUS (LINGULELLA) COLLICIA Matthew.

*Leptobolus?* *collicia* MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, 1899, p. 200, pl. 1, figs. 3 a-c.

This shell is associated with *O.* (*L.*) *atarus*. It differs from it in being larger and in having a more acuminate and broader ventral valve and a more broadly oval dorsal valve. The exterior surface is marked by very fine, slightly irregular, concentric striae.

*Formation and locality.*—Middle Cambrian, Matthew's Etcheminian, just above the conglomerate at the base of the section on Dougal Brook, branch of Indian River, Cape Breton, Nova Scotia.

#### OBOLUS (LINGULELLA) CANIUS, new species.

Shell small; general form elongate oval, with the ventral valve slightly acuminate. In both the ventral and dorsal valve the shell narrows posteriorly, the front being broadly rounded. The convexity of the two valves is well marked, and it is nearly the same in each.

Surface of the shell marked by fine concentric striae and a few lines of growth. When the outer shell is exfoliated fine radiating striae cross the fine concentric striae. The shell appears to be of moderate thickness and formed of several thin layers or lamellae. The largest ventral valve in the collection has a length of 5 mm. and a width of 3 mm., and a dorsal valve 4 mm. in length has a width of 2 mm.

The area of the ventral valve is elongate, being nearly one-fifth the length of the shell. It is divided midway by a very distinctly

defined pedicle furrow. The flexure line is just perceptible about half the distance out from the pedicle furrow to the lateral margin. The area extends well forward on the cardinal slopes, and is marked by strong striae of growth parallel to its base. The area of the dorsal valve is shorter than that of the ventral. It is marked by fine lines of growth and clearly marked flexure lines that extend from the apex forward on a line with the main vascular sinuses.

The cast of the interior of the ventral valves shows a general outline of the visceral cavity and the main vascular sinuses. Only the base of the main vascular sinus has been seen in the dorsal valve.

*Observations.*—This very pretty little species occurs in association with *Paradosides*. In my first study of the brachiopods collected by S. Ward Loper from Cape Breton I confused it with the young of *O. (L.) gregwa*. By means of a larger collection made by him in 1901 I have been able to separate it from the young of the associated *O. (Lingulepis) paradosides*, and from the somewhat similar species that occur at a lower horizon, *O. (L.) atavus* and *O. (L.) collicia*. It differs from both the latter species in having a more elongate oval outline.

*Formation and locality.*—Middle Cambrian; compact, fine-grained, thin-bedded, grayish sandstone, McLean's Brook, 1½ miles west of Marian Bridge, Cape Breton, Nova Scotia.

#### OBOLUS (WESTONIA) FINLANDENSIS, new species.

General form elongate ovate, with the ventral valve subacuminate and the dorsal valve ovate in outline. Convexity of the two valves moderate. A ventral valve 11 mm. in length has a convexity of about 1.25 mm., and a dorsal valve 8 mm. in length a convexity of 1 mm. above the plane of the margin.

The outer surface of the shell is marked by concentric lines of growth, with very fine interstitial striae. The latter are crossed by fine radiating striae that are interrupted more or less by the concentric lines of growth. In addition to the concentric radiating striae there is a series of imbricating lines that are slightly oblique to the longitudinal axis of the shell. These lines terminate at right angles to the margins, curving inward and backward apparently to the opposite side. This type of ornamentation is much like that of several species of *Westonia*, except that it is somewhat more complicated.

The cast of the interior of the shell shows the interior surface to have been marked by scattered punctæ that had a tendency to gather concentrically on the lines of growth. A few rather strong radiating striae also occur outside of the visceral area.

The shell is rather thick. It is formed of a thin outer layer and several inner layers or lamellæ that are more or less oblique to the outer surface and marked near the front margin by fine radiating striae. The largest specimen has a length of 11 mm. with a width of 7 mm. The dorsal valve of the same width has a length of 8 mm.

The area of the ventral valve is unknown. That of the dorsal valve is strongly defined and extends well forward on the cardinal slopes. It is marked by transverse striae of growth parallel to the base.

The only interior markings known are in the dorsal valve. These indicate the course of the main vascular sinus and the size and length of the median ridge; also the position of the central muscle scars.

*Observations.*—The oblique imbricating lines on the outer surface of this species relate it closely to *O. (Westonia) stoneanus* and *O. (W.) escasoni*. The two specimens showing the outer shells are unfortunately slightly worn along the median line, so that it is not possible to trace the growth of the oblique imbricating lines entirely across the shell. In form the shell resembles *O. (L.) acutangulus*. It occurs in the compact, fine-grained, quartzitic sandstone, in association with *Ellipsocephalus (Liostracus) muticus* Angelin, in the *Paradoxides tessini* series. The material was collected by M. v. Schmalensee.

*Formation and locality.*—Middle Cambrian, Aland Saltvik, Finland.