CAMBRIAN BRACHIOPODA: OBOLELLA, SUBGENUS GLYPTIAS; BICIA; OBOLUS, SUBGENUS WESTONIA; WITH DESCRIPTIONS OF NEW SPECIES.

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In continuation of the study of the Cambrian Brachiopoda[1] the following notes have been assembled, which may be of service to students prior to the publication of a monograph on the subject:

Genus OBOLELLA Billings, 1861.

1861. *Obolella* Billings, Pamphlet, and Geology of Vermont, II, p. 946, fig. 346.
1861. *Obolella* Billings, Geol. Surv. Canada; Palæozoic Fossils, I, p. 7, fig. 7.
1862. *Obolella* Meek and Hayden, Proc. Acad. Nat. Sci. Phila., XIII, p. 435.
1863. *Obolella* Hall, Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 133, pl. VI, figs. 17–21.
1865. *Obolella* Meek and Hayden, Smithsonian Contb. No. 172, Palæontology Upper Missouri, pp. 3, 4.
1866. *Obolella* Davidson, British Silurian Brachiopoda, p. 60.
1867. *Obolella* Hall, Trans. Albany Inst., V, p. 108.
1870. *Obolella* Dall, Am. Jour. Conchology, VI, pp. 162–164.
1871. *Obolella* Billings, Canadian Naturalist and Geologist, new ser., VI, p. 217, figs. 5, 6.
1872. *Obolella* Billings, American Journal of Science, 3d ser., III, p. 355, figs. 5, 7.
1876. *Obolella* Billings, American Journal of Science, 3d ser., XI, p. 176.
1881. *Obolella* Ford, American Journal of Science, 3d ser., XXI, p. 131.
1884. *Obolella?* Walcott, Monograph U. S. Geol. Survey, VIII, Palæontology Eureka District, pp. 67, 68.
1886. *Obolella* Walcott, Bulletin U. S. Geol. Survey, No. 30, pp. 109–119.
1889. *Obolella* Walcott, Proc. U. S. National Museum, XII, p. 36.
1892. *Obolella* Hall and Clarke, Pal. New York, VIII, Pt. 1, pp. 66, 164.
1892. *Obolella* Matthew, Trans. Roy. Soc. Canada, IX, p. 39.
1894. *Obolella* Hall and Clarke, Eleventh Annual Report New York State Geologist, p. 240, pl. III, figs. 5, 6, 7.
1896. *Obolella* Mickwitz, Mém. Acad. Imp. Sci. St. Pétersbourg, VIII, p. 116.

Generic characters.—Shell subequivalve, moderately convex; dorsal valve more elevated at the umbo than the ventral; longitudinally ovate or oval in outline, with the dorsal valve sometimes transversely oval. Surface marked by concentric striæ of growth and radiating striæ, except in the subgenus *O.* (*Glyptias*) *favosa*, which has irregular transverse lines crossing the concentric striæ.

Shell substance unknown in an unaltered condition; it appears to have been calcareo-corneous, as in Obolus. Shell structure formed of a thin outer layer with many thin inner layers or lamellæ more or less oblique to the outer layer; the short lamellæ of the anterior portion of the valves are more oblique than the longer lamellæ of the central and

[1] Note on the genus Lingulepis: Am. 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.

posterior portions and lie on the edges in the same plane as the margins of the valves.

Area of the ventral valve rises from the plane of the margins of the valve at angles varying from 10° to 70°; broadly subtriangular when the beak is projecting, otherwise rounded at the posterior margin almost as much as the area of the dorsal valve; the latter is usually on the plane of the margins of the valve and broadly rounded posteriorly; both areas are striated parallel to the base and divided midway differently in each valve and in an unusual manner; in the ventral valve a sharp, narrow pedicle slit cuts through the area from its base to the apex; this slit opens into a cylindro-conical chamber, varying in size and form, that terminates in the shell substance of the beak but does not penetrate to the surface of the shell; the striæ of the area pass into the slit and encircle the pedicle chamber; the latter is in form similar to the pedicle tube of the Siphonatretidæ, except that it is closed at the outer end, and the pedicle obtained egress through the narrow slit in the area; the area of the dorsal valve is divided by a narrow, raised, triangular space that is bordered on either side by a more or less deeply impressed groove formed by a narrow fold of the areal lamellæ; outside of this groove, and between it and the outer flexure fold of the area, occurs a depressed triangular space that has been considered by authors as the scar of the point of attachment of cardinal muscles. Sometimes the inner angle of the area of the ventral valve adjoining the pedicle slit projects forward so as to form a tooth-like knob, which in the cast is shown by a deep indentation beside the cast of the pedicle chamber and between the latter and the projecting cast of the undercut beneath the area.

Splanchnocœle[1] of the ventral valve confined to the posterior half, while in the dorsal valve it extends forward to and in some instances beyond the center; in both valves it extends back to the splanchnocœle part of the area, which is bounded by the flexure lines. Traces of a median septum are shown in the dorsal valve, but no definite septum has been observed in the ventral valve. A central median ridge of varying degree of size and length often extends toward the central portion of the dorsal valve; when it is large a deep, rounded groove usually occurs on each side of it, on the inner slope of which the central muscle scars may be situated. Often the median ridge is practically absent.

The grooves of the main vascular sinuses begin in each valve at the front margin of the area near the median line, and in the ventral valve gradually extend forward and outward toward the front half of the shell, where they begin to gently curve inward, terminating toward the front of the valve, the distance and curvature varying in different species. In the dorsal valve the main vascular sinuses curve out more rapidly, and are much less prominent; none of the secondary radial canals or the peripheral vascular sinuses have been observed. The

[1] Using nomenclature of Mickwitz.

course of the parietal scar between the main vascular sinuses is in front of the splanchnocœle in the ventral valve; also in the same valves it passes around the muscle scars between the main sinuses and the base of the area, in line with the flexure line of the area; in the dorsal valve it closely follows the outside limits of the muscle scars, but it has not been traced across the main vascular sinuses.

The size and position of the pedicle and umbonal muscle scars are unknown, but they are probably similar to those of Obolus. The central scars are placed a little distance each side of the median line in the dorsal valve. In the ventral valve they are not separable from the middle and outside laterals, which occur on each side of the front of the visceral area. The middle and outside laterals of the dorsal valve are blended and lie obliquely outward, before the transmedian scars. The transmedian scars are close to the base of the area in both valves, and lie in the line of the prolongation of the flexure line of the area. In number and relative position the muscle scars of Obolella are essentially the same as those of Obolus.

Observations.—The genus Obolella has been under discussion by authors for nearly forty years. In the original description Mr. Billings noted its resemblance to Obolus, but claimed that it is distinct on account of the difference in "the arrangement of the muscular impressions." Later (1876) he compared it again with Obolus, but having poor illustrations of both Obolus and Obolella he failed to discover the true position and relations of the muscle scars in either. It was not until after Mickwitz's memoir on Obolus appeared, and the collections of Obolella made during the summer of 1899 were studied, that any correct comparisons could be made. It then became evident that there is practically no difference in the arrangement of the muscle scars of the two genera, but that there are most essential differences in the areas of the ventral valve. Before working out the relations of the narrow pedicle slit of Obolella to the cylindro-conical pedicle chamber, I was at a loss to find generic differences of value, although I felt that the area of the dorsal valve of Obolella indicated differences not readily explained.

The pedicle passage of Obolus varies greatly in size and form, but it is always an open furrow. In Obolella it is in the ventral valve a cylindro-conical inner chamber opening through a narrow slit in the area of the ventral valve, the area rising from the plane of the margin of the valve; in the ventral valve a slightly raised area occupies the place of the broad furrow in Obolus.

Obolella is confined to the Olenellus or Lower Cambrian fauna. Obolus, as now limited, appears in the Middle Cambrian, but has its greatest development in the Upper Cambrian fauna. Of the subgenera *Obolus* (*Lingulella*) *schucherti* is found associated with Obolus (*O. crassa*) at Troy, New York.

Bicia gemma is associated with *Obolella crassa* both at Bic and Troy,

and the species was referred to Obolella by Mr. Billings. It differs so radically from Obolella in the character of the areas of the valves and the interior markings that it is scarcely necessary to institute comparisons between them.

