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No. 6.—OLENELLUS AND OTHER GENERA OF
THE MESONACIDÆ

WITH TWENTY-TWO PLATES

BY

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INTRODUCTION

This paper was first planned to include the descriptions of the new genera and species of the Mesonacidae that had been collected by me or under my direction since the publication of the memoir on the *Olenellus* fauna in 1891 [Walcott, 1891]. When the material was assembled, I wrote to my friend, Prof. Atreus Wanner, of York, Pennsylvania, asking if he had any new material. In response he sent me a beautiful series of specimens showing the growth of the dorsal shield of *Pædeumias transitans* and specimens of *Wanneria walcottanus* with a large spine on the fifteenth segment. I also found in the collections from central Alabama a very interesting series of specimens of the young cephalons of *Pædeumias* and *Wanneria*. The result has been that I have reviewed and discussed the family Mesonacidae and illustrated the known genera and species more or less fully.

When in 1891 I proposed to use the term Mesonacidae [Walcott, 1891, p. 635] I thought it a better selection than to propose Olenellidae and so stated. Vogdes [1893, p. 254] evidently misunderstood my intention and used the term Olenellidae. Later Moberg [1899, p. 316], evidently without knowing of Vogdes' use of the term, proposed to use Olenellidae, as he thought it did not conflict with Olenidae. Lindström [1901, p. 12] simply followed Moberg. The term Olenellidae is a good one, but Mesonacidae has priority, and also the genus *Mesonacis* is much more typical of the family than the genus *Olenellus*; the latter is the last phase of the evolution of one branch of the family, while *Mesonacis* illustrates the stage in which the marked characteristics of most if not all of the genera are present.

Mesonacis vermontana (Hall) was founded on a specimen preserving the cephalon and a portion of the thorax [Hall, 1859, fig. 2, p. 60]. In 1886 I found this form was essentially similar to *Olenellus thompsoni* [Walcott, 1886, pl. 24, fig. 1a] back to the fourteenth segment, but that the fifteenth segment instead of being a telson was a thoracic segment with a long median spine. Posterior to the fifteenth segment there were ten segments with short pleural lobes and a plate-like pygidium [pl. 26, figs. 1 and 2]. For this strange form the genus *Mesonacis* was proposed [Walcott, 1885, p. 328], and I [Walcott, 1886, p. 166] concluded that the telson of *Olenellus thompsoni* was represented in *Mesonacis* by the fifteenth segment and the posterior segments and pygidium. Subsequently other specimens were found with segments posterior to the fifteenth [pl. 26, fig. 3], and one large specimen [see pl. 33, fig. 1, and pl. 24, fig. 12] that had

three very short rudimentary segments and a plate-like pygidium beneath the great spine on the fifteenth segment.¹ These specimens convinced me that *Olenellus thompsoni* passed through a *Mesonacis* stage before becoming a typical *Olenellus*. I put the specimens away in hopes that others would be found throwing more light on the problem. In the collection made by Dr. Charles Schuchert at York in 1896 an otherwise typical form of *Olenellus thompsoni* 40 mm. in length was found to have four rudimentary segments and a pygidium beneath the spine on the fifteenth segment, but it was not until 1909 when Prof. Atreus Wanner sent me a large series of specimens showing young stages of growth, also adults with from two to four rudimentary segments posterior to the fifteenth spine bearing segment that sufficient material was available to definitely conclude that *Olenellus thompsoni* passed through a *Holmia*, a *Mesonacis*, and a *Pædenmias* stage of development, and later became a typical *O. thompsoni* with a terminal telson by the absorption of certain rudimentary segments and a plate-like pygidium.

FUTURE WORK

It is exceedingly desirable that more collecting should be done in the Lower Cambrian formations of the Reval region of Russia; in Finland; and in the various localities in Sweden, Norway, and England. I am sure that important information in relation to the Mesonacidae would be secured by a systematic search for more and better material. In America we will continue the work in 1910 in western Newfoundland and the Straits of Belle Isle, and in British Columbia and Alberta, and another season will be spent in Nevada and California.

ACKNOWLEDGMENTS

I am greatly indebted to Prof. Atreus Wanner, Superintendent of Public Schools at York, Pennsylvania, for very generously permitting me to study and illustrate the material in his collection.² Prof. H. Justin Roddy, of the State Normal School at Lancaster, Pennsylvania, permitted me to examine the collection he had made in Lancaster County, and loaned me specimens, and both he and Professor Wanner took me over the areas from which they collected specimens in central Pennsylvania. Dr. Joh. Chr. Moberg, of the

¹ This form is now included in *Pædenmias transitans*.

² Professor Wanner has since presented to the United States National Museum the specimens illustrated and described in this paper.

University of Lund, Sweden, sent me casts and specimens of the species described by him. Dr. B. N. Peach most kindly guided me to the Loch Maree localities in northwest Scotland and, by the permission of the Director of the Geological Survey of Great Britain, Dr. J. Horne, in charge of the Scottish Survey, sent me the material in the collections of the Geological Survey and the Royal Scottish Museum at Edinburgh. Mr. Frank Raw of the University of Birmingham sent me photographs and plaster casts of the specimens described by him from the Comley sandstone of Shropshire, England.

