

CAMBRIAN BRACHIOPODA: OBOLUS AND LINGULELLA,  
WITH DESCRIPTION OF NEW SPECIES.

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In continuation of the study of the Cambrian Brachiopoda all the American forms of *Obolus* known to me have been considered, and those that may be referred to *Lingulella*, which is a somewhat doubtful sub-genus of *Obolus*. A few species from the Lower Ordovician rocks are added, as they form a part of the passage fauna between the Cambrian and Ordovician faunas.

OBOLUS Eichwald, 1829.

(Plate XXVI, figs 3-6.)

*Obolus* EICHWALD, Zool. Spec., pars, 1829, II, p. 271; and most other writers.—  
MICKWITZ, Mem. Acad. Imp. Sciences, St. Pétersbourg, 1896, 8th ser., IV, No. 2,  
pp. 1-215, pls. I-III.

The student is referred to the memoir of Mickwitz for the synonymy, detailed description, and illustration of *Obolus* and the species referred to the genus. I have illustrated the interiors of the two valves of *O. celutus* and several interiors of *O. apollinis* from specimens worked out of material kindly sent to me by Dr. F. Schmidt.

It is stated in the Paleontology of New York<sup>1</sup> that Mickwitz did not obtain his results from the type species of the genus *Obolus apollinis*, but from a hitherto undescribed form, *Obolus quenstedti*. I find that Mickwitz diagnoses the genus and cites *Obolus apollinis* as the type (p. 128). He says (p. 24), "A more accurate study of the greatly increased material has convinced me that *O. quenstedti* can not be maintained as a species, since it is merely the terminal link of a series of variations, which, like var. *maximus* and *ingricus*, can be traced back to *O. apollinis*. Thus, the typical species remains *O. apollinis* Eichwald."

The figures illustrating the new species are now made up as plates for a monograph of the U. S. Geological Survey, and will be transmitted for publication probably during 1899.

<sup>1</sup> Volume VIII, pl. 1, p. 339.

The American species of *Obolus* now known to me are:

American species of *Obolus*.

Name of species.	Cambrian.			Lower Ordovician.
	L.	M.	U.	
<i>Obolus anceps</i> Walcott.....				x
<i>Obolus loperi</i> Walcott.....			x	x
<i>Obolus mæra</i> Hall and Whitfield.....			x	
<i>Obolus matinalis</i> Hall.....		x		
<i>Obolus mickwitzi</i> Walcott.....		x		
<i>Obolus murrayi</i> Billings.....				x
<i>Obolus pandemia</i> Walcott.....		x		
<i>Obolus namouana</i> Walcott.....		x		
<i>Obolus refulgens</i> Matthew.....			x	
<i>Obolus rhea</i> Walcott.....		x		

OBOLUS MICKWITZI, new species.

General form rounded ovate, with the ventral valve broadly subacuminate, and the dorsal valve obtusely rounded; valves, as shown by the casts, moderately convex, which would give a rather strongly convex shell, as fragments show that it was quite thick over the central portions. Fragments of the shell showing the outer surface indicate that it was marked by concentric lines and striæ of growth; radiating striæ may have been present; they are strongly developed when the outer surface is exfoliated; the casts of the interior of the valves show very strongly concentric undulations and lines of growth, although in some specimens these characters are scarcely perceptible. The fragments of the shell preserved show that it was formed of a thin outer layer, several inner layers or lamellæ of varying thickness, and numerous lamellæ over the anterior and lateral portions of the shell that are slightly oblique to the outer surface. A somewhat rounded ventral valve has a length of 9 mm.; width, 9 mm.; a dorsal valve 9 mm. long has a width of 8 mm.; a more elongate ventral valve is 9 mm. in length and 8 mm. in width; an associated dorsal valve 7.5 mm. in length has a width of 7 mm.

Casts of the interior of the ventral valve show an area of medium length, divided midway by the cast of a strong, rather broad, pedicle furrow, and again a short distance each side of the pedicle furrow by a narrow, sharp, flexure line; striæ of growth cross the area of the pedicle furrow parallel with the front margin. There is slight evidence in one of the casts that the area formed a shelf between the pedicle groove and the lateral margin. The area of the dorsal valve is of medium length and fairly well extended out on to the cardinal slopes. The cast of the visceral cavity is well shown by several specimens. It resembles that of *O. matinalis* and *O. quenstedti* in the extension of the anterior margins almost directly outward from the center toward the impression of the main vascular sinuses; one of the peculiarities of the species is the great development of the area within the parietal scar (Splanchnocœle); in some examples it occupies all the central portions

of the shell, extending to within a short distance of the frontal margin; in others it is limited to the posterior half of the shell. The same features occur in the dorsal valve. There are no traces of a median septum in the ventral valve; in the dorsal valve it is shown in the cast as a very narrow depression between and a little forward of the central muscle scars.

In the ventral valve the anterior lateral muscle scars are distinctly shown; also the trapezoidal area, in which the central, middle, and outside lateral scars occur. In the dorsal valve large central and small anterior lateral scars are clearly defined; also the transmedian scars. Of the markings left on the interior of the shell by the vascular system, the trunk sinuses are usually strongly defined in the smaller shells, extending nearly to the anterior margin, and in the larger shells about three-fourths of the way over the area to the frontal margin.

Owing to the condition of the casts of the interior, the parietal scar is usually not well defined; in the ventral valve it appears to extend from where it arches forward at the center almost directly outward to the trunk sinuses, where it curves backward across the sinus and outside of the anterior lateral muscle scars; it occurs in the dorsal valve over the median line in front, is outward and backward around the side of the large central muscle scar, where it curves outward across the trunk sinuses.

*Observations.*—Attention has been called to the relatively large size of the visceral cavity (Splanchnocœle) in both valves of the smaller shells. The range of variation in this respect is so great, that it might be accepted as indicating a distinct species if there were not shells intermediate in size in which the splanchnocœle was also intermediate in proportional size. Another marked character in the specimens is the very strong impressions in the cast of the trunk sinuses and muscle scars and visceral markings. This species is somewhat more rounded in outline than *O. mæra* and *O. matinalis*, and it is very distinctly marked by the muscle scars of the dorsal valve.

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

*Type.*—No. 27299, U.S.N.M.

#### OBOLUS RHEA, new species.

General form elongate ovate, with the ventral valve subacuminate, and the dorsal valve elongate ovate in outline. Outer surface unknown, as all of the shells referred to this species are more or less exfoliated. The surface of the inner layers shows numerous, rather broad, radiating striæ, and concentric lines of growth. The shell appears to have been formed of a thin outer layer and several inner layers or lamellæ arranged in the same manner as in *O. matinalis*. A ventral valve 8 mm. in length has a width of 6 mm.; a shorter broader valve is 6.5 mm. long and 5.5 mm. wide. The two dorsal valves referred to this

species are larger than the ventral valve; one 9.25 mm. long has a width of 6.75 mm., and another 9.25 mm. long has a width of 7.25 mm.

Casts of the interior of the ventral valve show a rather short area that is not clearly defined in any of the specimens.

The cast of the pedicle groove is narrow and merges into the east of the groove extending forward to the visceral area; the area is also marked by flexure lines, and transverse striae of growth. The area of the dorsal valve is short in the one specimen showing it. The east of the visceral cavity on the ventral valve is clearly defined by a rather narrow ridge that is expanded anteriorly in what may have represented the heart-shaped cavity. The parietal scar passes around in front of the visceral cavity, and then a little backward to the main vascular sinuses. No traces of a median septum have been seen in either valve.

The only traces of muscle scars observed are some irregular markings in the trapezoidal area, in which the central, middle, and outside lateral scars occur in the ventral valve.

*Observations.*—This somewhat peculiar species is associated with *Dicellomus politus* and *Obolus namouna*. The dorsal valves are clearly distinct from any described form, approaching in some respects the elongate dorsal valve of *Lingulepis acuminata*, differing, however, in being narrower and more elongate; the ventral valves appear to be broader in proportion than the dorsal valve and approach *O. matinalis* in outline, but are more elongate.

*Formation and locality.*—Middle Cambrian, St. Croix sandstone, middle bed, at Ean Claire, Wisconsin.

*Type.*—No. 27300, U.S.N.M.

#### OBOLUS PANDEMIA, new species.

The external form of this species is much like that of *O. matinalis* Hall. It differs mainly in the characters of the interiors of the valves. In the ventral valve the central ridge is elevated so as to be the most pronounced feature; it not only fills up the space usually occupied by the heart-shaped cavity, but rises much above the interior surface of the shell. The trapezoidal areas and the depressions occupied by the main vascular sinuses are seen only with difficulty. The essential characters of the species are shown by the figures.

*Formation and locality.*—Middle Cambrian, argillaceous shales embedded in the Rome sandstone, at Shooks Gap, Bays Mountain, 10 miles east of Knoxville, Tennessee.

*Type.*—No. 27301, U.S.N.M.

#### OBOLUS ANCEPS, new species.

General form broadly ovate, somewhat subeuneate. Valves moderately convex. Surface marked by fine lines of growth and finer slightly undulating concentric striae. When the outer layer is exfoliated the

outer surface of the inner layer is marked by very fine radiating striae and numerous lines of growth. The inner surface of the shell is nearly smooth, judging from a partial cast in the limestone. The shell is relatively thin and formed of a very thin outer layer and one or more thin inner layers or lamellae, which thicken the shell from the umbonal region and toward the front and sides.

A cast of the interior of a dorsal valve that is referred to this species shows that a strong median ridge was present; also a median septum and a strong main vascular sinus. The area is short and marked by rather prominent flexure lines, as indicated by the flexures in the transverse lines of growth.

*Observations.*—This species might be taken for the young of *O. matinalis* or *O. mara*, were it not for the great difference in the thickness of the shell. It occurs at a slightly higher horizon at the base of the Pogonip limestone.

*Formation and locality.*—Lower Ordovician, lower portion of Pogonip group, northeast of Adams Hill, Eureka district, Nevada.

*Type.*—No. 27302, U.S.N.M.

#### OBOLUS LOPERI, new species.

General form subsemicircular, with the ventral valve subacuminate, and the dorsal valve broad ovate to circular in outline. Some of the shells are more elongate than in what is considered to be the typical form. This type of variation is also observed in *O. matinalis* and other species of the genus. Valves moderately convex as they occur in the sandstone. Surface of the shell marked by concentric lines and fine striae of growth, and very narrow radiating undulations that are more or less interrupted by the concentric lines of growth. When the outer layer of the shell is exfoliated the inner layers are seen to be marked by numerous fine, rounded, radiating striae in addition to the concentric lines of growth, exceedingly fine, irregular, interrupted striae that give it in places a pitted appearance, while in a different light it appears to be granulated, a feature of the surface that seems to be present on the surface of all of the inner lamellae; sometimes the impression given is that the shell is minutely punctate.

The markings of the interior, so far as known, are rounded radiating striae. The shell is rather thick and built up of a thin outer layer and several inner layers or lamellae that in the anterior portions of the shell are rounded obliquely to the outer surface.

The largest shell in the collection is a somewhat imperfect dorsal valve 8 mm. in length. A smaller valve, 6 mm. in length, has the same width. A ventral valve, 6 mm. in length, has the portion about the beak broken away and is a little longer than wide.

The only traces of the interior of the valves is a partial cast of the dorsal valve. This shows that the interior lateral muscle scars were

situated on the anterior portion of the valve about one-third the length of the shell from the anterior margin.

*Observations.*—This species resembles in many respects *O. matinalis*; especially the Texan form referred to that species. The material is poorly preserved, but it appears to be clearly distinct from any described species. Its surface characters are more like those of some species of *Lingulella*, such as *O. (L.) prindlei*, than those of the typical American forms of *Obolus*, such as *O. matinalis*.

The species is named in recognition of the difficult and persevering work of Mr. S. Ward Loper, curator of the Museum of Middlebury College, who made a large collection of fossils, under the most adverse circumstances, in the mountains of Colorado.

*Formation and locality.*—Reddish sandstone, carrying a fauna intermediate between the Cambrian and Ordovician. Cement Creek, 3 miles north of Hot Springs, and 8 to 10 miles southeast of Crested Butte, Colorado.