Obolella as known at present is limited to six species and one variety:

Obolella chromatica Billings.
Obolella atlantica Walcott.
Obolella crassa Hall.
Obolella crassa var. *elongata* Walcott.
Obolella farosa Linnarsson.
Obolella lindströmi Walcott.
Obolella mobergi Walcott.

Of the above two species *O. chromatica* and *O. atlantica* belong to the upper portion of the Olenellus fauna, and *O. crassa* and var. *elongata* to the lower portion. The three Swedish species *O. farosa*, *O. lindströmi*, and *O. mobergi* are from the basal Cambrian sandstones and may belong to the same horizon as *O. crassa*.

The species that have heretofore been referred to Obolella, in addition to those listed above, are now distributed in the following genera:

O. ? ambigua	Walcott	=Elkania.
O. cingulata	Billings	=Kutorgina.
O. circe	Billings	=Billingsella.
O. coelata	Billings	=Acrothele.
O. desquamata	Billings	=Obolella crassa.
O. desiderata	Billings	=Elkania.
O. discoidea	Hall and Whitfield	=Obolus (Lingulella).
O. gemma	Billings	=Bicia.
O. gemmula	Matthew	=Obolus (Lingulella).
O. ida	Billings	=(?)
O. minuta	Hall and Whitfield	=Acrotreta.
O. misera	Billings	=Linnarssonia.
O. nana	Meek and Hayden	=Dicellomus.
O. nitida	Ford	=Linnarssonia (?).
O. pectenoides	Whitfield	=Dicellomus.
O. polita	Hall	=Dicellomus.
O. pretiosa	Billings	=Linnarssonia.
O. prima	Whitfield	=Obolus (Lingulepis).
O. transversa	Hartt	=Linnarssonia.

OBOLELLA MOBERGI, new species.

General form ovate, with the ventral valve subacuminate and the dorsal valve obtusely subacuminate; valves moderately convex. Beak of the ventral valve slightly elevated above the plane of the shell; beak of the dorsal valve curved down to the plane of the margin. Surface of the shell marked by concentric lines and striæ of growth, and in some examples by rather strong, radiating, broken, and slightly irregular raised lines. The elevated lines are of the same character as those on *Bicia gemma*. The shell is formed of a thin outer layer and numerous inner layers or lamellæ, the latter over the anterior half of

the shell. These inner lamellæ are oblique to the outer layer and are arranged as imbricating layers, very much as in *O. farosa*.

A ventral valve 10 mm. in length has a width of 9 mm. A dorsal valve 9 mm. long has the same width.

The area of the ventral valve is of medium length and tipped back of the edge of the valve to meet the beak. It extends well out on to the cardinal slopes of the valve. It is divided midway by a narrow pedicle furrow that passes inward into a large cylindrical chamber, closed at its outer end. The surface of the area is marked by rather strong transverse striæ crossing the area and extending in and around the pedicle slit and chamber. On each side of the pedicle chamber there is a rather strong undercut which in the cast is replaced by a marked tooth-like projection. The area of the dorsal valve is narrow and, as far as can be determined from the single cast, very much like that of *O. crassa*.

The casts of the interior of the ventral valves show a central visceral area, very much like that in *O. crassa;* also two strongly marked vascular sinuses that extend well into the middle of the valve. No clearly defined muscle scars are shown on any of the specimens. Casts of the interior of the dorsal valve give little satisfactory data in relation to the muscle scars. The cast shows a part of the outline of the visceral area, also the impression of the transmedian muscle scar.

Observations.—This species appears to be the European representative of *O. crassa*, which occurs at the same relative stratigraphic horizon at Troy, New York. The Swedish species differs from the American in being slightly more elongate in outline and in having the interior thickenings of the area more strongly developed. The exterior surface also appears to be marked by stronger radiating lines. It differs from *O. atlantica* and *O. chromatica* in being a much more robust shell, and in many slight details. *O. pristinus* is more rotund and convex.

O. mobergi is associated with the Olenellus fauna in Sweden in the *Schmidtia tordli* zone.

Formation and locality.—Lower Cambrian. Zone of *Schmidtia tordli*, Bjorkelunda, south of Simrishamr, in a gray sandstone. Sularp, near Lund, Sweden, in a brown sandstone.

Received from Dr. Joh. Chr. Moberg.

OBOLELLA LINDSTRÖMI, new species.

This species differs from *Obolella mobergi* in the more subacuminate outline of the valves, the surface characters, and the interior of the dorsal valve. The surface of *O. lindströmi* is much like that of *Bicia gemma*.

The ventral valve occurs in a hard gray sandstone of the *Schmidtia tordli* zone, and the cast of the dorsal valve is from one of the brown

sandstone spots that occur within the gray sandstone at Sularp. I am not sure that the dorsal valve illustrated actually belongs to this species, as it is not associated with the typical ventral valve.

It differs from the typical dorsal valves of *O. moberyi* in being more acuminate, and there is no corresponding ventral valve associated with it in the material studied.

I take pleasure in naming the species in honor of Dr. G. Lindström, to whom all paleontologists are deeply indebted for his many contributions to the paleontology of the Silurian formations of Scandinavia.

Formation and locality.—Lower Cambrian. Zone of *Schmidtia torelli*, Bjorkelunda, south of Simrishamn, in a gray sandstone. Sularp, near Lund, Sweden, in a brown sandstone.

GLYPTIAS, new subgenus.

The subgenus Glyptias is based on the peculiar surface sculpture and the very short area.

Type.—*Obolella* (*Glyptias*) *favosa* Linnarsson.

OBOLELLA (GLYPTIAS) FAVOSA Linnarsson.

Lingula (?) *favosa* Linnarsson, Öfversigt af Kongl. Vetenskaps-Akad. Forhandlingar, No. 3. Om nagra försteningar fran Vestergötlands sandstenslager, p. 356, 1869. Also the English translation, published as a pamphlet, p. 16. Stockholm, 1869.

General form ovate, with the ventral valve subacuminate and the dorsal valve obtusely rounded; valves moderately convex. The dorsal valve is abruptly curved downward at the beak to the plane of the edge of the shell, while the beak of the ventral valve is slightly above the margin, the posterior edges of the shell curving up to meet it, and thus forming a passage for the pedicle out of a narrow pedicle slit. Surface of the shell marked by very fine concentric lines or striæ of growth, crossed transversely by undulating, slightly lamellose lines in almost identically the same manner as in *Obolus* (*Westonia*) *stonecanus* of the Upper Cambrian of Wisconsin. When the outer surface of the shell is exfoliated or worn off by attrition, which is the usual condition, the surface of the inner layers shows fine, radiating, and concentric striæ. The shell is formed of a very thin, highly ornamented outer layer and numerous inner layers or lamellæ; the latter over the anterior portions are oblique to the outer layer, and when the shell is partially exfoliated they appear as imbricating layers, very much as in *Obolus matinalis*.

The largest ventral valve in the collection has a length of 7 mm. and a width of 6 mm. An associated dorsal valve 6 mm. long has a width of 6.25 mm.

The area of the ventral valve is narrow and rises slightly to meet the beak, which is elevated above the posterior margin. The pedicle

furrow or slit is short and narrow, and, judging from the appearance of the specimens, where the beak of the valve is broken away it opened into a pedicle chamber that was closed at the outer end as in *Obolella crassa* and other species of the genus. On the dorsal valve there is no evidence of a true area except in the presence of a narrow, thickened rim somewhat like that of the dorsal valve of *Bicia gemma*. None of the muscle scars are shown in the ventral valve. The position of the central and anterior lateral scars of the dorsal valve is indicated by the outline of the visceral cavity. Of the vascular markings the main sinuses are clearly shown in each valve, also the outline of the position of the parietal scar.

Observations.—This beautiful little shell has remained without illustration since Dr. Linnarsson gave it a name in 1869, based on the "singular sculpture" of the outer shell. In a collection made for me by M. Schmalensee, the collector of the Swedish Geological Survey, there were several specimens showing casts of the interior more or less imperfectly. From these I was able to ascertain that the shell had the generic characters of Obolella, although differing from the typical species of that genus in the character of the surface ornamentation. The outer surface has been seen only on the posterior umbonal portion of the valves in the shells collected for me by M. Schmalensee.