*Type.*—No. 27303, U.S.N.M.

#### OBOLUS NAMOUNA, new species.

This form is closely related to *O. matinalis*. It differs mainly in the internal character of the dorsal valve. The area, in addition to the narrow area of *O. matinalis*, extends its lines of growth nearly one-fifth the length of the shell. The visceral area is shorter also than in *O. matinalis*, the central and interior lateral scars being closer together. Owing to the somewhat imperfect character of the ventral valve, no special points of difference with the ventral valve of *O. matinalis* can be determined. It is associated on the same slabs of sandstone with *O. rhea*.

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

*Type.*—No. 27304, U.S.N.M.

#### LINGULELLA, a subgenus of OBOLUS.

*Glossina* PHILLIPS, 1848; not defined.

*Lingulella* SALTER, 1866, Mem. Geol. Surv. Gt. Brit., III, p. 333.

*Schmidtia* VOLBORTH, 1869.

Heretofore the data relating to *Lingulella* have been too meager to permit of detailed comparison with other genera. The presence of a peculiar central channel in the cardinal area was the only character of importance observed by Davidson that served to distinguish *Lingulella* from *Lingula*,<sup>1</sup> and the illustrations of *Lingulella ella*, by Walcott, and of *L. celata*,<sup>2</sup> by Hall, have added little. The present careful working up of all the material relating to *L. ella* has brought out much more than

<sup>1</sup>Brit. Foss. Brach., Sil. Brach., 1866-71, Pt. 7, p. 55.

<sup>2</sup>This is not a *Lingulella*.

is shown in the former illustrations of that species, and we now have good material of *L. davisii*, the type of *Lingulella*, and of several closely allied species. Before making any comparisons I wish to call attention to the observations that have been made by Salter, Davidson, and Mickwitz. In the original description, Salter calls attention to the resemblance of the muscular scars of *Lingulella* to those of *Obolus*, but he considers that the difference in relative position is sufficient to distinguish the two genera. Attention is also called to *Obolella* Billings, and to the fact that the later figures of Billings "show a very different set of muscular scars."<sup>1</sup> Davidson had the same material that Salter had and more, but was unable to find any satisfactory interiors, and hence left the genus as doubtful; but he evidently considered it as nearly related to *Lingula*.

Mickwitz met with the same difficulty as Davidson, in having unsatisfactory material upon which to base an opinion. After stating that *Obolella* Billings would probably have to make room for the genus *Obolus* Eichwald, he says:

Whether *Lingulella* Salter will share the same fate, I will not venture to predict with the same degree of certainty, since the diagnosis and figures are even more imperfect than in Billings's genus.<sup>2</sup>

At first thought American paleontologists will be inclined to consider that there must be strong generic distinctions between *Obolus* and *Lingulella*. They have been accustomed to think of *Obolus* as a thick, strong shell, possessing such prominent and peculiar interior scars and markings that nothing in *Lingulella* would suggest generic identity. If we consider, however, that *Obolus* occurs in the Cambrian and Lower Ordovician strata of continental Europe, and that it has not been unquestionably recognized in America at the same horizons, we are led at once to ask, What represents it in America? The first answer is, *Obolella*; but when we compare the calcareous shell of *Obolella* with the semiphosphatic shell of *Obolus*, and note the marked difference in the interior of the ventral valve as compared with that of *Obolus*, we can hardly share Mickwitz's view that the two are congeneric, or, at the best, that *Obolella* is a subgenus of *Obolus*. If *Obolella* does not represent *Obolus* in America, there is only the widely distributed *Lingulella* to compare with *Obolus*.

The study of a series of finely preserved specimens of *Obolus celatus* Volborth leads to the conclusion that the small, thin shells of the *O. celatus* type are representatives of the *Lingulella* type in America and Britain. If the comparison is extended to *Obolus apollinis*, it is found that it is essentially the same, except that the muscular and other markings have been more strongly impressed on the thicker shell. In order to facilitate a comparison of *Obolus* and *Lingulella*, figures of the interior of the shell, drawn from specimens of *Obolus celatus* and *O.*

<sup>1</sup> Mem. Geol. Surv. Gt. Brit., 1866, III, p. 333.

<sup>2</sup> Mém. Acad. Imp. St. Pétersbourg, 1896, 8th ser., IV, No. 2, p. 126.

*apollinis*, are given on Plate XXVI, and of the type of *Lingulella* (*L. darisi*) on Plate XXVII. Three other strongly marked forms of *Lingulella* are illustrated on Plate XXVIII.

The memoir of Mickwitz gives the genus *Obolus* a position that it had not held prior to this very thorough investigation. With his descriptions and plates and a fine suit of specimens worked out from material given me by Dr. F. Schmidt, I have been able to make a series of comparisons that at times have led me to doubt the advisability of distinguishing *Lingulella* even as a subgenus of *Obolus*. This distinction is 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*. There are differences in the position, size, and form of the muscular scars, visceral area, and vascular canals of the two, but they are not greater than those between different species referred to *Lingulella* or to *Obolus*. The same general arrangement of muscle scars prevails, but on comparing the interior of the dorsal valve of *O. (L.) darisi* (Plate XXVII, fig. 4), with that of *O. (L.) acutangulus* (Plate XXVIII, fig. 2), or *O. (L.) amplus* (Plate XXVIII, fig. 4), we find as great variation as when the comparison is made with the dorsal valve of *Obolus* (Plate XXVI, fig. 2). The same is true of the ventral valve, although the means of comparison are in this case not so good. The oldest species of *Lingulella* (*L. grænvillensis*) of the Upper Olenellus zone has the outline of *Obolus celatus*, and the interior markings of the ventral valve are also of the same type. *O. (L.) acutangulus* (Plate XXVIII, fig. 1) has the heart-shaped pit so characteristic of *Obolus* (Plate XXVI, figs. 1, 4, 5), and the arrangement of the muscular scars is essentially as in *Obolus*, but the outline of the valve is much more elongate. *O. (L.) darisi* and *O. (L.) amplus* vary decidedly from *Obolus* in the interior markings, but not more than from *O. (L.) amplus* and *O. (L.) acutangulus*. The variations are so well shown by the figures on the plates that detailed descriptions will not be entered upon.

The genus *Schmidtia* Volborth is considered as a subgenus of *Obolus* by Mickwitz. A comparison of typical specimens of *Schmidtia celatus* and *Lingulella darisi* leads to the view that *Schmidtia* is identical with *Lingulella*.



The following table gives a list of all the species referred by me to *Lingulella* in this preliminary study of *Obolus* and *Lingulella*:

American species of *Lingulella*.

Name of species.	Cambrian.			Ordovician.
	Lower.	Middle.	Upper.	
<i>O. (L.) acutangulus</i> Roemer.....			x	
<i>O. (L.) amplus</i> Owen.....		x		
<i>O. (L.) argutus</i> Walcott.....			x?	
<i>O. (L.) auge</i> Walcott.....		x		
<i>O. (L.) aurora</i> Hall.....			x	
<i>O. (L.) bellus</i> Walcott.....			x	
<i>O. (L.) bellulus</i> Walcott.....			x	
<i>O. (L.) billingsianus</i> Whiteaves.....			x	
<i>O. (L.) chwarensis</i> Walcott.....		x		
<i>O. (L.) cuneolus</i> Whitfield.....		x		
<i>O. (L.) cyane</i> Billings.....				x
<i>O. (L.) desideratus</i> Walcott.....		x?	x	x
<i>O. (L.) dubius</i> Walcott.....		x		
<i>O. (L.) ella</i> Hall and Whitfield.....		x		
<i>O. (L.) elli</i> Walcott.....			x	
<i>O. (L.) euglyphus</i> Walcott.....		x		
<i>O. (L.) ferrugineus</i> Salter.....		x		
<i>O. (L.) fragilis</i> Walcott.....		x		
<i>O. (L.) franklinensis</i> Walcott.....		x?		
<i>O. (L.) grandis</i> Matthew.....				x
<i>O. (L.) grandiloensis</i> Walcott.....	x			
<i>O. (L.) hapsi</i> Walcott.....		x		
<i>O. (L.) helena</i> Walcott.....		x		
<i>O. (L.) iole</i> Billings.....				x
<i>O. (L.) mo</i> Walcott.....		x		
<i>O. (L.) irene</i> Billings.....				x
<i>O. (L.) iris</i> Billings.....				x
<i>O. (L.) laevis</i> Matthew.....			x	
<i>O. (L.) lamborni</i> Meek.....			x	
<i>O. (L.) lamborni</i> var. <i>minimus</i> Walcott.....			x	
<i>O. (L.) leas</i> Walcott.....			x	
<i>O. (L.) lineolatus</i> Walcott.....		x		
<i>O. (L.) mantichus</i> White.....				x
<i>O. (L.) martinensis</i> Matthew.....		x		
<i>O. (L.) mucconelli</i> Walcott.....		x		
<i>O. (L.) mosia</i> Hall.....			x	
<i>O. (L.) mosia</i> var. <i>osceola</i> Walcott.....			x	
<i>O. (L.) nanno</i> Walcott.....				
<i>O. (L.) oweni</i> Walcott.....		x		
<i>O. (L.) peratommatus</i> Whitfield.....			x	
<i>O. (L.) phaon</i> Walcott.....		x		
<i>O. (L.) poyonipensis</i> Walcott.....				x
<i>O. (L.) prius</i> (Conrad) Hall.....			x	
<i>O. (L.) prindleyi</i> Walcott.....	x			
<i>O. (L.) punctatus</i> Walcott.....		x		
<i>O. (L.) radulus</i> Matthew.....			x	
<i>O. (L.) roberti</i> Matthew.....				x
<i>O. (L.) rogersi</i> Walcott.....				x
<i>O. (L.) rotundatus</i> Walcott.....			x	x
<i>O. (L.) selwyni</i> Matthew.....				x
<i>O. (L.) similis</i> Walcott.....		x	x	
<i>O. (L.) sinoc</i> Walcott.....		x		
<i>O. (L.) starri</i> Matthew.....			x	
<i>O. (L.) starri</i> var. <i>minor</i> Matthew.....			x	
<i>O. (L.) stoucanus</i> Whitfield.....			x	
<i>O. (L.) tarpa</i> Walcott.....		x		
<i>O. (L.) willisi</i> Walcott.....		x		
<i>O. (L.) winona</i> Hall.....		x		
<i>O. (L.) zetis</i> Walcott.....			x	

## SUMMARY.

Fifty-six species, 3 varieties.

Lower Cambrian, 2 species in extreme upper part.

Middle Cambrian, 26 species.

Upper Cambrian, 19 species and 3 varieties.

Ordovician (Lower), 12 species.

Passing from Lower to Middle Cambrian, 2 species in passage beds.

Passing from Middle to Upper Cambrian, 2 species.

Passing from Upper Cambrian to base of Ordovician, 2 species.

Subgenus **LINGULELLA** Salter.

(Plate XXVII, figs. 1-5.)

*Lingulella* SALTER, Mem. Geol. Surv. Gt. Brit., 1866, III, p. 333.—DAVIDSON, Brit. Foss. Brach., Silur. Brach., 1866, Pl. 7, p. 55.—WALCOTT, 1886, Bull. U. S. Geol. Surv., No. 30, pp. 95-98; Tenth Ann. Rept. U. S. Geol. Surv., 1891, pp. 607-608, pl. LXVII.—HALL and CLARKE (pars), 1892, Pal. New York, VIII, Pl. 1, pp. 55-59, 163, pl. II, figs. 5-13; Eleventh Ann. Rept. New York State Geol., 1894, p. 232, figures in text only.

*Diagnosis*.—Shell subequivalve, equilateral; elongate-ovate, broad ovate, or subtriangular in outline. Ventral or pedicle valve usually subacuminate, with a distinct cardinal area, pedicle groove, and flexure lines. Dorsal or brachial valve somewhat the shorter, less acuminate, and with a less clearly marked pedicle groove on the shorter cardinal area. Surface of shell marked by fine concentric striae and lines of growth, and in some species finely inosculating and lamellose striae, also, in most if not all species, radiating striae.

Muscular impressions usually indistinctly preserved. In the ventral valve what appears to be a divided umbonal scar has been observed in *O. (L.) darisi* (Plate XXVII, fig. 3, *g*) and *O. (L.) acutangulus* (Plate XXVIII, fig. 1, *h*). A faint trace of a pedicle scar was found in the latter specimen on the shallow groove between the umbonal scars at *m*, Plate XXVIII, fig. 1. Its position is also indicated on Plate XXVII, fig. 3, at *m*. The anterior and concrete laterals are well shown in *O. (L.) acutangulus* (Plate XXVIII, fig. 1, *j* and *c*), but they have not been seen in *O. (L.) darisi* except doubtfully, as shown by *c*, Plate XXVII, fig. 1. The muscular scars of the dorsal (brachial) valve are quite satisfactorily preserved in several species of the genus. The central scars (*h*, Plate XXVII, fig. 4) of *O. (L.) darisi* are clearly defined in a specimen from Port Madoc, and the small anterior laterals and outside laterals are also well shown in the same specimen. In *O. (L.) amplus* (Plate XXVIII, fig. 4) the centrals occur in the same relative position as in *O. (L.) darisi*, but they are much smaller, while in *O. (L.) acutangulus* (fig. 2) they are situated much farther forward and are only a little longer than in *O. (L.) amplus*. The anterior laterals of *O. (L.) darisi* (*j*, Plate XXVII, fig. 4) are situated close to the anterior end of a median ridge, while in *O. (L.) acutangulus* they are a short distance away from the median ridge and much farther forward than in *O. (L.)*

*davisi* or *O. (L.) amplus*. The outside laterals (*l*, figs. 4, 5) are finely preserved in *O. (L.) davisi*, as are also the transmedian scars (*i*, fig. 5).

The interior markings show vascular sinuses in both valves (*s*, Plate XXVII, figs. 1, 2, 4; Plate XXVIII, figs. 2, 3, 4, 5, 6, 7) and a distinctly marked visceral area (*v*) on the ventral valve. A considerable variation in the outline and position of the vascular sinuses and visceral areas occurs in the species illustrated on the plate, and important modifications occur in several other species.

A narrow median ridge or septum is frequently observable in the dorsal valve (Plate XXVII, fig. 4; Plate XXVIII, figs. 2, 4); but with the exception of what may be considered as indicating its probable presence in one specimen of a ventral valve of *O. (L.) davisi* (see Plate XXVII, fig. 1), no traces of a septum have been observed in the ventral valve of any species referred to the genus.

Type of subgenus, *Lingulella davisi* McCoy.

*Observations.*—When in Wales, in 1888, I made a small collection of *O. (L.) davisi* at the type locality at Port Madoc, and later Mr. G. J. Williams sent me a number of fine specimens for study. All of the material was carefully prepared by Dr. George H. Girty, who made a preliminary study of the type and other species referred to the genus when superintending the preparation of the drawings. The systematic study of all the species that have been referred to *Lingulella* is now in progress in connection with the study of a considerable amount of new material from various localities in the Cambrian rocks of North America.

The vertical range of *Lingulella* is from the upper horizon of the Olenellus or Lower Cambrian fauna to the summit of the Cambrian and into the Ordovician fauna. The oldest known species is *O. (L.) granvillensis*, which is associated with Olenellus in strata referred to the upper portion of the Olenellus zone. The greatest development of species is in the Middle and Upper Cambrian, only a few forms continuing on into the Lower Ordovician fauna.

There are two other species of *Obolus* in the Lower Ordovician of Newfoundland that will be fully illustrated in the general work upon Cambrian Brachiopoda. They are *Obolus (Lingulobolus) affinis* and *Obolus (Lingulobolus) spissus*. Mr. G. F. Matthew placed the two species under distinct genera, *Lingulobolus affinis* and *Spharobolus spissus*.

The study of a considerable quantity of material that I collected at the typical locality on Great Belle Island leads to the conclusion that both species should be referred to the genus *Obolus*, subgenus *Lingulobolus*, 1895, the latter being the same as the subgenus of *Obolus (Thysanotos)* Mickwitz, 1896, of which *O. (T.) siluricus* Eichwald is the type.

It is a curious and interesting fact that the peculiarity of the area of the dorsal valve, to which Mr. Matthew gives much importance, is also present in the oldest of the *Obolus* group, *O. (L.) granvillensis*, and in one or two other species in the Middle and Upper Cambrian.

DESCRIPTION OF NEW SPECIES.<sup>1</sup>

## OBOLUS (LINGULELLA) ARGUTUS, new species.

*Lingula ? manticula* WHITE (pars), Expl. and Sur. West of the 100th Merid., 1874 Prelim. Rep., p. 9; (pars) Expl. and Sur. West of the 100th Merid., 1875, IV, p. 52, pl. III, fig. 2a (not fig. 2b).

General form ovate, with the ventral valve obtusely acuminate; valves moderately convex. Exterior surface of the shell unknown. Very fine radiating striae and concentric lines of growth occur on the outer surface of the inner layer of the shell. The shell appears to be of medium thickness and formed of a thin outer layer and one or more thin inner layers or lamellae. The type specimen of the ventral valve has a length of 6 mm. and a width of 4.5 mm.

*Observations.*—This species is founded upon one of the specimens illustrated by White as *Lingula ? manticula*. The broadly ovate form of the ventral valve clearly distinguishes it from that species. From the associated fragments of trilobites, it evidently occurs at a lower horizon, which may be either Upper or Middle Cambrian. A dorsal valve from the same locality and in a slightly different character of limestone is provisionally referred to the same species.

In outline this shell resembles *O. (L.) bellus* and *O. (L.) bellulus* from Newfoundland. It may also be compared with *O. (L.) punctatus*, from which it differs in being more ovate.

*Formation and locality.*—Upper (?) Cambrian, Schellbourne, Schell Creek Range, Nevada.

*Type.*—No. 27305, U.S.N.M.

## OBOLUS (LINGULELLA) AUGA, new species.

General form subemulate, with the ventral valve obtusely acuminate and the dorsal valve rounded acuminate; valves moderately convex. Surface of the shell, as indicated by casts in the fine sandstone, marked by lines of growth and fine, slightly undulating striae. The inner surface is marked by somewhat irregularly scattered pits or puncta, some of which are unusually large for the size of the shell. The few traces remaining of the shell indicate that it was relatively thin. The largest well-preserved cast of the ventral valve has a length of 5 mm., with a width of 4.5 mm. The dorsal valves are a little shorter, the length and breadth being nearly the same. Casts of the interior of the ventral valve show the presence of a rather long area, divided midway by a narrow, clearly defined cast of a pedicle groove; traces of flexure lines are also preserved. The area of the dorsal valve is proportionately shorter than that of the ventral valve; traces of the visceral cavity (*v*) and the base of the main vascular sinuses are also preserved

<sup>1</sup>The figures illustrating the new species are now made up as plates for a monograph of the United States Geological Survey.

in a few specimens, and in one specimen the anterior lateral muscle scars appear to be present.

*Observations.*—In the form of the valves this species is somewhat similar to *O. (L.) grandis*; otherwise it appears to be quite distinct from any other described species.

*Formation and locality.*—Middle Cambrian, sandy layers of the Rome formation, at Shooks Gap in Bays Mountain, 10 miles east of Knoxville, Tennessee.

*Type.*—No. 27306, U.S.N.M.

OBOLUS (LINGULELLA) BELLUS, new species.

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

Surface of shell with numerous concentric lines of growth, with exceedingly fine, slightly irregular striae on the interspaces between the stronger concentric lines. Owing to the roughened surface formed by the fine striae, 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 striae.

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

The cast of the area of the ventral valve shows that it was rather long and extended well out onto 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 striae 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 *Spharobolus 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 described form. It may be compared with *O. (L.) davisii* in relation to its size, but not in other respects, except that it has something of the same general outline.

*Formation and locality.*—Upper Cambrian, arenaceous shales of the upper beds on Little Bell Island and Great Bell Island, Conception Bay, Newfoundland.

*Types.*—Nos. 27307-8, U.S.N.M.

OBOLUS (LINGULELLA) BELLULUS, new species.

General form ovate, with the ventral valve obtusely acuminate, and the dorsal valve round ovate. Valves moderately convex. Surface of shell marked by concentric lines of growth and exceedingly fine, irregular striae, that give the same appearance to the surface as that seen on *O. (L.) ella*, *O. (L.) dawsoni*, *O. (L.) fragilis*, and on a larger scale on *O. (L.) radulus*. The outer layer of the shell usually adheres to the arenaceous matrix, leaving the shiny inner layer of the shell. This is marked by concentric striae and lines of growth, and fine radiating striae. The shell is thin and formed of a very thin outer layer, and one or more thin inner layers or lamellae.

The average length of the ventral valve is from 4 to 5 mm.; width, 3 to 3.5 mm. The dorsal valves are a little shorter, 0.5 mm. to 1 mm.

The cast of the area of the ventral valve shows it to be elongate, divided midway by a narrow but strong pedicle furrow and about midway between the pedicle furrow and the lateral margin by a narrow flexure line; it is marked by striae of growth parallel to its base. The area of the dorsal valve is not well shown by the specimens in the collection.

The casts of the interior of the ventral valve show somewhat imperfectly the visceral cavity, but not the muscle scars. In an interior of the dorsal valve the main vascular sinuses are well shown, also the median septum. The central muscle scars are faintly shown in one fragmentary interior of the dorsal valve.

*Observations.*—This beautiful little species occurs in the arenaceous shales and thin bedded sandstones of Little Bell Island in association with the larger species *O. (L.) bellus*. It is closely related to *O. (L.) dawsoni*, but differs somewhat in form and the more anterior position of the visceral cavity in the dorsal valve. The species is the Upper Cambrian representative of the Middle Cambrian species *O. (L.) dawsoni*. It occurs at about the same horizon as *O. (L.) billingsiana*, but differs decidedly from it in form and convexity, the only points of comparison the material permits of being made.

*Formation and locality.*—Upper Cambrian, arenaceous shales about 75 feet down in the section of Little Bell Island, Conception Bay, Newfoundland.

*Type.*—No. 27309, U.S.N.M.

## OBOLUS (LINGULELLA) CHUARENSIS, new species.

General form broadly ovate, almost subquadrate, with the ventral valve obtusely acuminate, and the dorsal valve rounded subquadrate, the posterior margin being broadly obtuse; convexity moderate, increasing somewhat in the older shells. Surface of shell marked by rather strong, concentric lines and striæ of growth, and very fine, more or less transverse and irregular, apparently imbricating striæ such as ornament the surface of *O. (L.) ella*, *O. (L.) willisi*, and *O. (L.) euglyphus*. Fine radiating striæ also appear under a strong magnifying glass; when the outer surface is exfoliated the inner layers of the shell show traces of radiating striæ; the inner surface is marked by pits or punctæ, arranged in more or less irregular concentric lines; also fine radiating striæ. The shell is strong and formed of a thin outer layer and several inner layers or lamellæ, those near the outer margin being arranged obliquely to the outer surface.

The only traces of the interior markings are those on the casts of the dorsal valve. These show a short and rather broad area, strong vascular sinuses, and traces of the interior lateral muscle scars.

*Observations.*—The character of the surface ornamentation and the subquadrate form of the dorsal valve leads to comparison with *O. (L.) willisi* of the Middle Cambrian of the Southern Appalachian fauna, and with *O. (L.) ella* of the Rocky Mountain fauna. The species differs from those in being a thicker, stronger shell, and relatively shorter in proportion to its length. The surface is also of the same type as that of *O. (L.) euglyphus*, which occurs at the same horizon in the upper portion of the Tonto sandstone, but not associated with it. It differs from *O. (L.) euglyphus* in being much shorter and broader in proportion to its length.

*Formation and locality.*—Middle Cambrian, upper layer of the Tonto sandstone, at the head of Nunkoweap and Chuar valleys, Grand Canyon of the Colorado, Arizona.