Formation and locality.—Lower Cambrian. Fucoid sandstone. Vestergotland, Bithingen, Sweden.

Genus BICIA, new genus.

Shell subequivalve, moderately convex; longitudinally ovate, with the ventral valve sometimes subacuminate and the dorsal valve subcircular. Beaks of both valves as now known terminate at the posterior margin. Surface marked by concentric and radiating striæ.

Shell substance unknown in an unaltered condition. Shell structure formed of a thin surface layer and numerous inner layers or lamellæ more or less oblique to the outer layer. Area of the ventral valve usually on the plane of the edges of the valve, but in some instances rising at a low angle; it is usually high, and triangular in outline, but the apex may be rounded and the base curved forward at the median line; divided midway by a narrow pedicle furrow and again at each side by a narrow flexure line that extends forward and outward from the apex. Area of dorsal valve short, appearing in both of the known species to rise from the plane of the edges of the valve. Striæ of growth subparallel to the base cross the areas.

The main vascular sinuses of the ventral valve are narrow and extend forward from the projecting center of the base of the area, gradually separating as they cross the visceral area and extending forward beyond the transverse center of the shell; in the dorsal valve they appear to separate more rapidly and to follow the outer margin

of the ventral cavity except in the second species. A narrow median septum is indicated in the dorsal valve on the crest of a strong median ridge.

One of the striking features in both of the known species of this genus is the oblong oval boss that is present in the ventral valve of most adult shells. It is situated on each side of the forward projecting central portion of the area, with the larger axis extending forward and outward when the shell is subacuminate or transversely when the shell is broadly rounded. In the dorsal valve of *B. gemma* it is not so well defined as in *B. whitneavesi*. The boss is bounded by the margin of the base of the area, the narrow elongate sulcus containing the marginal muscle scars and the base of the main vascular sinuses. In *B. whitneavesi* it reached its greatest development in both valves, resembling in position and surface characters the posterior adductor scars of the Craniidæ. Somewhat similar bosses occur in the ventral valve of *Obolella crassa* and *Obolus apollinis*, but they are not developed to the extent they are in Bicia. They appear to occur only in those thick shells that have deposits of shell substance over the visceral area.

The outline of the parietal scar in the ventral valve incloses a heart-shaped visceral area in the ventral valve, closely circumscribing the muscle scars. Its general course in the dorsal valve is suggested by the position of the muscle scars.

Five pairs of muscle scars have been observed. The rather large central scars in the dorsal valve are placed close to the broad median ridge, a little back of the center; the small anterior laterals are slightly in advance of the centrals on the median ridge, close to the median line; the transmedian scars are almost under the edge of the area and near the outer margin; the outside and middle laterals are slightly in advance and further out than the transmedian scars; the centrals, middle laterals, and outside laterals of the ventral valve are grouped in the narrow space on each side of the U-shaped forward projecting portion of the visceral area. Traces of individual scars have been seen, but they can not be separated so as to identify them. The transmedian and anterior lateral scars are close to the outer margin of the valve and just in advance of the oblong boss in front and each side of the forward-projecting base of the area. Umbonal and pedicle scars unknown except what may possibly be a small umbonal scar in the dorsal valve of *B. whitneavesi*.

Type.—*Obolella gemma* Billings; second species, *Bicia whitneavesi* Walcott.

Observations.—Bicia is a form that combines many of the characteristics of Obolella and Obolus. It resembles Obolella in the arrangement of the muscle scars and main vascular sinuses of the interior of the valves. It differs in having a high area with an open pedicle groove

in the ventral valve and an elevated ridge or boss in the back portion of the dorsal valve that in one species, *B. whitfieldi*, appear to have been the base of attachment of some portion of the muscular system. The ensemble of the dorsal valve of Bicia is unlike that of either Obolella or Obolus. Bicia, with its thick shell, high area, deep central cavity (heart-shaped cavity of Mickwitz), arrangement of visceral cavity, muscle scars, and vascular markings in the ventral valve, is a true Obolus of the *O. apollinis* type, but in its more elongate outline, strongly striated surface, and in nearly all details of the dorsal valve it is quite distinct.

Of the two species now referred to, the genus *B. gemma* has an unusually thick shell and a very marked deposit of shell substance over the visceral area in the ventral valve, the posterior portion of the same area in the dorsal valve, and along its median line. In the second species there is a considerable deposit over the same area with the exception of the median line, where the strong median ridge is absent.

BICIA GEMMA Billings sp.

Obolella gemma Billings, Can. Nat., 1872, new ser., VI, p. 218, fig. 5, p. 217.
Obolella gemma Walcott, Bull. U. S. Geol. Sur., No. 30, 1886, p. 116, pl. x, figs. 2, 2a–e; Tenth Annual Report U. S. Geol. Sur., 1881, p. 612, pl. lxxi, figs. 5, 5a–c; pl. lxxii, figs. 2, 2a.
Obolella gemma Hall and Clarke, Pal. N. Y., 1892, VIII, Pt. I, pl. h, figs. 42–44.

General form ovate, with ventral valve subacuminate when the beak is extended or obtusely acuminate when the beak is rounded; dorsal valve oval to subcircular in outline. The convexity of the valves is fairly strong and nearly the same in each where they are embedded in the same matrix.

Surface of shell marked by numerous slightly irregular concentric striæ and lines of growth; by fine radiating striæ between stronger radiating lines, and on some shells by undulations of strongly developed, elevated, radiating striæ; the radiating striæ are often slightly irregular and interrupted. When the outer surface is partially worn away it is smooth, or the shell has a peculiar surface formed by traces of the radiating undulations and striæ. The concentric striæ and lines of growth are shown on the outer surface of the inner layers of the shell and on the interior surface, where rather strong radiating striæ are often beautifully shown.

The shell is usually thick and strong for one so small; those from St. Simon and Troy appear to be calcareous and formed of one solid layer. This is probably owing to their condition of preservation, as in a weathered specimen lamellæ oblique to the outer surface are clearly shown, and indications of lamellæ on the central and posterior portions that point to the same shell structure as in Obolus and Obolella.

The ventral valves average about 5 mm. in length; the largest is

7 mm. Width, average, 4 mm.; largest, 5 mm. The dorsal valve is about one-fifth shorter than the ventral.

The area of the ventral valve is usually on the plane of the margins of the valve, but many specimens show it rising at angles varying from 1° to 10°. It is high and narrow, somewhat as in *Obolus* (*Lingulella*) *acuminatus* Mickwitz, and divided midway by a strong, rounded, narrow pedicle furrow; the striæ of growth are rather coarse and arch forward at the center and across the pedicle furrow, following the contour of the base of the area; the position of the flexure line is sometimes clearly shown by a narrow depression. The area of the dorsal valve is short and easily escapes observation except in well-preserved shells. It sometimes has a slight central pedicle depression, and often is only a short, almost smooth surface extending well out on the cardinal slopes of the valve.

The muscle scars, as far as determined, are arranged as in Obolus. The umbonal and pedicle scars have not been observed. The elongate oval central scars are rather large in the dorsal valve, and situated on each side of the strong median ridge about the middle of the valve; in the ventral valve they are crowded in with the scars of the middle and outside laterals; the anterior laterals are barely discernible in one specimen of the dorsal valve as small oval dots on the central ridge a short distance in advance of the centrals. In the ventral valve they are close to the base of the area and near the outer edge of the shell. The middle and outside laterals in the ventral valve are situated in the trapezoidal area, but do not appear to be separable on the specimens in the collection. In the dorsal valve they are well shown in advance of the transmedian scar. The latter in the ventral valve is merged with the anterior lateral.