*Type.*—No. 27310, U.S.N.M.

## OBOLUS (LINGULELLA) DESIDERATUS, new species.

Shell small, subovate, with the ventral valve obtusely acuminate, and dorsal valve broadly ovate. Valves are strongly convex, with the ventral valve fully as much so as the dorsal. There is a slight variation in the outline of the valves, some being slightly more rounded posteriorly than others.

The surface of the shell is marked by fine, concentric lines of growth, and between them very fine, slightly irregular striæ; a few rather narrow indistinct undulations radiate from the umbo toward the front and lateral margins; when the outer shell is partially exfoliated the outer surface of the inner layer is marked by very fine, indistinct radiating striæ; there are a few traces of small, scattered pits or punctæ on the

inner surface. The shell is thin and formed of an outer layer and one or more inner layers or lamellæ.

The average length of the ventral valve is about 4 mm.; width, 3 mm. A dorsal valve 3.5 mm. long has a width of 3 mm.

A cast of the interior of a ventral valve shows an area of medium length, divided midway by a narrow, clearly defined pedicle groove. The area of the dorsal valve is short. Nothing is known of the interior of the ventral valve, but in a cast of a dorsal valve there are traces of the main vascular sinuses, central median septum, and the central muscle scars.

*Observations.*—This species may be compared with the Middle Cambrian *O. (L.) ferrugineus* of the Atlantic Basin fauna, and *O. (L.) similis* of the Black Hills, Upper Mississippi Valley, and Appalachian faunas. Compared with the Rocky Mountain species it is intermediate between *O. (L.) manticulus* and *O. (L.) rotundatus*. It may also be compared with *O. (L.) granvillensis* of the Olenellus fauna of eastern New York, and *O. (L.) iole* of the Lower Ordovician fauna of Newfoundland.

The specimens that occur at the same geological horizon in the Eureka district, Nevada, are broader proportionately than the typical specimens, and what appears to be the same, or a closely related species, occurs in the upper beds of the Secret Canyon shale just beneath the Hamburg limestone, 1,200 feet lower in the Eureka Cambrian section.

A form that appears to be identical occurs in considerable abundance in the shaly limestone at the base of the lower Knox of Alabama, and also in similar limestones in Tennessee. This similarity is even more striking when the specimens are compared directly with each other and some allowance made for the fact that the Appalachian specimens have all been more or less compressed.

The Tennessee specimens occur in limestones interbedded in or at the summit of the Upper Cambrian Connasauga shale, a short distance beneath the Knox dolomite. Those from Alabama occur at the same horizon on the south side of the Coosa Valley. Compressed specimens referred to *O. (L.) similis* are found in the Coosa shales at Yanceys bend, Coosa River, Cherokee County, Alabama, that can scarcely be distinguished from *O. (L.) desideratus*.

A shell that appears to be identical with this species occurs in the red sandstone and agrillaceous shale of the Lower Ordovician of Colorado. The specimens from Trout Creek below Bergen Park are much like those from the Gallatin Range, and the same species of *Billing-sella* is associated with them. At Cement Creek, 10 miles southeast of Crested Butte, the shells occur in a fine conglomerate and coarse sandstone, associated with a species of *Bathyurus* much like that from the beds containing *O. (L.) desideratus* at Trout Creek.

The vertical range of the shells referred to this species appears to be from the upper beds of the Cambrian into the lower beds of the Ordo-



vician in the Rocky Mountain region. It will require thorough, systematic collecting to establish its range definitely.

*Formation and locality.*—Upper Cambrian and Lower Ordovician, Gallatin limestone, Crowfoot section, Gallatin range, Yellowstone National Park, Wyoming; Hamburg shale near the Hamburg mine. A variety also occurs in the Secret Canyon shale 1,200 feet below the Hamburg shale, Eureka district, Nevada.

Reddish, sandy beds west side of Trout Creek, below Bergen Park, and Cement Creek; 3 miles north of Hot Springs, 8 to 10 miles southeast of Crested Butte, Colorado.

Shaly limestones at base of Knox dolomite, west of top of Copper Ridge, near railroad cut, 11 miles northwest of Knoxville, Tennessee; also abundantly in the Rogersville shale, both NNE. and SSW. of Rogersville, Tennessee; in thin layers of limestones at base of Knox dolomite along Cowan Creek, Coosa Valley, Cherokee County; also in shaly limestone in suburb of Attala, Alabama; also at same horizon a large variety occurs both on Cowan Creek and in the Oothecala Valley, Bartow County, Georgia.

*Types.*—Nos. 27311-3, U.S.N.M.

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

This is a small shell associated with *O. (L.) ella*. It occurs in the form of casts in argillaceous shale, no traces of the shell substance remaining. The ventral valve averages about 3 mm. in length, and the dorsal valves are a little shorter. A cast of the interior of the ventral valve shows the visceral cavity (*v*) and an unusually strong main vascular sinus on each side. Only one specimen shows these characters. Others only faintly indicate them.

The dorsal valve is rounded ovate, and the cast of its interior shows a very short area that extends well out on the cardinal slopes. The interior markings are a portion of the main vascular sinuses, which resemble somewhat in their form and extension those of the dorsal valve of *O. (L.) chuarensis*. The only muscle scars preserved are the anterior laterals of the dorsal valve.

As far as can be determined by casts, the outer surface is marked by lines of growth and fine, slightly undulating, concentric striae.

*Observations.*—At first I thought the specimens now referred to this species were the young of *O. (L.) ella*, and so illustrated them.<sup>1</sup> There is still considerable doubt as to their specific relation, but in view of their very distinct interior markings I have referred them to a new species.

*Formation and locality.*—Middle Cambrian, Chisholm Mine, southwest slope of Ely Mountains, 3 miles northwest of Pioche, Nevada.

*Type.*—No. 27314, U.S.N.M.

<sup>1</sup>Tenth Annual Rept. U. S. Geol. Sur., 1891, pl. LXVII, figs. 2c, 2d.

## OBOLUS (LINGULELLA) ELLSI, new species.

Shell small, broad ovate in outline, with the ventral valve obtusely acuminate and the dorsal valve broadly rounded; valves appear to have been moderately convex, judging from the appearance in the siliceous shale. The surface of the shell is marked by rather strong concentric lines and striae of growth, the striae indicating a slightly lamellose surface. Very fine radiating striae occur on the surface of the inner layers of the shell. A ventral valve 3.5 mm. in length had a width of 2.75 mm.; the dorsal valve is a little shorter than the ventral valve.

Partial casts of the interior of the ventral valve show a very clearly defined area that extended as a shelf on each side of the rather deep, narrow pedicle furrow; portions of the casts that fill the undercut may be observed in several specimens; the flexure lines are narrow, sharp, and situated well out toward the lateral margins. The cast of the visceral area of the ventral valve extends about one third the distance from the area to the anterior margin; it is not well defined, and no traces of muscle scars have been detected; of the vascular system only the base of the main sinuses are shown in any of the casts.

*Observations.*—This very pretty little species is closely related in form to *O. (L.) rotundatus*, and comparison should also be made with the more rotund variety of *O. (L.) ferrugineus*. It occurs in association with *Aerothele pretiosa* (*Obolella pretiosa* Billings).

The specific name is given in honor of Dr. R. W. Ells reports, whose fine work on the geology of a portion of the Province of Quebec unraveled the stratigraphic relations of the Lauzon slates in which the species occurs. Dr. Ells also guided me to the locality at which the species occurs.

*Formation and locality.*—Upper Cambrian, Upper Sillery (Lauzon of Logan), Chaudiere River, Grand Trunk Railroad bridge, Province of Quebec, Canada.

*Type.*—No. 27315, U.S.N.M.

## OBOLUS (LINGULELLA) EUGLYPHUS, new species.

General form ovate, with the ventral valve subacuminate, and the dorsal valve broad ovate in outline. There is some range of variation in the outline of the valves; the convexity of the valves is fairly strong, and is nearly the same in each. A ventral valve 11 mm. in length has a width of 8 mm.; convexity,  $1\frac{1}{2}$  mm.; and a dorsal valve 9 mm. in length has a width of 8 mm.; convexity,  $1\frac{1}{2}$  mm.

The outer surface of the shell is marked by strong concentric lines and striae of growth, and a complex system of lamellose striae of the type of those on *O. (L.) ella*. The striae have a transverse direction, are irregular, and sometimes inosculating. The striae are a little coarser than those on the surface of *O. (L.) ella*, and finer than those of *O. (L.) aurora*. They are also less irregular than those of *O. (L.) ella*,

and more so than those of *O. (L.) aurora*, the result being a surface character intermediate between that of these two species. When the outer layer is exfoliated, the surface of the inner layer is marked by numerous fine, radiating striae and concentric lines of growth. The east of the inner surface of the shell shows rather numerous papillae that fill the pits or punctae in the shell. The shell is strong and formed of a thin outer layer, and several inner layers or lamellae that are arranged very much as in *O. (L.) acutangulus*.

As shown by casts of the interior, the cardinal area of the ventral valve is rather long and well extended out on the cardinal slopes. It is divided at the center by a cast of a strong, rather deep pedicle furrow, and about three-fifths of the distance between the pedicle furrow and the lateral margin by a sharp, narrow flexure line. The striae of growth cross the area parallel to its base. Only a few traces of them are preserved in the pedicle furrow. The area formed a thin shelf between the pedicle groove and the lateral margins, the undercut extending far back under the area as in *O. (L.) acutangulus*. This is shown in the cast by a thin projection of the embedding rock over the area. The area of the dorsal valve is lower and less prominent. It arches forward at the median line and extends well out on the cardinal slopes.

The cast of the visceral cavity of the ventral valve includes the heart-shaped pit and a slight trace of the trapezoidal area, in which the central, middle, and outside lateral muscle scars occur. There are no traces of a median septum in the ventral valve, and it is only slightly indicated in one specimen of the dorsal valve. This is owing, however, more to the condition of preservation of the specimen than to the character of the septum. No muscle scars are clearly defined in either valve. Of the visceral system the main or trunk sinuses are fairly well shown in the ventral valve, but less so for the dorsal valve.

*Observations.*—This form has the shape of *O. (L.) acutangulus*, but differs radically in the arrangement of the markings on the interior of the shell. This is especially true of the dorsal valve. In *O. (L.) euglyphus* the traces remaining on the casts indicate a very close resemblance to *O. (L.) churensis*. The thickness of the shell also allies it with *Obolus* rather than the subgenus *Lingulella*. Attention has been called to the character of the surface, which is intermediate between that of *O. (L.) ella* and *O. (L.) aurora*.

This species is associated with *O. (L.) lineolatus* in the upper beds of the Tonto sandstone. It differs from that species in its surface characters, thickness of shell, and usually in outline. It is also usually a larger species, although a few examples of *O. (L.) lineolatus* approach it in size.

*Formation and locality.*—Middle Cambrian, Tonto sandstone at the head of Lava and Nunkowep valleys, Grand Canyon of the Colorado, Arizona.

*Type.*—No. 27316, U.S.N.M.

## OBOLUS (LINGULELLA) FRAGILIS, new species.

General form ovate, with the ventral valve subacuminate and the dorsal valve broad ovate; valves apparently moderately convex, as determined from the specimens more or less compressed in the shale. Surface of shell marked by concentric lines of growth and what appears to be an exceedingly fine papillose surface, which is apparently produced by the inosculating of irregular raised striae, as on the surface of *O. (L.) radulus*. When the outer layer of the shell is exfoliated very fine concentric and radiating striae occur on the surface of the inner layer. The shell is thin and formed of an outer layer and one or more thin inner layers or lamellae.

The average length of the ventral valve is about 5 mm; width, 4 mm. The dorsal valve is a little shorter.

The rather long area of the ventral valve is divided midway by a strong pedicle groove. The area of the dorsal valve is clearly defined on casts of the interior. It is about three-fifths the width of the valve and arched forward at the center.

The casts of the interior of the valves show traces of the vascular markings, but nothing very definite can be said of them.

*Observations.*—This pretty little species is closely related to *O. (L.) dawsoni*, with which it is associated in the shales of Mannels Brook.

*Formation and locality.*—Middle Cambrian, shales on Mannels Brook, Conception Bay, Newfoundland. It occurs abundantly with the *Paradoxides davisi* fauna, and also in a band of shales 45 feet lower in the section.

*Type.*—No. 27317, U.S.N.M.

## OBOLUS (LINGULELLA) FRANKLINENSIS, new species.

Shell small, ovate, with the apex of the dorsal valve subacuminate; convexity moderate. Surface of the shell marked by rather strong lines and striae of growth, with very fine, slightly irregular, wavy striae between the coarser concentric striae. Two ventral valves referred to this species have a length of 3 and 3.5 mm., respectively, with a width of about 2.75 mm. There are no dorsal valves in the collection. A partial cast of the interior of the shell carries an impression of radiating striae, and a strong cast of a narrow pedicle furrow, and a few concentric lines of growth.

*Observations.*—This species is founded on three specimens of the ventral valve that occur in the limestones interbedded in the dark shales above the Lower Cambrian *Olenellus* bearing shales. A larger shell has the same surface characters and occurs at the same relative geologic horizon, and it may belong to this species. The only specimen of it in the collection is apparently a dorsal valve. The exact stratigraphic horizon has not been determined, but from the associated species of *Agostus* and *Ptychoparia* it appears that the reference should be to the Middle Cambrian.

The material for study is so limited it is difficult to make comparisons with other species. In form the ventral valves resemble that of *O. (L.) lineolatus*, *O. (L.) turpa*, and in some respects *O. (L.) gracillensis*, with which it would be more naturally compared, owing to its belonging to the Appalachian fauna.

*Formation and locality.*—Middle (?) Cambrian, St. Albans shale, in limestone lentile a little west of the town of Georgia, about a mile east of Parker's quarry; also a mile SSW. of Highgate Falls, Franklin County, Vermont.

*Type.*—No. 27318, U.S.N.M.

OBOLUS (LINGULELLA) HAYESI, new species.

Shell small; general form broad ovate, with the ventral valve obtusely acuminate and the dorsal valve rounded ovate; valves moderately convex. Outer surface, as seen in casts, marked by fine, concentric lines and striae of growth; the inner surface had fine, radiating striae and scattered pits or punctae. The shell appears from the casts to have been of medium thickness and built up of several layers or lamella.

The average length of the ventral valve is about 3.5 mm.; width about 3 mm. The dorsal valves are a little shorter than the ventral valves, the length and width being about the same, although some of the shells are a little wider than long.

The casts of the interior of the ventral valve show a clearly defined strong area, divided midway by the cast of a narrow pedicle groove, and again by a sharp flexure line situated a little nearer the pedicle groove than to the lateral margin. The striae of growth cross the area parallel with its base, arching over the cast of the pedicle furrow. The area formed a thin shelf between the pedicle groove and the lateral margins, the undercut extending back under the area, as shown in the cast, by a thin projection of the imbedding rock over the area. The area of the dorsal valve is of medium length and marked by striae of growth and rather clearly defined flexure lines.

The cast of a ventral valve shows the visceral cavity (*v*) and rather strong and long main vascular sinuses. In the dorsal valve the main vascular sinuses are frequently outlined very beautifully on the siliceous casts; the visceral area surrounded by the parietal band is clearly defined, also the central and anterior lateral muscle scars, and in one cast the transmedian muscle scars.

*Observations.*—This very pretty species occurs quite abundantly on the siliceous nodules imbedded in the Coosa shales. It resembles in form *O. (L.) lamborni* and *O. (L.) willisi*, but is a much smaller species. The elongate visceral cavity of the dorsal valve is also of the same type as that of those species. The thickening in front of the visceral cavity is similar to that which occurs in *O. matinalis*. In this character and in its broadly ovate form it comes very close to the forms which are referred to *Obolus*.

*Formation and locality.*—Middle Cambrian, Coosa formation; in and attached to the outer surface of siliceous nodules, Coosa Valley, Cherokee County, Alabama.

*Type.*—No. 27319, U.S.N.M.

OBOLUS (LINGULELLA) HELENA, new species.

General form ovate, with the ventral valve obtusely acuminate, and the dorsal valve rounded ovate. Valves moderately convex, as far as can be determined from their condition of preservation, in the shales. Surface of shell marked by rather strong lines of growth and very fine irregular, radiating and concentric striae that appear to inosculate, the surface having something of the appearance of *O. (L.) ella*; the character of the surface markings of the inner layers and the interior of the shell is unknown. So far as can be determined, the shell is rather thin and formed of a thin outer layer and one or more thin inner layers or lamellae. A ventral valve 8 mm. in length has a width of 6 mm.; another 7.5 mm. in length has a width of 6 mm. An associated dorsal valve 7 mm. in length has a width of 5 mm. These variations in outline are due to considerable extent to distortion.

As shown in the cast of the interior of the shell, the area of the ventral valve is rather long and marked midway by a strongly defined cast of a pedicle groove, and midway between that and the outer margin by a very distinct flexure line. The area of the dorsal valve is rather long and quite distinctly marked on a cast of the interior. The cast of the interior of the ventral valve shows a strong main vascular sinus on each side of the visceral area, and in a cast of the dorsal valve a slight median septum is indicated; also traces of the main vascular sinuses. The only traces of the muscle scars observed are the anterior laterals and a suggestion of the central scars of the dorsal valve.

*Observations.*—This species is associated with *O. (L.) ella* in the siliceous shales near Helena, Montana, and what appears to be a similar form occurs with the same species in Big Cottonwood Canyon. In form and surface characters it belongs to the group of which *O. (L.) ella* may be taken as a type.

*Formation and locality.*—Middle Cambrian; dark siliceous shale in a quarry 1½ miles south of Helena, Montana.

*Type.*—No. 27320, U.S.N.M.

OBOLUS (LINGULELLA) INO, new species.

Shell a little smaller than the average of the species of the subgenus. General form ovate, with the ventral valve subacuminate and the dorsal valve ovate in outline. There is some range of variation in the outline of the valves. The convexity of the valves is fairly strong, as the shells are preserved in the somewhat shaly sandstones. Ventral valves 7 mm. in length have a width of from 5.5 to 6 mm.; a dorsal valve 5 mm. in width has a length of 5.25 mm.

As far as may be determined from the casts, the outer surface is marked by concentric lines and striae of growth and the inner surface by radiating striae and concentric lines of growth and scattered pits or punctae. The shell appears to have been rather thick and built up of a thin outer layer and numerous lamellae that over the anterior two-thirds of the shell were oblique to the outer layer; the edges of the lamellae show very plainly when the outer layer is removed.

The area of the ventral valve, as shown by casts of the interior, is of medium length, divided midway by a narrow elevated cast of the pedicle furrow, and again by a narrow flexure line about half way between the pedicle groove and the lateral margin; striae of growth cross it parallel with the base. The area of the dorsal valve is relatively long, with the flexure lines clearly defined. The interior markings shown in the cast of the ventral valve are the main vascular sinuses and the outline of the visceral area; in the dorsal valve only traces of the visceral area and main vascular sinuses have been observed.

*Observations.*—This species appears to be more nearly related to *O. (L.) tarpa* than any other of the Middle Cambrian forms. It is a smaller shell than *O. (L.) tarpa* and less acuminate. It has the outline of some of the species of the Atlantic Basin fauna, such as *O. (L.) radulus*, but it does not appear to be specifically identical with any of them.

*Formation and locality.*—Middle Cambrian, Rome formation, 2½ miles south of Rome, Georgia, where it occurs abundantly in a layer of shaly sandstone.

*Type.*—No. 27321, U.S.N.M.

OBOLUS (LINGULELLA) LAMBORNI, var. MINIMUS, new variety.

This variety in its ventral valve closely resembles the adult forms of the ventral valve of *O. (L.) lamborni*. The dorsal valve also has the same general form as most of the dorsal valves of the species. In comparing, however, the young specimens of the same size with the variety *minimus* the ventral valves appear to be more obtuse in the young of *O. (L.) lamborni*.

All of the specimens occur as casts in a somewhat decomposed light-colored buff shale.

*Formation and locality.*—Upper Cambrian, Rogersville shale, 3½ miles SSW. of Rogersville, Hawkins County, Tennessee.

*Type.*—No. 27322, U.S.N.M.

OBOLUS (LINGULELLA) LEOS, new species.

Shell small; general form elongate ovate, with the ventral valve subacuminate. The valves are rather strongly convex in the narrow form of the species. Average length of a ventral valve 5 mm., the largest ventral valve has a length of 6 mm.; the dorsal valve is somewhat shorter. The width of the valves varies considerably in

shells occurring in the same hand specimens in the limestone. The surface of the shell is marked by fine concentric lines and striae of growth and very fine, interrupted, radiating striae. Casts of the interior of the shell show stronger radiating striae than the outer surface, also in many specimens unusually large papillae that fill the pits or punctae on the inner surface. The number and strength of the papillae varies in different casts.

The shell appears to have been rather thin and formed of a thin outer layer and one or more thin inner layers or lamellae.

Casts of the interior of the ventral valve show a well defined area, divided midway by the cast of a strong pedicle groove. The area of the dorsal valve is obscured by adhering fragments.

Casts of the ventral valve show traces of the visceral cavity (*v*) and the main vascular sinuses (*vs*). In the dorsal valve a narrow, long median sinus is clearly defined; also the casts of the central and anterior lateral muscle scars.

*Observations.*—This neat little species resembles in some respects *O. (L.) similis*. It differs in being more elongate, the interior being more strongly punctate, and in the more anterior position of the central muscle scars in the dorsal valve. Some of the Wisconsin shells referred to *O. (L.) similis* show greater length in proportion to the width than those from the Black Hills, Tennessee, and Georgia. This, however, appears to be confined to a few shells.

*Formation and locality.*—Upper Cambrian, limestones, Conasauga shale, 1½ miles south of Rome, Georgia.

*Type.*—No. 27323, U.S.N.M.

OBOLUS (LINGULELLA) LINEOLATUS, new species.

General form ovate, with the ventral valve subacuminate and the dorsal valve ovate to broad ovate. The range of variation in the outline of the valves is quite strongly marked. The convexity of the valves is moderate, that of the dorsal valve being a little more than that of the ventral.

The surface of the shell is marked by concentric lines and striae of growth, with very fine, concentric striae between them that are sometimes slightly undulating; on some specimens very faint radiating striae can be seen with a strong lens; when the outer layer is exfoliated the inner layer is marked by fine radiating and concentric striae in addition to the stronger concentric striae; as far as can be determined from the imperfect casts of the interior, the inner surface of the shell was nearly smooth. The shell appears to be formed of a very thin outer layer and one or more thin inner layers or lamellae; toward the frontal margins the oblique lamellae increase in number, but do not give any considerable thickness to the shell.

One of the largest of the ventral valves referred without doubt to this species has a length of 7 mm. and a width of 5 mm. An associated



dorsal valve is slightly shorter in proportion to the width. The average size is smaller, not exceeding 5 mm. for the length of the ventral valve. One unusually large ventral valve that is referred to this species with some doubt has a length of 9 mm.

The only traces of the interior of the shell that have been observed are portions of the area and pedicle furrow of the ventral valve and the area of a dorsal valve.

*Observations.*—This species is very abundant in the upper beds of the Tonto sandstone. It is associated with *O. (L.) euglyphus*, and it is often difficult when the two are in the form of imperfect casts to distinguish between the larger specimens of the two species. They are readily distinguished when the shells are well preserved by the difference in surface markings and the more acuminate ventral valves of *O. (L.) lincolatus*. The latter character, however, is not always of service, especially in the larger shells. In form the ventral valve of this species may be compared with *O. (L.) acutangulus*.

*Formation and locality.*—Middle Cambrian, Tonto sandstone at the head of Chuar, Kwagunt, and Nunkoweap canyons, Grand Canyon of the Colorado, Arizona.

*Types.*—Nos. 27324-6, U.S.N.M.

OBOLUS (LINGULELLA) MOSIA var. OSCEOLA, new variety.