Of the vascular markings the main sinuses of the ventral valve are about all that are clearly shown, although the position of the parietal scar is indicated in advance of the center of the shell. One of the most strongly marked characters of the dorsal valve is the median ridge; it varies in strength and outline in different shells, but is usually a prominent feature; it extends to the frontal margin in most shells, but in some it narrows and is less prominent anteriorly. A few specimens show a slight depression crossing it just in front of the central scars, and one has two minute anterior lateral muscle scars directly on the ridge, the parietal scar passing across just in front of them. The thickened shell beneath the visceral cavity of the ventral valve is present in nearly all adult shells; it varies greatly in size, form, and thickness; in some valves it covers the entire area within the parietal scar, and in others only a portion. The thickening in the dorsal valve is along the posterior border of the central cavity; this is best shown in the cast; the median ridge is also frequently more or less enlarged.

Formation and localities.—Lower Cambrian. Limestone conglomerates at Bic and St. Simon, on the St. Lawrence River, Province of Quebec, Canada. Also in Lower Cambrian limestones, both bedded and conglomerate, on the ridge east of Troy, New York, and 1 mile south of Schodack Landing, Rensselaer County, New York.

BICIA WHITEAVESI, new species.

This species is associated with *B. gemma* in a bedded limestone at Troy, New York. It differs from the latter in the dorsal valve by the absence of the median ridge, the presence of a broad area, and the presence in the interior of both valves of two large, circular, scar-like spots, one on each side of the median line and just in front of the area, that recall in appearance and position the posterior adductor scars of Crania. The ventral valve is so much like that of *B. gemma* that it is difficult to decide whether some shells should not be referred to *B. gemma*. There is a gradual transition, in form and character of the interior of the ventral valve, between the extremes represented in *B. gemma* and the extreme form of *B. whiteavesi*. If it had not been for the bosses of the dorsal valve associated with it I should have hesitated to refer it to a distinct species.

Formation and locality.—Lower Cambrian. Bedded limestone in siliceous shale on ridge in the eastern suburbs of Troy, New York.

OBOLUS, Additional notes on.

Observations.—Dr. Mickwitz[1] has given, in his exhaustive memoir on Obolus, a very complete historical sketch and full description of the genus and its subgenera so far as known to him. The material was so well preserved, and the study was conducted with such care and thoroughness, that our present knowledge of the adult shell of Obolus is as complete as that of the adult shell of the recent Lingula. In this note I shall present only such details as are essential to an understanding of the relations of (1) Obolus to Lingula; (2) Obolus to Obolella; (3) Obolus to its subgenera.

The student is referred to the memoir of Mickwitz for the literature, history, a geological sketch of the Cambrian formations of the eastern Baltic region of Russia, a minute description of the external and internal characters of the shells of Obolus, an exposition of the relations of Obolus to Lingula and Obolella, and detailed observations on Obolus and its subgenera as known to him.

Obolus and Lingula.—After studying the species from American rocks and a very good series from the typical localities in Russia, I am prepared to agree with Mickwitz that Obolus should be referred

[1] Über die Brachiopodengattung Obolus Eichwald: Mém. Acad. Imp. Sci. St. Pétersbourg, 8th ser., IV, No. 2.

to the Lingulidæ, and that there is no good reason for establishing the family Obolidæ.

Their points of similarity as described by Mickwitz are:

1. The chemical constitution and microscopic structure are the same.

2. The position of the umbonal muscle is the same in the dorsal valve.

3. The arrangement of the vessels of the circulatory system is the same in the two genera. Mickwitz says of this:[1]

Issuing between the same muscle scars from the splanchnocœle, two main vessels extend in each valve into the fore part of the mantle lobes and branch inward and outward into numerous secondary vessels. The only difference in the arrangement of the vessels consists in this, that in Lingula the main vessels of the two valves empty into the peripheral canal, while in Obolus this takes place only in the large valve. In the small valve the main vessels, shortly before reaching the peripheral canals, bend into the interior of the valves and end at the scars of the anterior lateral muscles.

4. The general arrangement of the muscle scars is essentially the same, the points of difference being of a generic character.[1]

Their points of difference, according to Mickwitz, are:

1. In the area of the valves.

2. In Lingula the pedicle muscle is attached back of the scar of the umbonal muscle of the ventral valve, while in Obolus it is situated between the divided scar of the umbonal muscle of the ventral valve.

3. Quoting from Mickwitz:

Besides the somewhat unlike arrangement of some scars, to which we shall presently return, the bipartition of certain muscles constitutes the most characteristic difference in the internal organization of the two genera. The umbonal muscle of Obolus, which is divided on the side of the large valve, while conversely the two transmedial muscles of Lingula, one of which is divided throughout its length, are represented in Obolus by a pair of undivided muscles.

The position of the umbonal muscle is the same in the two genera; at most it is somewhat crowded away from the base of the area in Lingula, because of the pedicle muscle. On the contrary, the transmedial muscles, besides their bipartition, present other differences. In Obolus the scars of that part of muscles on the large valve are combined with those of the anterior lateral muscles, while in the corresponding shell of Lingula, though lying in a similar position, they are separated from the anterior lateral muscles. With the small valves the case is reversed. Obolus shows the scars of the pair of muscles in question isolated, while in Lingula they are united with those of the middle and outside lateral muscles.

The scars of the two last-named muscles on the small valve of Obolus are combined in a manner analogous to those of Lingula, so that the whole difference in the arrangement of the scars in question (aside from the bipartition of one transmedial muscle in Lingula) consists in the reversal of their combination. In Obolus, on the large valve, the scars *i* and *j* are united, in Lingula they are separated; in Lingula, on the small valve, *i* and *k*, *l*, are united, while in Obolus they are separated.

The scars of the anterior lateral muscles of the small valve have a closely similar position in the two genera, except that in Obolus they are moved farther forward, and are separated by the median ridge, while in Lingula they are nearer to the center of the valve and are united.

[1] Über die Brachiopodengattung Obolus Eichwald, p. 121.

The other scars of the lateral muscles on the large valve of Obolus also are quite analogous in their position to the corresponding scars in Lingula. True, in their case, also small displacements and changes of form occur, but yet I am unable to attach to these any special value. The two genera show the scars of the outside lateral muscles combined with those of the central muscles, but we have seen that in some species of Eichwald's genus (*O. triangularis*, *O. pandori*, and some species of the subgenus Schmidtia), the first-named scars separate from those of the central muscles and change their subtriangular form, drawn out backward, into a rounded form, more like that in Lingula. The scars of the middle lateral muscles of the large valve, on the contrary, are only in Eichwald's genus combined with those of the central muscles, while in Lingula they are separated. It is probable, however, that some species of the above-named subgenus share this peculiarity with Lingula.

Finally, the scars of the central muscles of the two genera differ merely by their somewhat different form in the large valve, and by their somewhat different position with relation to the axis of symmetry on the small valve. It was pointed out, however, in speaking of the central muscles of Obolus, that the backward-protracted points of the subtrapezoidal scars in the large valve of the typical species (as well as those of the outside lateral muscles) are lacking in the species of the subgenus Schmidtia, so that even in regard to form there is an agreement with Lingula. In the small valve of Obolus the elliptic scars of the central muscles are parallel to the major axis of the valve or somewhat converging behind, while in Lingula they are strongly convergent anteriorly.

To the altered position of the muscle scars in Obolus corresponds the modified form of the parietal band. The latter in both valves of Lingula is rhombic, but in the smaller valve it is drawn farther forward than in the larger. In Obolus the parietal band on the small valve extends still farther toward the frontal edge than in Lingula, and in its posterior part is more markedly bent inward from both sides, producing a characteristic unequally three-lobed figure. The parietal band of the large valve of Obolus, on the contrary, is subelliptic in form, and rather approaches that of Lingula.