There is considerable variation in form of *O. (L.) mosia* as it occurs in the brown sandstone at Osceola Mills, and for the narrow, more elongate variety the name *osceola* is proposed. It is an intermediate form between *O. (L.) mosia* and *O. (L.) perattenuatus*.

*Formation and locality.*—Upper Cambrian, St. Croix sandstone, Osceola Mills, Wisconsin.

*Type.*—No. 27327, U.S.N.M.

OBOLUS (LINGULELLA) NANNO, new species.

Shell very small; general form elongate ovate, with the ventral valve subacuminate to acuminate and the dorsal valve elongate ovate in outline. The convexity of the two valves is moderate in the very small shells, increasing slightly with the increase in size. Average length of the ventral valve is about 2 mm. and that of the dorsal valve a little less.

The surface of the shell as it appears in the hard, fine-grained, drab-colored limestone is marked by fine, concentric striae and very faint traces of radiating striae.

*Observations.*—This minute species occurs in thin layers of limestone interbedded in the Coosa shales. Its small size and acuminate ventral valve distinguish it from other species. It is associated with *Acrotreta* and fragments of trilobites.

*Formation and locality.*—Middle Cambrian, limestones in Coosa shales, Bluntsville Valley, Alabama.

*Type.*—No. 27328, U.S.N.M.

## OBOLUS (LINGULELLA) OWENI, new species.

General form ovate, with the ventral valve obtusely acuminate, and the dorsal valve more broadly rounded posteriorly; valves appear to have been moderately convex, as far as can be determined from the flattened specimen in the shaly sandstones. Surface of shell marked by concentric lines and striae of growth and indistinct radiating striae. There are no traces of the interior markings observed. The shell is of medium thickness; none of the specimens show how it was built up, further than there were oblique lamellae attached to the outer layer in the anterior portion of the valve. The largest ventral valve from Gibraltar Bluff has a length of 16.5 mm.; width, about 12 mm.; an associated dorsal valve 14 mm. in length, has a width of 11 mm. as it occurs flattened on the surface of the sandstone; a smaller shell referred to this species from Osceola Mills averages from 6 to 8 mm. in length.

As shown in the cast of an interior of a shell, the area is rather long and divided midway by a sharp pedicle furrow; the flexure lines are situated about midway between the cast of the pedicle furrow and the lateral margin. The area formed a thin shelf between the pedicle groove and the lateral margins, the undercut extending far back under the area.

One cast of the interior of a ventral valve shows a slight trace of the visceral area. In a cast of a dorsal valve both the central and anterior lateral muscle scars are somewhat indistinctly preserved.

*Observations.*—This species is most nearly related to *O. (L.) amplus*. It differs, as far as can be determined from the material for comparison, in being less elongate and in the position of the central and interior lateral muscle scars in the dorsal valve.

The species differs strongly from *O. (L.) stoneanus* in its surface markings, although the outline of the valves is almost the same in the two species.

*Formation and locality.*—Upper Cambrian, Gibraltar Bluff, near Lodi, Prairie du Sac, and Osceola Mills, Wisconsin.

*Types.*—Nos. 27329–30, U.S.N.M.

## OBOLUS (LINGULELLA) PHAON, new species.

General form ovate, with the ventral valve subacuminate, and the dorsal broadly ovate; valves of moderate convexity; outer surface of the shell marked by fine concentric lines and striae of growth, and very fine, more or less interrupted radiating striae; the interior surface, as seen in casts, is more or less marked by rather large papillae arranged in concentric lines, the papillae corresponding to the pits or punctae on the inner surface of the shell. Judging from the casts, which show very deeply impressed vascular and other markings, the shell must have been rather thick; fragments of it indicate that it was built up of a thin outer layer and several inner layers or lamellae. A ventral valve

13 mm. in length has a width of 11 mm.; a dorsal valve 11 mm. long has a width of 10 mm.

As shown in the cast of the interior of the shell, the area of the ventral valve rises gradually from the margin toward the pedicle groove. It is broken midway by the cast of a strong pedicle furrow and a little more than half way up toward the lateral margin by a strong flexure line; the striae of growth are very fine and cross the area parallel with its base. The cast of the undercut shows that the area formed a thin shelf between the pedicle groove and the lateral margins. The area of the dorsal valve is well defined. As in the ventral valve, the area formed a thin shelf, as shown by the cast of the undercut extending well over the area in several of the specimens.

The cast of the interior of the ventral valve shows the strongly defined, narrow visceral area, the trapezoidal area in which the central, middle, and outside lateral muscle scars occur; also the anterior lateral muscle scars and unusually strong main vascular sinuses. In a specimen not illustrated, what appeared to be lines of growth occur on the ridge in front of the trapezoidal area—a feature that is present in *O. (L.) hayesi* and *O. matinalis*. In a dorsal valve the relatively narrow central vascular area extends forward to nearly the center of the shell; the central and anterior lateral scars are faintly indicated, also transmedian scars and the median septum; the main vascular sinuses are unusually deep and well defined.

*Observations.*—This species at first inspection might be taken for *O. (L.) amplus*. It occurs at the same horizon in association with *Dicelolomus polita*. It differs in being a broader and less elongate shell, in having the visceral area of the dorsal valve terminate near the center instead of forward of the center, and, as far as can be determined from the material at hand, in being a thicker shell. It also averages about one-fourth less in size.

*Formation and locality.*—Middle Cambrian, St. Croix sandstone, upper beds of the section at Eau Claire, Wisconsin.

*Type.*—No. 27331, U.S.N.M.

OBOLUS (LINGULELLA) POGONIPENSIS, new species.

Shell rather large, general form ovate, almost ovate-cuneate in the ventral valve; dorsal valve is more ovate. Valves moderately convex. Surface of the shell marked by numerous concentric lines and striae of growth and very fine radiating striae; the finer concentric striae are slightly irregular, but not nearly so much so as in many species of the subgenus. The outer surface of the inner layer is marked by very fine radiating striae, also concentric lines of growth. The shell is below the average thickness, and is formed of a thin outer layer and one or more inner layers or lamellae.

The largest ventral valve has a length of 15 mm.; width, 11 mm. As shown by a partial cast, the area is of medium length and divided midway by a narrow, strongly marked cast of the pedicle furrow.

*Observations.*—This fine species occurs in a shaly limestone in the passage beds between the Cambrian and Ordovician. In form the valves resemble somewhat those of *O. (L.) amplus*. In the absence of all interior markings, no further comparisons can be made.

*Formation and locality.*—Base of Pogonip limestone, east slope of the ridge east of Hamburg Ridge, Eureka district, Nevada.

*Type.*—No. 27332, U.S.N.M.

OBOLUS (LINGULELLA) PRINDLEI, new species.

This species was at first considered to be identical with *O. (L.) granvillensis*. The study of a new lot of well preserved specimens shows that it differs from *granvillensis* in being less elongate, more ovate in outline, and marked upon the interior by a very finely granulated surface; in the east the papillae and the fine depressions between them appear to be arranged in transverse undulating lines. The transverse lines of growth on the area of the ventral valve, as seen in the east, are peculiar in having an imbricating or lamellose-like arrangement. The areas of both valves are rather large for so small a species. The average length of the ventral valve is 3.5 mm. to 4 mm., and the width 3.25 mm. The dorsal valve is a little shorter than the ventral.

*O. (L.) prindlei* belongs to a group of small shells that is represented by *O. (L.) ferrugineus*, *O. (L.) rotundatus*, *O. (L.) desideratus*, and *O. (L.) granvillensis*. These forms are among the earliest species of the genus, and range through to the Ordovician fauna. *O. (L.) granvillensis* and *prindlei* occur in the upper limit of the Olenellus fauna of eastern New York and western Vermont, and *O. (L.) rotundatus* and *mauticulus* are found at the base of the Ordovician fauna.

The specific name is given in recognition of the effective work of Mr. L. M. Prindle, who, as assistant to Prof. T. Nelson Dale, collected the first specimens of the species.

*Formation and locality.*—Upper limit of Lower Cambrian or passage beds between Lower and Middle Cambrian. Thin bedded limestone in shale, 1 mile southwest of Wynantskill and 5 miles east of Albany, in Rensselaer County, New York.

*Types.*—Nos. 27333-4, U.S.N.M.

OBOLUS (LINGULELLA) PUNCTATUS, new species.

General form ovate, with the ventral valve subacuminate. Valves moderately convex, with the dorsal valve having a slightly depressed median sinus that extends from near the umbo to the anterior margin. Surface of shell marked by lines and striae of growth, and very fine, slightly undulating striae; also a few faintly indicated radiating striae; when the outer layer is exfoliated the outer surface of the inner layer is seen to be marked by numerous and very fine radiating striae, in

addition to the concentric lines of growth; the interior of the shell as shown by the casts was strongly pitted or punctate, the punctae being arranged in concentric lines following the lines of growth. The shell is relatively thin and formed of a thin outer layer and one or more thin inner layers or lamellae.

The type specimen of the ventral valve has a length of 9 mm.; width, 6.5 mm. An associated dorsal valve has a length of 7 mm.; width, 5.5 mm.

The only interior that shows anything more than the punctate surface is that of a dorsal valve. In this the area is partially shown; it is relatively short and marked by fine striae parallel to its base, and two imperfectly developed flexure lines. The cast of a narrow median septum is well shown and on each side of it the middle lateral muscle scars. The path of advance of the central muscle scars is quite plain; also one of the scars. The only traces of the vascular system is a portion of a main vascular sinus.

*Observations*—This is a very pretty and distinct species that occurs in the interbedded limestones of the Secret Canyon shale.

*Formations and locality*.—Middle Cambrian, upper beds of the Secret Canyon shale, east side of New York and Secret canyons; at the 700-foot level of the Richmond Mine, Ruby Hill, Eureka District, Nevada.

A somewhat similar, if not identical, ventral valve occurs in the upper beds of the Prospect Mountain limestones on the east slope of Prospect Mountain, New York Canyon.

*Type*.—No. 27335, U.S.N.M.

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

General form elongate-ovate, with the ventral valve subacuminate and the dorsal valve ovate in outline. There is considerable range of variation in the outline of the valves, owing largely to distortion apparently produced by movement of the matrix. The convexity of the valves is fairly strong and nearly the same in both, except that the dorsal valve curves more abruptly inward toward the beak.

The outer surface of the shell usually adheres to the matrix, but in three specimens portions of it are preserved which show that it is of essentially the same character as that of *O. (L.) stoncanus*. The surface is formed by very fine concentric lines and striae of growth crossed transversely by strong undulating, slightly lamellose lines. When the outer layer is exfoliated the inner layers are marked by concentric lines of growth and fine radiating striae. This is also the character of the inner surface, so far as can be determined from the specimens in the collection. The shell is rather thick and built up of a thin outer layer and several inner layers or lamellae, the latter becoming increasingly numerous toward the front. The largest dorsal valve in the collection has a length of 13 mm., with a width of 11 mm., and a smaller ventral valve with a length of 12 mm. has a width of 9 mm. The

dimensions of most of the specimens in the collection average less than those here given.

The area of the ventral valve is relatively short for a species of this type. It is divided midway, as seen in the cast, by a strong pedicle furrow. Owing to the imperfection of the material, none of the specimens show flexure lines or striæ of growth. The area of the dorsal valve is short and extends but a short distance on either side of the median line. The cast of the interior of the ventral valve is very much like that of the interior of *O. (L.) cyane*. It has the same median ridge and the transverse trapezoidal area, which includes the central, middle, and outside lateral muscle scars; the main vascular sinuses are indicated by slight ridges. The cast of the interior of the dorsal valve shows a narrow median septum, two central muscle scars of average size, situated a short distance back of the center of the shell, and two small anterior lateral scars, located some distance in advance of the center, which gives an elongated visceral cavity somewhat like that of *O. (L.) hayesi*, of the Middle Cambrian, and *O. (L.) lamborni*, of the Upper Cambrian.