More important than this difference in form of the splanchnocœle is the difference in the form of the mantle lobes, which is manifest from the position of the posterior part of the parietal band. In Lingula the parietal band is moved away from the base of the area, and thus constitutes a narrow space between the two pleurocœles, which space is occupied by the mantle lobes that extend around the entire beak part of the valves. These mantle lobes of the beak are in the small valve also covered with mantle bristles, while the border of the mantle of the large valve, in the splanchnocœle part of the area (deltidium King) is free from bristles. In Obolus, on the contrary, the posterior part of the parietal band is close to the base of the splanchnocœle part of the area, whose lamellæ, as we have seen, are bent up at right angles to the plane of the valve, and therefore could not have been deposited by mantle lobes resting against the valves. Hence the mantle lobes of Obolus extended only as far as the pleurocœles, and were lacking, as well as the mantle bristles, in the splanchnocœle part of the area of both valves. At that point there was only the muscular wall of the body connecting the two valves, from which the pedicle emerged.[1]

Obolus and Obolella.—Authors have compared Obolella with Obolus, and Mickwitz thought that they might possibly be congeneric.[2] The narrow pedicle slit in the area of the ventral valve of Obolella opening into a cylindro-conical chamber is so unlike the pedicle furrow of Obolus that a distinct generic reference is necessitated by its

[1] Über die Brachiopodengattung Obolus Eichwald, pp. 118–121. [2] Idem, p. 129.

discovery, despite the great similarity of the two genera in other respects. Except for the pedicle slit and chamber, the species of Obolella could not well be taken from Obolus.

OBOLUS AND ITS SUBGENERA.

Lingulella Salter. I have been at times almost doubtful of the advisability of characterizing Lingulella even as a subgenus of Obolus. This distinction is now based on the more elongate form of most of the species of Lingulella and the greater thickness of the shell of the typical forms of Obolus.

Type.—*Obolus* (*Lingulella*) *davisii*.

Lingulepis Hall is an elongate, acuminate form of Lingulella, thus departing most widely in form from Obolus.

Type.—*Obolus* (*Lingulepis*) *acuminatus*.

Lingulobolus Matthew is a Lingulella-like form, with a very thick shell.

Type.—*Obolus* (*Lingulobolus*) *affinis*.

Schmidtia Volborth is a Lingulella-like shell without radial striation. All the species are small, and as the concentric striæ are very fine the shell surface is nearly smooth.

Type.—*Obolus* (*Schmidtia*) *celatus*.

Westonia Walcott is a Lingulella-like form distinguished by peculiar, transverse, semiimbricating, "ripple-embossed" lines that cross both the concentric and radiating striæ.

Type.—*Obolus* (*Westonia*) *aurora*.

Thysanotos Mickwitz. An Obolus with strong, uniformly curved concentric striæ, with lamellæ of growth fringed along their anterior (external) edges.

Type.—*Obolus* (*Thysanotus*) *siluricus* Eichwald.

Acritis Volborth. Concentric lines elevated, irregular, undulating. Valves strongly arched, massive. Visceral area (splanchnocœle) small and short; pedicle furrow conical and deeply impressed in area.

Type.—*Obolus* (*Acritis*) *antiquissimus* Eichwald.

Leptembolon Mickwitz. This subgenus is rather difficult to characterize. Mickwitz says of it:

> The subgenus Leptembolon is based on a species of Obolus which externally resembles Lingula very closely, and in fact was by earlier authors[1] regarded as such. The specimens of the internal surfaces of the valves, however, showed, together with some suggestions of the last-mentioned genus (Lingula), unmistakable marks of the genus Obolus, so that the species, which could not be assigned to any of the other groups, had to be ranked in a special subgenus of Eichwald's genus."[2]

Type.—*Obolus* (*Leptembolon*) *lingulaformis* Mickwitz.

[1] Schmidt, Fr., Revision der silurischen ostbaltischen Trilobiten, Pt. I, p. 17.

[2] Über die Brachiopodengattung Obolus Eichwald, p. 199.

OBOLUS (?) MENEGHINI, new species.

Lingula petalon BORNEMANN, Nova Acta der Kais. Leop.-Carol. Deutsch. Acad. Naturf., LVI, p. 438, pl. XIX, figs. 12–14. 1891.

Obolella (?) sp. BORNEMANN, Nova Acta der Kais. Leop.-Carol. Deutsch. Acad. Naturf., LVI, p. 440, pl. XIX, fig. 18.

Rounded triangular frontal margin at times almost straight. Shells rather flat, their arching being greatest in the middle. Concentric and rather coarse lines of growth. Size, 5–11 mm.

Occurrence: In yellow, friable sandstone of Punta Pintau (Canalgrande) and of Gruguetta, Sardinia.

The specimen referred to Obolella (?) sp. is from the slate of Porto Canalgrande. It is not an Obolella, and may be identical with the species from the sandstones.

The shells referred to *Lingula petalon* suggest Obolus in form and surface ornamentation and are tentatively referred to that genus.

OBOLUS TETONENSIS, new species.

The general form, convexity, and appearance of this species is so much like that of *Obolus matinalis* that a full description is unnecessary. It varies from that species in the shorter, more transverse dorsal valve, and the narrower outline of the ventral valve toward the beak.

This species occurs in great abundance in the thin bedded limestone in the upper portion of the Cambrian section of the Teton Range, Wyoming, in association with *Billingsella pepina* and *Obolus* (*Lingulepis*) *acuminatus* var. *meeki*. What appears to be the same species occurs nearly 700 feet lower in the section in a thin bedded sandstone. The dorsal valve is broader and more transverse posteriorly than the dorsal valve from the upper horizon.

Formation and locality.—Middle Cambrian, on the divide at the head of Sheep Creek, near north end of the Teton Range, Wyoming. Thin bedded limestones, Belt Park, 6 miles out from Neihart, Montana. Three miles southeast of Malad City, Idaho. A smaller form collected by Dr. A. C. Peale in Bostwick Canyon, Bridger Range, Montana, may belong to this species. It occurs in a fine-grained sandstone low down in the Paleozoic section.

OBOLUS (?) ZOPPI, new species.

Obolella crassa BORNEMANN, Nova Acta der Kais. Leop.-Carol. Deutsch. Acad. Naturf., 1891, LVI, p. 439, pl. XIX, figs. 15–17.

Broadly oval or circular, with somewhat pointed vertex. Shells strongly arched, one somewhat more than the other. They are marked with prominent concentric lines; no radial striation is noticed. Found in a red-yellow sandstone layer not far from the houses of Canalgrande, Sardinia, on the road to Punta Pintau.

In view of the imperfect state of preservation, a determination can be based only on the outer form, whose habit agrees with the American species from the Cambrian limestone of Troy.

Dr. Bornemann kindly sent me two specimens of this form. They suggest *Obolella crassa* in form and outline, but the material is too imperfect to enable me to identify the species or genus. I find in one specimen indications of the presence of a high area that rises slightly above the plane of the ventral valve. In two there is nothing to suggest the foramen, which is usually well preserved in the ventral valve of species of *Obolella atlantica*. As the material is probably from the Middle Cambrian, a provisional reference is made to Obolus.

Subgenus LINGULELLA.

OBOLUS (LINGULELLA) BELLUS Walcott.

Obolus (Lingulella) bellus Walcott, Proc. U. S. Nat. Museum, 1898, XXI, p. 397.
Lingulella concinna Matthew, Bull. Nat. Hist. Soc., New Brunswick, 1900, IV, p. 273, pl. v, figs. 2a–b.
Lingula? lens Matthew, Bull. Nat. Hist. Soc., New Brunswick, 1900, p. 274, pl. v, figs. 3a–b.

General form ovate, with ventral valve obtusely acuminate; dorsal valve broad ovate; valves moderately convex, so far as can be determined from the somewhat compressed specimens as they occur in the sandy shales.

Surface of shell bearing numerous concentric lines of growth, with exceedingly fine, slightly irregular striæ on the interspaces between the stronger concentric lines that form a surface somewhat like that of *O. (L.) ella*. Owing to the roughened surface formed by the fine striæ, the outer layer of the shell adheres to the arenaceous matrix, leaving the shiny inner layer on the shell. This is marked by concentric and numerous fine radiating striæ.

The shell is apparently thin, and is formed of a very thin outer layer, with one or more thin inner layers or lamellæ. The casts of the interior surface of the ventral valves show numerous papillæ arranged in concentric lines on the posterior half of the shell. These correspond to the punctæ of the inner surface.

A large ventral valve has a length of 15 mm.; width 9 mm.; and a dorsal valve 13 mm. in length has a width of 10 mm. The specimens in the collection average from 2 to 3 mm. smaller than those measured.

The cast of the area of the ventral valve shows that it was rather long and extended well out on to the cardinal slope; it is divided midway by a strong pedicle furrow, and toward the lateral margin by a narrow flexure line. The area is marked by fine striæ of growth parallel to the margin. The area of the dorsal valve is rather short, but it extends laterally well out on the cardinal slopes. The shallow

curve corresponding to the pedicle groove of the larger valve is wide and clearly defined.