*Observations.*—The external form of the more elongate specimens of this species is very much like that of *O. (L.) acutangulus*. When compressed laterally it occasionally has the form of *Lingulepis acuminatus*, and before taking up the detailed study of this group of brachiopods I was led to identify some of the specimens as of that species. It is distinguished, however, from all described species of this genus known to me by its highly characteristic surface ornamentation. *O. (L.) stoneanus* has the same type of surface, but it differs from the latter in being a much more elongate shell.

The material studied was collected by Prof. N. S. Shaler and Mr. J. B. Woodworth from the pebbles on the beach on the northern shore of Marthas Vineyard, Massachusetts, and at several points along the shores of Narragansett Bay. The first notice we have of these fossiliferous pebbles is that of Prof. William B. Rogers, who in 1861 announced the discovery, by Mr. Norman Easton, of pebbles carrying fossils of the Potsdam fauna in the Carboniferous conglomerate north of Fall River, Massachusetts. Professor Rogers thought the forms distinctly recognizable as *Lingula* of two species, *Lingula prima* and *Lingula antiqua* Emmons.<sup>1</sup>

In 1875 Professor Rogers announced the discovery of impressions suggestive of the fossil *Lingula* mentioned by him from Fall River in the pebbles in the conglomerate at Newport, Rhode Island.<sup>2</sup> He thought that the pebbles were derived from rocks probably closely connected in time with the Braintree Paradoxides beds.

Among the material sent by Professor Shaler I found the remains of

<sup>1</sup> On Fossiliferous Pebbles of the Potsdam and Carboniferous Conglomerate, North of Fall River, Massachusetts, Boston Soc. Nat. Hist. Proc., 1861, VII, pp. 389-391.

<sup>2</sup> On the Newport Conglomerate, Boston Soc. Nat. Hist. Proc., 1875, XVIII, p. 100.

a large linguloid brachiopod, which appears to be identical with *Obolus* (*Lingulobolus*) *affinis* Billings, from the Lower Ordovician rocks of Newfoundland. The material is somewhat imperfect, but I do not know of any other large brachiopod of this type from the Cambrian or Ordovician rocks.

On Great Bell Island, Newfoundland, *O. (L.) rogersi* is associated with *O. (L.) bellus* and *O. (Lingulobolus) affinis*.

*Formation and locality.*—Lower Ordovician, quartzitic pebbles in the Carboniferous conglomerates about Narragansett Bay, Rhode Island, and in the drift along the beaches of the coast of Rhode Island, and also of Marthas Vineyard, Massachusetts, and probably also at other points where the pebbles may have been carried by the glacial drift. Great Bell Island, Conception Bay, Newfoundland.

*Type.*—No. 27336, U.S.N.M.

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

This small species is associated with *O. (L.) manticulus*. It differs from it in its nearly circular form and more strongly pitted or punctate interior of the valves. A cast of the interior of a dorsal valve shows a well-defined area, the cast of the median ridge and septum, and the central muscle scars. The ventral valve has a length of 3.5 mm.; width, 3 mm. Dorsal valve, length, 3 mm.; width, 3 mm.

*Formation and locality.*—Upper Cambrian, and in the lower beds of the Ordovician. The type specimens from the Lower Ordovician are from Schellbourne, Schell Creek Range, Nevada; and the Montana specimens from a point west of Bear Creek, south of Gallatin Valley.

*Types.*—Nos. 27337-8, U.S.N.M.

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

Shell small, general form ovate, with the ventral valve subacuminate, and the dorsal valve rounded-ovate in outline. There is some variation in the outline of the valves. Surface of the shell marked by concentric lines of growth and very fine, slightly irregular, concentric striae; where the outer surface is well preserved fine radiating striae may be seen with a strong magnifying glass. When the outer layer of the shell is exfoliated the outer surface of the inner layer is marked by fine concentric lines and very fine numerous radiating striae; the inner surface of the shell shows concentric lines of growth, and faint, scattered pits or punctae. The shell is of medium thickness, and formed of a thin outer layer, with one or more inner layers or lamellae; the latter are especially prominent toward the front, where they have essentially the same arrangement as in *O. (L.) acutangulus*. The average length of the ventral valve is from 4 to 5 mm.; width, 2.5 mm. An associated dorsal valve 4 mm. in length had a width of 3 mm.

A cast of the interior of a ventral valve shows a clearly defined area of medium length. It is divided midway by a cast of a narrow, strong pedicle furrow, and on each side by flexure lines situated about two-thirds the distance from the pedicle furrow to the lateral margin; a few indistinct striae cross the area parallel with its base. The area of the dorsal valve as seen in a cast is well defined, and rather large; it is marked by fine, transverse striae of growth and indistinct flexure lines. A cast of the interior of the dorsal valve shows a trace of the visceral cavity and a narrow median septum. The only muscle scars observed are the two umbonal scars in the ventral valve and the central scars of the dorsal valve.

*Observations.*—This very pretty little species occurs in abundance in the compact gray limestone associated with numerous fragments of trilobites and *Dicellogomus nana*. The more elongate forms strongly resemble *O. (L.) perattenuatus*, which occurs in the Middle Cambrian sandstones on the southern margin of the Black Hills. The species differs, however, from the latter, in being more ovate, and in having the dorsal valve more obtusely rounded posteriorly. This species may be also compared with *O. (L.) desideratus* and *O. (L.) manticulus*.

A small shell occurs in the St. Croix sandstone of the Upper Mississippi region that appears to be identical with this species, both in its typical form and in its comparatively wide range of variation. With the somewhat abundant supply of material from both the Black Hills and Wisconsin, I am unable to determine any specific differences that are constant.

*Formation and locality.*—Middle Cambrian, limestone beds in the northern suburbs of Deadwood, Black Hills, South Dakota.

In the Upper Mississippi region the form identified with this species occurs in the yellow or buff colored sandstones of the lower portion of the Upper Cambrian fauna, at Winfield, and 4 miles north of Winfield, Wisconsin, Redwing and Reeds, Minnesota.

A slightly larger shell occurs in the sandstone at Osceola Mills, Wisconsin, that appears to be identical with those from a lower horizon at Winfield, Wisconsin. In the elongate outline of the ventral valve it resembles *O. (L.) perattenuatus*, but the data is insufficient to identify it with that species.

*Types.*—Nos. 27339-40, U.S.N.M.

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

General form broad ovate, with the ventral valve broadly subacuminate, and the dorsal valve broadly ovate. Valves moderately convex, as far as can be determined from the series of shells preserved in the fine-grained sandstone. A ventral valve 5 mm. in length has a width of 4.25 mm. A dorsal valve 4 mm. in length has an equal width.

The traces remaining of the exterior shell show it to have been



marked by concentric lines and striae of growth; when the outer layer is exfoliated radiating striae cross the lamellae; a fragment of the inner surface of the shell indicates that there were scattered pits or punctae and fine radiating striae; the shell was relatively thick, and formed of a thin outer layer and several inner layers or lamellae, the lamellae of the interior portion of the shell being arranged in layers slightly oblique to the outer surface of the shell.

Casts of the interior of the ventral valve show a well-defined area marked by strong flexure lines that occur midway between the lateral margins and the narrow, well-defined pedicle groove; striae of growth cross the area parallel with its base. The area of the dorsal valve is relatively short and does not extend very far out on the cardinal slopes. The interior markings of the ventral and dorsal valves show imperfectly the main vascular sinuses and visceral area.

*Observations.*—This species occurs at the same relative stratigraphic horizon as *O. (L.) ino*, and is about the same size. It differs, however, in its more circular form, which is persistent in a large number of shells. In form it more nearly resembles *O. (L.) rotundatus* of the Upper Cambrian. It differs from that in being uniformly larger and having a thicker, stronger shell. It is also not probable that a Middle Cambrian species would continue to exist until the close of Cambrian time.

*Formation and locality.*—Middle Cambrian, brown sandstone beneath the alternating layers of sandstone and limestone northwest end of Packsaddle Mountain, Llano County, Texas.

*Type.*—No. 27341, U.S.N.M.

OBOLUS (LINGULELLA) TARPA, new species.

General form elongate ovate, with the ventral valve subacuminate, and the dorsal valve ovate in outline. There is considerable range of variation in the outline of both valves, owing in part possibly to distortion. The convexity of the two valves is fairly strong, as far as can be determined from the somewhat compressed condition of the shells in the shale and calcareous sandy shales. The largest ventral valve in the collection has a length of 14 mm. The average length of the ventral valve is from 10 to 11 mm. One 11.5 in length has a width of 8 mm.

None of the specimens of the collection show the outer surface, and only traces of concentric and radiating lines have been observed on the inner surface. The shell appears to be moderately thick and formed of numerous lamellae that were oblique to the outer layer in the anterior portions of the shell, in this respect resembling the shell of *O. (L.) acutangulus*.

Casts of the interior of the ventral valve have a moderately long area divided midway by the cast of a strong pedicle furrow, and marked about midway between the pedicle furrow and the lateral margin by a

sharp flexure line; striæ of growth cross the area parallel with its base and arch over the east of the pedicle furrow. The area of the dorsal valve is relatively short, arching forward slightly at the median portion. The only interior markings observed are seen in the casts of the ventral valve, where the visceral area and a portion of the main vascular sinuses are imperfectly preserved.

*Observations.*—This species strongly recalls in external form *O. (L.) acutangulus*. The material is too imperfect to identify it with the latter. It occurs at a considerable lower geologic horizon, and what is preserved of the interior markings of the ventral valve indicates a considerable difference in the position of the visceral area.

*Formation and locality.*—Middle Cambrian, Rome formation, a mile east of Postoak Springs, Roane County, Tennessee.

*Type.*—No. 27342, U.S.N.M.

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

General form broadly ovate, with the ventral valve obtusely acuminate, and the dorsal valve almost transversely ovate, the posterior margin being very broadly obtuse; convexity moderate in the specimens preserved in the calcareous sandstone. Surface of shell marked by concentric lines and striæ of growth, and very fine irregular striæ between them; a few specimens show very narrow, slightly irregular, interrupted radiating ridges or undulations; the inner surface of the shell was more or less strongly pitted or punctate; this character varies greatly in casts from the same layer of shale. The shell, as preserved in the argillaceous shale is relatively thin.

The largest ventral valve, which is shortened slightly by distortion, has a length of 10 mm.; width, 8.5 mm. A well-preserved dorsal valve 8.5 mm. in length has the same width, while another associated dorsal valve 6.5 mm. in length has a width of 7 mm.

As shown in the casts, the area of the ventral valve is rather long, and is divided midway by a strong east of the pedicle furrow, and again midway between the pedicle furrow and the lateral margins by a well-defined flexure line; fine striæ of growth cross the area parallel with its base. The area of the dorsal valve is relatively short, and extends far out onto the cardinal slopes; it is marked by clearly defined, but not strong, flexure lines. Casts of the interior of the ventral valve show traces of the visceral cavity and the main vascular sinuses. In the dorsal valve a narrow median septum is all that is shown, with the exception of faint indications of the central and interior lateral scars and what appears to be the transmedian scar.

*Observations.*—This species was at first compared with *O. (L.) lamborni*. Like that, it has a strongly pitted or punctate inner surface, and the ventral valve has the same general outline; the dorsal valve, however, is much more transverse and obtuse, and the central muscle scars in the dorsal valve appear to be somewhat differently located.

A single specimen doubtfully referred to this species from near Montevallo, Georgia, shows a surface over a small portion of its area, much like that of *O. (L.) ella*. It is too doubtful to refer to *O. (L.) ella*. This species has quite a vertical range as it occurs in the Rome formation and in the subjacent Coosa shales. Its range of variation is considerable; some of the Coosa shale specimens associated with the Middle Cambrian fauna are very much like *O. (L.) lamborni* from the Rogersville shale of Tennessee.

I take pleasure in naming this species in honor of Mr. Bailey Willis, geologist, who for a considerable time had charge of the work in that region where these specimens were collected by Dr. Cooper Curtice.