The casts of the interior of the valves show almost no traces of the vascular markings or muscle scars. Only the anterior lateral muscle scars have been observed in the ventral valve.

Observations.—This fine species occurs in great abundance in the upper beds of Little Bell Island, associated with *O.* (*L.*) *bellulus*, and also in the higher beds on Great Bell Island, a little below the layers carrying *Lingulobolus affinis* and *L. spissus*. Although found at some little distance above the horizon in which I collected a species of *Olenus*, I refer the horizon to the Upper Cambrian.

This species appears to be clearly distinct from any yet described. It may be compared with *O.* (*L.*) *davisi* in relation to its size and outline, but not in other respects. *O.* (*L.*) *lepis* ranges from the Lingula flags into the Tremadoc.

This is one of the most abundant forms in the shales and interbedded sandy layers of Cape Breton Island. Mr. Matthew described a compressed dorsal valve occurring in shale as *Lingulella concinna*, and some fragmentary shells occurring in limestone as *Lingula ? lens*. With his two types before me in comparison with a large series collected by Mr. S. Ward Loper at the same or near-by localities, I find that the two species merge into one and that they are identical with *O.* (*L.*) *bellus* as it occurs in Newfoundland.

The diagrammatic figures of *O.* (*L.*) *lens* as given by Mr. Matthew are misleading. The material from which his description was written and figures drawn is badly crushed and broken, the fragments of shells being embedded together in the limestone. None of the specimens show the apex of the ventral valve. The one used in illustration by Mr. Matthew has the apex broken away, and the shell is somewhat compressed laterally. The diagrammatic drawing of the dorsal valve is also inaccurate. His illustrations of the outer surface appear to be based on specimens from which the true outer surface has been exfoliated.

Among the collections made by Mr. Loper there are a large number of shells crushed and crowded together, very much as is the typical material used by Mr. Matthew. There are, however, in the accompanying shales large numbers of individual specimens that are beautifully preserved, which illustrate the outline and convexity of the shell. The series illustrates the growth of the shell, also the various forms in which it occurs owing to differences in the sediment in which it has been embedded. The material collected by Mr. Loper came from several horizons of the Upper Cambrian. Mr. Matthew assigns *Lingulella concinna* to the Dictyonema zone and *Lingula lens* to the Parabolena zone of the Cape Breton section.

Formation and locality.—Upper Cambrian. Arenaceous shales of

the upper beds on Little Belle Island and Great Belle Island, Conception Bay, Newfoundland.

Several localities on McNeils Brook, 1 mile east of Marion Bridge, especially about the mill pond. 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) BORNEMANNI, new species.

Lingula attenuata BORNEMANN, Nova Acta der Kais. Leop.-Carol. Deutsch. Acad. Naturf., 1891, LVI, p. 437, pl. XIX, figs. 1–10.

Form an oblong oval, sharply pointed toward the beak, marked with concentric, fine stripes, mostly regular, often also with large irregular concentric folds. Faint radial or longitudinal striation usually appears distinctly on the middle of the surface. At the vertex there is mostly a distinct straight longitudinal impression.

Shape greatly variable, often unsymmetric; short-rounded-triangular or almost circular, or narrower and elongated; more or less arched, or even flat. The long-extended specimens resemble *L. acuminata* Conrad. Others agree perfectly with Murchison's original figures. Others, again, may be compared with *L. davisii*, and were at first placed with that species. The simultaneous occurrence in enormous multitudes and the numerous transition stages leave no doubt that all those forms belong to one species, and the middle type of them fits best to *L. attenuata* Sowerby. Size, 2 to 9 mm.

Occurrence.—Very common in the Cambrian strata of Canalgrande, in yellowish-brown slates not far from the buildings of Canalgrande, in white-gray quartz sandstone in the valley of Gutturu Sartu, in yellow sandstones with Archæocyathus of Punta Pintau and elsewhere in Sardinia.

The state of preservation is best in the slates, yet there the specimens are mostly pressed flat. The specimens, existing in great numbers in the sandstones, often still exhibit their original arching, but the delicate shells are ordinarily distorted in an irregular manner and ill preserved.

The above notes are taken from a rather literal translation of the original description.

Dr. Bornemann identified this species with *Lingula attenuata* Sowerby, on account of the resemblance in outline of many of the specimens. Other specimens closely resemble *O. (L.) acuminatus* Conrad, from the Middle and Upper Cambrian of North America. It is so improbable that a species of this character should persist from Middle Cambrian time to Middle Ordovician time that, notwithstanding the resemblance, I think it is better to distinguish it from *L. attenuata* Sowerby, and give a specific name that will not lead to erroneous

stratigraphic correlations. The Cambrian fauna of Sardinia is so distinct from that of other localities and the stratigraphic succession of the subfauna is so confused I think it unwise to identify its species with described species unless the material is so full and well preserved that there can be no doubt of their specific identity.

OBOLUS (LINGULELLA?) BICENSIS, new species.

Shell small, general form of ventral valve broad ovate, with the greatest width at the anterior third, from which there is a slightly curved, quite uniform slope to the beak. Moderately convex. Length of the one specimen known, 3 mm. Surface marked by fine, concentric striæ and very slight undulations of growth; also fine radiating striæ. The shell appears to have been thin, and formed of several very thin lamellæ, and marked on the interior by fine punctæ.

Observations.—This small species is known only by one specimen and its matrix that I found in a limestone bowlder of the conglomerate at Bic. It is associated with fragments of Olenellus and Agraulos. In form the ventral valve recalls *Dicellomus politus*. It is probable that if a number of specimens were obtained it would not be found to differ from typical forms of Obolus and its subgenus Lingulella.

Formation and locality.—Bowlder containing Lower Cambrian fossils, Bic conglomerate, eastern point of Bic Harbor, Province of Quebec, Canada.

OBOLUS (LINGULELLA) LINNARSSONI, new species.

Ventral valve elongate oval, subacuminate. Surface marked by fine, undulating, depressed, radiating, ridge-like lines; closely undulating, concentric striæ; and very fine papillæ that appear to terminate in fine, sharp points; the papillæ are situated on the narrow, irregular, elevated spaces between the striæ. Shell relatively thin and formed of several lamellæ more or less oblique to the outer surface.

Observations.—This species is based on a fine specimen of a ventral valve associated with *Orthis lindströmi* in the Paradoxides series of Lovened. It is broader than *O.* (*L.*) *ferrugineus*, and the surface ornamentation is quite different. The latter is more like that of the associated *Acrothele coriacea*. In outline it approaches more nearly to *O.* (*L.*) *lepis*.

Formation and locality.—Middle Cambrian. Lovened, Westrogothia, Sweden.

OBOLUS (LINGULELLA) RANDOMENSIS, new species.

General form elongate ovate; ventral valve rather broadly subacuminate, and dorsal valve slightly acuminate. The widest portion of the valves is the anterior third, from which they very gradually narrow toward the cardinal slopes. The convexity of the valves is moderate and uniform and nearly the same in each. Surface of the

shell marked by fine concentric striæ and rather strong lines of growth, also fine radiating striæ. The shell is formed of a few thin lamellæ or layers, as far as can be determined from the fragments preserved on the casts in the sandstone. The longest ventral valve in the collection has a length of 10 mm., with a maximum width of 6 mm. The dorsal valve is slightly shorter.

As shown by the interior cast, the area of the ventral valve is rather long, and extends well forward on the cardinal slopes. It is divided at the center by a narrow pedicle furrow and midway by a very slight flexure line. The base of the area curves backward over the margin, arching slightly forward before reaching a rather deep indentation at the center. The striæ of growth cross the area parallel to its base. They are very sharp and fine and quite uniformly distributed over the area. Area of the dorsal valve unknown.

Observations.—This pretty species occurs in great numbers in thin layers of brown sandstone embedded in a dark shale a short distance below the Olenus zone. In form it resembles *Obolus* (*Lingulella*) *iowia* var. *osceola*. It differs from it in having a narrower pedicle furrow, and, upon comparison of a large number of specimens, in being slightly more elongate. It is narrower proportionately toward the beak.

Formation and locality.—Upper Cambrian, north side of Random Island, between Birch and Sandy Points, Smith Sound, Trinity Bay, Newfoundland.

OBOLUS (LINGULELLA) SCHUCHERTI, new species.

General form elongate ovate, ventral valve subacuminate and dorsal valve elongate ovate in outline. Surface marked by fine concentric striæ and rather strong concentric undulations or lines of growth; also fine radiating striæ, and on some specimens indistinct, rather narrow radiating depressed furrows.

The outer surface of the inner layers shows radiating striæ and concentric lines of growth. The radiating striæ are also present on the inner surface outside of the area of the vascular cavity.

The shell is formed of a thin outer layer and several thin inner layers or lamellæ arranged very much as in other thin shells of the subgenus Lingulella. The largest ventral valve has a length of about 11 mm.; width, 7 mm. A dorsal valve 8 mm. in length has a width of $5\frac{1}{2}$ mm.

Casts of the interior of the ventral valve show a well-marked area, with a broad, strong pedicle furrow. The base of the area arches strongly forward. At the center across the pedicle furrow it has a slight backward arch just at the center. None of the specimens show the flexure line or the extent of the area along the cardinal slopes of the valve. The area of the dorsal valve is unknown. None of the characters of the visceral cavity or vascular markings are shown with

sufficient clearness to permit me to describe them. A tubercle on each side of the median line, just in advance of the area, indicates the main vascular sinus, and a depression marks the position of the anterior portion of the visceral cavity.

Observations.—This is probably the oldest species of the subgenus Lingulella. It is associated with *Acrothele calata*, *Olenellus asaphoides*, and other characteristic species of the Lower Cambrian fauna. In its elongate dorsal valve it recalls *Obolus rhea* of the Middle Cambrian. It differs from that species in the character of the shell and the outline of the valve.

The specific name is given in honor of Mr. Charles Schuchert, who collected the only specimen of the species known to me.

Formation and locality.—Lower Cambrian conglomerate and bedded limestone, Troy, New York.

OBOLUS (LINGULELLA) SIEMIRADZKII, new species.

Lingula sp. cf. *cuneata* Eichwald, Siemiradzki, Jahrb. K. K. Geol. Reichsanst., 1886, XXXVI, p. 672.

Lingula cf. *cuneata* Eichwald, Gurich, Neues Jahrb. Min. Geol. Pal. 1892, I, p. 69; Verhandl. (Zapiski) Russ. Kais. Min. Gesell., St. Petersburg, 2d ser. 1896, XXXII, pp. 17, 214.

Attention was called to this species by Dr. Jos. Siemiradzki in 1886 in connection with his study of the Paleozoic rocks of the Middle Mountains of Poland. He speaks of it as *Lingula* sp. in the Black conglomerate, comparing it with *L. cuneata* Eichwald.[1] In the associated gray sandstone he found an Obolus "identical" with *O. silurica* Eich.

Dr. G. Gurich wrote on the Paleozoic of the Middle Mountains (Mittelgebirge) in 1896, and, in a discussion of the Cambrian of Sandomir, mentions Siemiradzki's discovery of fossils in the lower sandstones and shales.[2]

Dr. Gurich added greatly to the fauna found by Dr. Siemiradzki. He mentions Paradoxides resembling *P. tessini*, *P. bohemicus*, *Agnostus fallax* Linnæus, *A. gibbus* Linnæus, *Liostracus linnarssoni* and refers the fauna to the Middle Cambrian. The "Lingula" he compared with *Lingula crassa* Eichwald, calling attention to the resemblance in the surface characters, also to those of *Lingulella davisii* Salter.

This is a small shell belonging to the group of species containing *O.* (*L.*) *ferrugineus*, *O.* (*L.*) *desideratus*, etc. The outer surface is marked by concentric, slightly undulating and imbricating striæ of growth, and the outer surface of the inner layers by fine, radiating striæ.

Through the kindness of Dr. F. Schmidt, I received a fragment of

[1] Jahrb. K. K. Geol. Reichsanst, XXXVI, 1886, p. 672.

[2] Neues Jahrb. Min. Geol. Pal., I, 1892, p. 69; Verhandl. (Zapiski) Russ. Kais. Min. Gesell., St. Petersburg, 2d ser., XXXII, 1896, p. 17.

gray quartzitic sandstone containing a large number of specimens of the "Lingula" of Siemiradzki. The shell proves to be a true Lingulella. In the same piece of rock an obscure form of Obolus occurs that may be a medium-sized *Obolus apollinis*. I take pleasure in naming the Lingulella after its discoverer, Dr. Siemiradzki.

Formation and locality.—Middle Cambrian. Quartzitic sandstone. Pepper Mountains, near Sandomir on the Vistula, Russian Poland.

OBOLUS (LINGULELLA) WINONA var. CONVEXUS.

A small, relatively convex shell occurs abundantly in the brown sandstones at Osceola Mills, Wisconsin, that appears to be an intermediate form between *O.* (*L.*) *winona* and *O.* (*L.*) *mosia*. It differs from *O.* (*L.*) *mosia* in being a shorter shell, and from *O.* (*L.*) *winona* in the more regularly ovate to semicircular dorsal valve and more acuminate ventral valve.

Observations.—The group of shells represented by *O.* (*L.*) *winona*, *mosia*, and their varieties appear to range from the Middle Cambrian beds of Hudson up and into the Upper Cambrian beds of Osceola Mills, etc. There is so much variety of form, owing to the different conditions of preservation, that it is very difficult to always be sure of the correctness of the specific reference. The variety *convexus* may be only the uncompressed form of *O.* (*L.*) *winona*, which is usually flattened in the shaly sandstones, or it may be a distinct species that from the material available for comparison can not be clearly determined.

Formation and locality.—Upper Cambrian. St. Croix sandstone, Osceola Mills, Menomonee, Prairie du Sac, Wisconsin. Middle Cambrian, Hudson, and Trempealeau, Wisconsin.

WESTONIA, new subgenus of OBOLUS.

Ovate, with ventral valve slightly acuminate; area of ventral valve strongly defined and divided by a relatively large pedicle groove. Surface marked by concentric and radiating striæ that are crossed by transverse, semiimbricating, "ripple-embossed" lines. As far as known the muscle scars and vascular markings are essentially the same as in Obolus.

Eight species are referred to Westonia—*Obolus* (W.) *aurora*, *O.* (W.) *stonеanus*, *O.* (W.) *rogersi*, *O.* (W.?) *lamellosus* Barr, *O.* (W.) *escasoni* Matthew, *O.* (W.) *ella*, *O.* (W.) *euglyphus*, and *O.* (W.) *chuarensis*. They all have transverse, irregular, elevated lines; that in *O.* (W.) *stonеanus* and *O.* (W.) *rogersi* have two or three sharp undulations near the median line and in *O.* (W.) *aurora* many short and more or less irregular undulations on the entire central portion of the shell. Beyond the short, central undulations, more or less wavelike, long undulations extend to the sides of the valve, usually with a slight backward curvature toward the margin.

OBOLUS (LINGULEPIS) GREGWA Matthew.

Lingulella gregwa MATTHEW, Bull. Nat. Hist. Soc., New Brunswick, 1899, IV, p. 199, pl. I, figs. 1a–f.

Lingulella tumida MATTHEW, Bull. Nat. Hist. Soc., New Brunswick, 1899, p. 200, pl. I, figs. 2a–c.