*Formation and locality.*—Middle Cambrian, Rome formation; both in shales and calcareous sandstones, Copper Ridge, 11 miles northwest of Knoxville; 4 miles north-northeast of Knoxville, along First Creek Gap; also 3½ miles southwest of Rogersville, Tennessee; 5 miles north of Cave Spring, Georgia, in shales beneath the limestone; doubtfully in shale one-fourth mile west of hotel at Montevallo, Georgia; Coosa shales of Coosa Valley, on line of Cowan Creek, Cherokee County, Alabama.

*Types.*—Nos. 27343-6, U.S.N.M.

OBOLUS (LINGULELLA) ZETUS, new species.

This is a small shell that has somewhat the general form of *O. (L.) lamborni*. It differs, however, in being more transverse across the front, and in having a broad, shallow depression in the dorsal valve. It occurs at a higher horizon than *O. (L.) chuarensis*, *O. (L.) euglyphus*, and *O. (L.) lineolatus* of the upper beds of the Tonto sandstone. It has more the form of the true *Obolus* than those species, but its shell is relatively thin and marked by fine radiating striae. All of its essential characters are well shown by the figures illustrating the species.

*Formation and locality.*—Upper Cambrian, shaly sandstone in the upper beds of the Tonto formation, at the head of Nunkoweap valley, Grand Canyon of the Colorado, Arizona.

*Type.*—No. 27347, U.S.N.M.

EXPLANATION OF PLATES.

[The letters on the plates refer to the parts as indicated herewith.]

PLATE XXVI.

- |   |  |
|---|--|
| <p><i>g.</i> Umbonal<br/> <i>h.</i> Central.<br/> <i>z.</i> Transmedian.<br/> <i>j.</i> Anterior laterals.<br/> <i>k.</i> Middle laterals.<br/> <i>l.</i> Outside laterals.<br/> <i>p.</i> Pedicle groove.<br/> <i>a.</i> Central lateral space.<br/> <i>a'.</i> Outer lateral space.</p> | <p><i>f.</i> Flexure lines.<br/> <i>vs.</i> Vasculiar sinus.<br/> <i>ps.</i> Parietal band.<br/> <i>x.</i> Heart-shaped cavity.<br/> <i>o.</i> Scar-like depressions in heart-shaped cavity.<br/> <i>s.</i> Median septum and ridge.<br/> <i>d.</i> Outline in heart-shaped cavity, showing a stage in the growth of the cavity.</p> |
|---|--|

<i>Obolus (Lingulella) velatus</i> Volborth .....	Page. 385
Fig. 1. Interior of a ventral valve from the Upper Cambrian strata, near Jogslecht.	
2. Interior of dorsal valve, associated with fig. 1.	
<i>Obolus apallinis</i> Eichwald .....	385, 391
Figs. 3-6. Interior of the posterior portions of four ventral valves from Estland. The variation in form and position of the muscle scars is well shown.	

## PLATE XXVII.

<i>g.</i> Umbonal.	<i>l.</i> Outside laterals.
<i>c.</i> Trapezoidal area, including central scars, middle and outside laterals.	<i>p.</i> Pedicle groove.
<i>m.</i> Pedicle.	<i>a.</i> Central lateral space.
<i>h.</i> Central.	<i>a'</i> . Outer lateral space.
<i>i.</i> Transmedian.	<i>f.</i> Flexure lines.
<i>j.</i> Anterior laterals.	<i>vs.</i> Vascular sinus.
<i>k.</i> Middle laterals.	<i>ps.</i> Parietal band.
	<i>v.</i> Visceral cavity.

<i>Obolus (Lingulella) darisi</i> McCoy .....	Page. 392-4
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- Fig. 1. Cast of interior of a flattened ventral valve (x 3), preserving nearly the normal outline of the shell.
2. Cast of interior of a flattened and distorted ventral valve, in which the vascular sinuses and visceral cavity are fairly well indicated.
3. Cast of interior of the posterior portion of a ventral valve (x 3), drawn to illustrate the umbonal and pedicle muscle scars.
4. Cast of interior of dorsal valve (x 3).
5. Cast of interior of a dorsal valve longitudinally shortened by compression.
- From the Lingula Flags at the typical locality—Port Madoc, North Wales.

<i>Obolus (L.) acutangulus</i> Roemer .....	392-4
6. Cast of interior of ventral valve, from the Upper Cambrian, Llano County, Texas.	

## PLATE XXVIII.

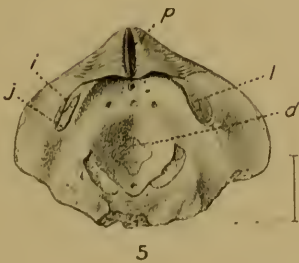
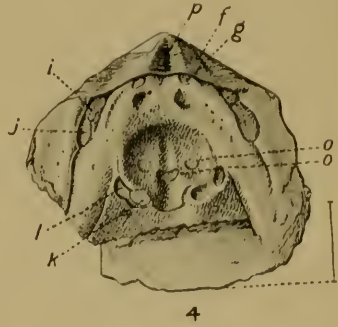
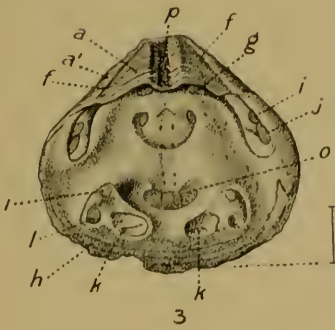
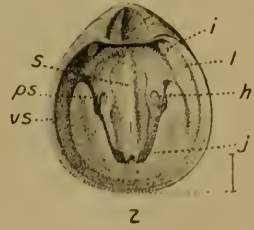
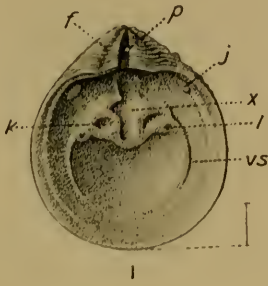
<i>g.</i> Umbonal.	<i>f.</i> Flexure lines.
<i>m.</i> Pedicle.	<i>vs.</i> Vascular sinus.
<i>c.</i> Trapezoidal area, including central scars, middle and outside laterals.	<i>ps.</i> Parietal band.
<i>h.</i> Central.	<i>v.</i> Visceral cavity.
<i>i.</i> Transmedian.	<i>r.</i> Heart-shaped cavity.
<i>j.</i> Anterior laterals.	<i>s.</i> Median septum.
<i>l.</i> Outside laterals.	<i>z.</i> Lateral branches of the vascular system.
<i>p.</i> Pedicle groove.	<i>n.</i> Supposed accidental marking.

<i>Obolus (L.) acutangulus</i> Roemer .....	Page. 392-4
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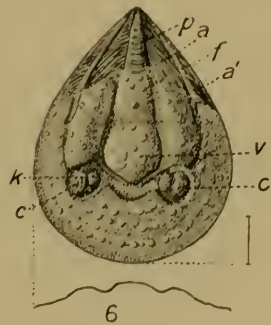
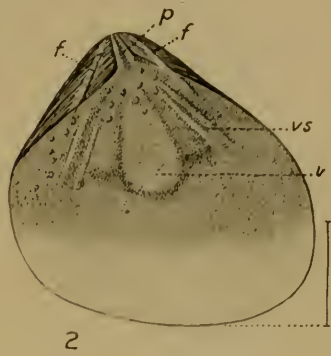
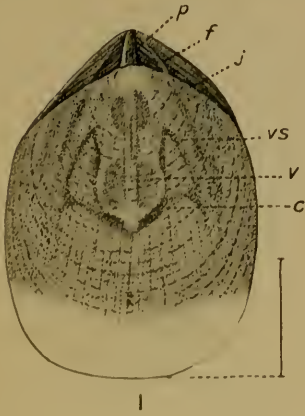
- Fig. 1. Cast of interior of ventral valve (x 6). This is a beautiful specimen from the Upper Cambrian, Llano County, Texas.
2. Cast of interior of dorsal valve (x 5) and outline of specimen associated with fig. 1.

<i>Obolus (L.) amplus</i> Owen .....	392-4
3. Cast of interior of ventral valve from the Middle Cambrian sandstone at Dakota, Minnesota.	
4. Cast of dorsal valve associated with fig. 3.	

<i>Obolus (L.) ella</i> Hall and Whitfield .....	390
5. Cast of interior of ventral valve from the Middle Cambrian shales, near Helena, Montana.	
6. Cast of interior of dorsal valve associated with fig. 5.	
7. Cast of interior of ventral valve from the Middle Cambrian shales of East Canyon, Oquirrh Mountains, Utah.	
8. Cast of interior of dorsal valve from the Middle Cambrian shales, near Pioche, Nevada.	

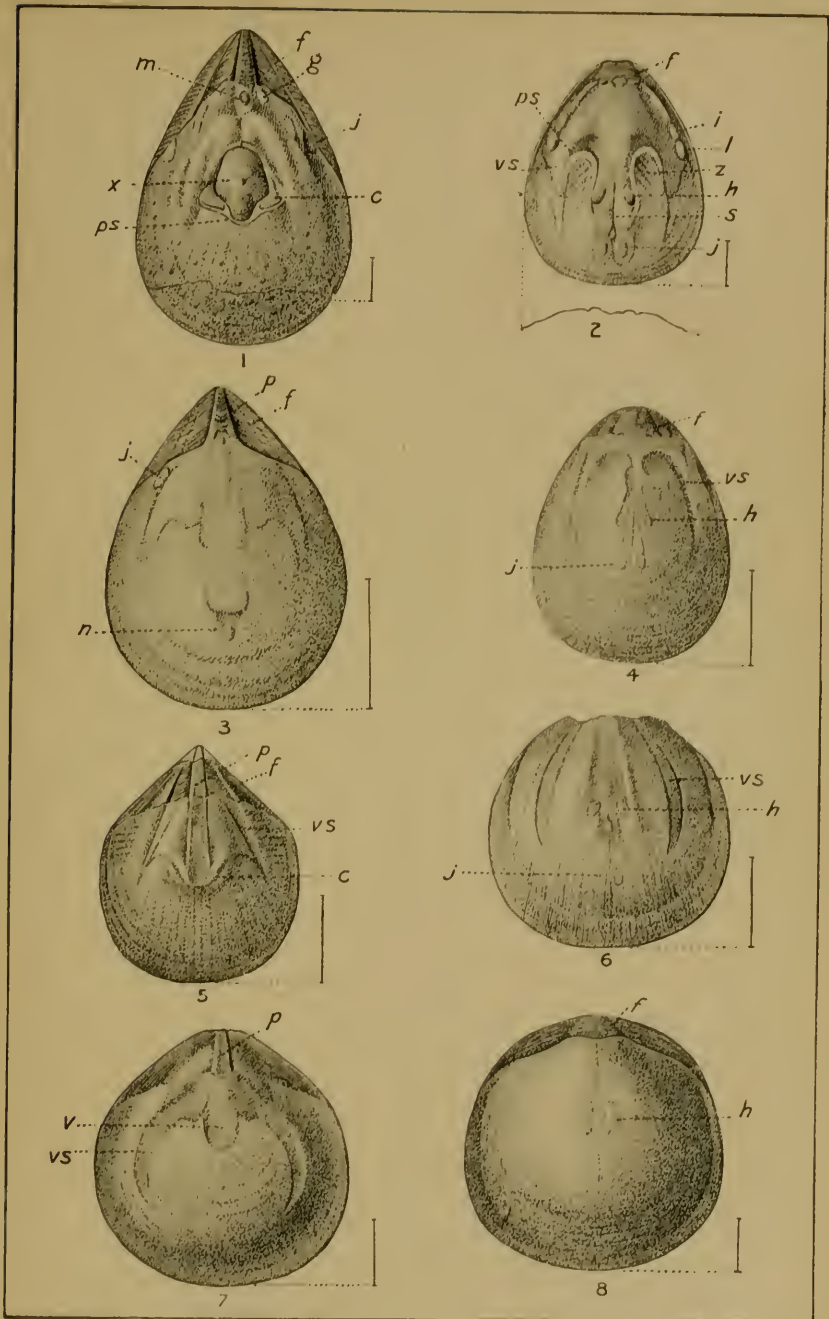












CAMBRIAN BRACHIOPODA