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

General form elongate ovate, with the ventral valve acuminate and dorsal valve ovate-triangular in outline. The outlines of the valves vary, as shown by a series of specimens. The convexity of the valves varies with the condition of preservation. Those from the sandstone are rather strongly convex, while in the shale they are very much compressed. On the dorsal valve of most young shells there is a marked and rather broad, shallow sinus extending from the umbo to the front, where it flattens out. One of the largest ventral valves has a length of 21 mm., with a width of 18 mm. A dorsal valve 16 mm. in width has the same length; other examples are a little wider than long. Surface of the shell marked by concentric striæ and undulations of growth, over which there is a series of very fine, elevated, sharply undulating and inosculating lines that form a minute, irregular network over the surface, very much like that of *O.* (*Lingulella*) *ella*. Where the lines are strongly elevated the effect is that of a minutely granulose surface. When the thin outer layer of the shell is exfoliated the surfaces of the various inner layers is minutely granulose in addition to the flattened, radiating striæ and concentric lines of growth. The interior surface of both valves is often marked by concentric rows of strong pits or punctæ, very much as in *O.* (*Lingulella*) *davisi*. In some specimens the lines of punctæ extend over the surface of the visceral cavity so as to obscure the vascular markings and muscle scars. In some examples only a few scattered punctæ occur, while in others they are present over nearly the entire surface. The small shells are thin, but the larger ones are built up of a very thin outer layer and several inner layers or lamellæ that are more or less oblique to the outer surface, especially over the anterior and lateral portions of the shell.

The plane of the cardinal area of the ventral valve is nearly coincident near its edges with the edge of the shell. The area is long and extends well forward on the cardinal slope. It is divided midway by a narrow, rounded, deep pedicle furrow, and about halfway between the pedicle furrow and the lateral margins by an unusually well-defined flexure line which is in line with the main vascular furrows of the interior of the valves; fine striæ of growth cross the area and arch around the pedicle furrow parallel to the base of the area. There is practically no undercut beneath the area except near the flexure line at the frontal margin of the area. The area of the dorsal valve is short, narrow, and crossed by fine lines of growth parallel to its base.

The cast of the visceral cavity in the ventral valve shows it to have been relatively small and usually confined to the posterior half of the shell, although when the shell is laterally compressed it may be drawn out to the center of the valve, as in the specimen illustrated by Dr. G. F. Matthew. There are no traces of a median septum in the ventral valve; in the dorsal valve a slightly elevated median line occurs at the bottom of the groove between the central muscle scars, that extends forward to the anterior margin of the visceral cavity beyond the anterior lateral muscle scars. The visceral cavity of the ventral valve extends forward to about the center: in some shells it is back of the center, and in others a little in front. It varies in width and outline very much as the shells vary, being wide in broad shells and narrow in elongate forms.

The markings left on the shell by the vascular system are very strong, and beautifully preserved in some portions. In some shells there is a double groove with a slight ridge between; in others the ridge is large, only a trace of an outer groove remaining; in some young shells the grove is broad and shallow; in all shells the large size of the main vessels is shown by the broad, strong grooves or ridges left on the shell. It frequently happens that the deeply indented lines of pits on the lines of growth deeply indent the grooves and rounded ridges left by the main vessels and mark them off into sections. The interior and lateral vessels left narrow but strong grooves or ridges on the shell, which, however, are usually obscured by the strong pitting of the surface. The parietal scar surrounds the visceral cavity in each valve, crosses the course of the main vascular vessels, and comes back around the spaces occupied by the muscle scars, terminating at the edge of the area at the flexure in the ventral valve; termination unknown on the dorsal valve.

Some of the muscle scars are finely shown in the dorsal valve and fairly well in the ventral. The umbonal scar of the ventral valve is divided, the pedicle scar being situated between the two parts. In the dorsal valve the umbonal scar is close to the area and extends nearly as far each side of the median line as the length of the area.

The scars of the central muscles in the ventral valve are crowded in with the middle and outside laterals within the trapezoidal space. In the dorsal valve they are located on a low ridge each side of a central, longitudinal median depression; they are elongate oval in outline, their major axis being subparallel to the median line of the shell; fine longitudinal lines cross the scars in the best preserved specimens; the ridge on which the central scars occur varies in strength, but it appears to be present in all adult shells; it narrows gradually posteriorly and rather rapidly to the inner side of the anterior lateral muscle scars. The anterior laterals of the ventral valve are placed well back on the narrow space between the edge of the area and the main vascu-

lar sinus; they are elongate and rather large; in the dorsal valve they are elongate, with the major axis inclining forward toward the median line. The middle and outside laterals are situated in the trapezoidal area of the ventral valve, but neither is clearly separable from the other or from the central scars. In the dorsal valve the position of the middle and outside laterals is shown, but not their form or size. The transmedian scars in the ventral valve are seen just back of the anterior laterals, but they have not been observed in the dorsal valve, owing to the imperfections of the shell.

Observations.—This appears to be a representative of *O.* (*L.*) *acuminatus*, which is so abundant in the Middle Cambrian of the Upper Mississippi Valley and the passage beds between the Cambrian and Ordovician adjoining the Adirondack Mountains of New York. It differs from that species in its greater average width and in its surface characters.

Mr. Matthew's illustrations are diagrammatic and drawn from compressed, imperfect material. With a large series of well-preserved specimens I find that the species does not depart materially from the typical *O.* (*Lingulepis*) *acuminatus*. Mr. Matthew referred the species to a pre-Cambrian fauna, but in collections made by Mr. S. Ward Loper it occurs on slabs of siliceous shale and sandstone associated with heads and fragments of Paradoxides.

Lingulella tumida Matthew is founded on a longitudinally compressed and distorted ventral valve of this species. A number of such in various stages of transition between the two forms occur in the U. S. National Museum collections.

Leptobolus ataeus Matthew appears to be founded on the young of *O.* (*L.*) *gregica*. There is a transition in form between the types of *Leptobolus ataeus* and the undoubted forms of *O.* (*L.*) *gregica*.

This is one of the most interesting species I have seen. By its coarsely pitted inner surface it recalls *O.* (*Lingulella*) *davisi* of England, and *O.* (*Lingulella*) *willisi* of the southern Appalachians. The elongate ventral valve is like that of *O.* (*Lingulepis*) *acuminatus*, while the interior scars and markings are those of Obolus.

Formation and locality.—Middle Cambrian. Paradoxides beds. Siliceous shale and thin-bedded sandstones west side of McLean Brook, above Marion bridge road, Salmon River, Gillis Hill, 13 miles south of Marion bridge, Cape Breton Island, Nova Scotia.

Subgenus ACRITIS.

OBOLUS (ACRITIS?) RUGATUS, new species.

The concentric surface lines which are the characteristic feature of this shell are of the same type as those of *O.* (*Acritis*) *antiquissimus*, although much coarser, and are prominent on the postero-lateral margins in much the same manner. It is a very rare form, only one specimen

having been collected, although the beds in which it occurs were very thoroughly searched during the survey of the Eureka mine district.

Formation and locality.—Upper portion of the Middle Cambrian shaly limestone in Secret Canyon shale, Secret Canyon, Eureka District, Nevada.

CAMBRIAN BRACHIOPODS OF SARDINIA.

Dr. J. G. Bornemann has illustrated several species of brachiopods that occur in association with Cambrian types of trilobites. He identifies most of them with well-known Ordovician species of Europe. The most abundant is a species that is identified as *Lingula attenuata* of Sowerby, which occurs in the middle and upper portions of the Ordovician fauna. It recalls by its form such American Cambrian species as *Obolus* (*Lingulepis*) *acuminatus* and *Obolus* (*Lingulella*) *acutangulus*. It resembles *Lingula attenuata* in outline, but it is highly improbable that a species of this character should exist from Middle Cambrian time to Middle Ordovician time. The same is true of two other species—one doubtfully identified as *Lingula ronaulti* Salter; another as *Lingula petalon* Hicks.

The shell named *Lingula hawkei* Rouault ? is too imperfect for either generic or specific identification. In size and form it suggests Mickwitzia. Another form, *Oboletta ?* sp., is probably the same as the shells referred to *Lingula petalon*. The study of specimens received from Dr. Bornemann, and the figures given by him as *Oboletta crassa* Hall, lead to the conclusion that the reference to the genus and species is incorrect. The identification of *Kutorgina cingulata* Billings appears to be correct as to genus, but probably not so as to species.

The brachiopod fauna of the Cambrian of Sardinia, as described in this memoir, is as follows:

Obolus (*Lingulella*) *bornemanni* Walcott.
Obolus (*?*) *meneghini* Walcott.
Obolus (*?*) *zoppi ?* Walcott.
Kutorgina sardiniensis Walcott.
Mickwitzia ? sp. ?