Dr. John M. Clarke, of the New York State Survey, loaned me the Ford specimens of *Elliptoccephala asaphoides*, and Prof. George H. Perkins, State Geologist of Vermont, sent me the material in the State Survey collections from western Vermont. The Director of the Geological Survey of Canada kindly loaned the specimens in the Survey Museum.

Among the collectors who have assisted in obtaining the material studied I wish to mention Mr. William P. Rust, of Trenton Falls, New York, and Dr. Cooper Curtice, of Moravia, New York, both of whom worked in the town of Georgia, Vermont, and in Washington County, New York. Also Mr. F. B. Weeks, Mr. Henry Dickhaut, and Mr. T. E. Williard, of the U. S. Geological Survey.

The material of value from Alberta and British Columbia was principally collected by Mrs. Walcott and myself during the summer of 1909.

To all I return my sincere thanks, and if I have omitted to mention any who may have given assistance I trust that they will accept an apology for my unintentional neglect.

Order OPISTHOPARIA Beecher

Order *Opisthoparia* BEECHER, 1897, American Journ. Sci., 4th ser., Vol. 3, p. 187. (Defined as below.)

“Free cheeks generally separate [but not in the Mesonacidæ], always bearing the genal angles. Facial sutures [when not in a state of synthesis] extending forwards from the posterior part of the cephalon within the genal angles, and cutting the anterior margin separately, or rarely uniting in front of the glabella. Compound, paired holochroal [?] eyes on free cheeks [or corresponding portion of cephalon], and well developed in all but the most primitive family.”

The words enclosed in brackets I have added to Dr. Beecher's definition of the order.

Family MESONACIDAE¹ Walcott

Mesonacidæ WALCOTT, 1891, Tenth Ann. Rept. U. S. Geol. Survey, p. 635.

(Cites *Olenellus (Mesonacis) vermontana* as typical of the family.

Declines to propose term *Olenellidæ* as it was too much like the family name *Olenidæ*.)

Olenellidæ VOGDES, 1893, Occasional Papers California Acad. Sci., 4, p. 254. (Cites *Olenellus thompsoni* Hall as the type.)

Olenellidæ MÖBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, p. 316. (The author includes under this family name the following species: *Georgiellus (Elliptocephala) asaphoides* (Emmons), *Olenellus thompsoni* Hall, *Holmia kjerulfi* (Linnarsson), *Mesonacis vermontana* (Hall), *Mesonacis mickwitzii* (Schmidt), and *Olenelloides armatus* Peach.)

Olenellidæ LINDSTRÖM, 1901, Kongl. Svenska Vet.-Akad. Handlingar, Vol. 34, No. 8, p. 12. (Uses *Olenellidæ* as a group name for the "*Olenellida* proper" and the *Paradoxinae*.)

Description.—Cephalon very large, wider than long, genal angles with spines; intergenal spines developed in young and may be present in adult. Facial suture rudimentary, or in a condition of synthesis. Eyes crescentic or semicircular and attached more or less closely to the anterior lobe of the glabella by a rounded ridge; visual surface of eyes with facets arranged in quincunx order. Hypostoma usually with more or less spinose posterior margin. Thorax long, composed of from 13 to 27 free segments. Pygidium small, margin usually entire but may have from one to three spines. Surface of test in adult specimens granular and usually with network of very fine thread-like raised inosculating ridges.

The genera included are *Nevadia*, *Mesonacis*, *Elliptocephala*, *Calavia*, *Holmia*, *Wanneria*, *Padeumias*, *Olenellus*, *Peachella*, and *Olenelloides*.

OBSERVATIONS—DEVELOPMENT

Cephalon.—The youngest stage of growth known to me is the Protaspis stage of *Elliptocephala asaphoides* [pl. 25, fig. 9]. In this the palpebral ridges are continuous with the transversely elongated anterior lobe of the glabella and arch about the spaces between the glabella and the eye lobe, and continue back across the posterior border of the cephalon. The segmentation of the cephalon is beautifully shown by figs. 9, 10, and 22, pl. 25. In figs. 9 and 10 the occipital segment merges into the strong ridge and spine formed by the next two anterior segments; the fourth anterior segment curves

¹ The genus *Mesonacis* is more typical of the family than the genus *Olenellus* and as Mesonacidae was first used, I shall continue it in this paper.

back against the palpebral ridge, and the latter, with the ocular segment, terminates against the large intergenal spine formed by the prolongation of the glabellar segments. The pygidium is a simple plate without axis or traces of segmentation. The young of *Pædecumias transitans* [pl. 25, fig. 22] of a little later stage of growth has the segmentation of the cephalon finely shown, also remarkably long, intergenal spines.

The progressive changes of the cephalon result in the gradual separation of the intergenal and genal spines and the straightening out of the posterior margin. This occurs in *Pædecumias* [pl. 25, figs. 20-22], *Elliptocephala* [pl. 25, figs. 9-12], and *Wanneria* [pl. 31, figs. 8, 7, 5, and 6]. A curious phase in the later development of the cephalon is the advancing of the genal angles from the line of the occipital segment until they are forward of the anterior margin of the glabella. [See pl. 32 for *Pædecumias*, pl. 25 for *Elliptocephala*, pl. 31 for *Wanneria*, and pl. 37 for *Olenellus*.]

The genal, intergenal, and antero-lateral spines of the cephalon undoubtedly represent the pleural ends of segments that have been fused together and greatly modified in the process. The genal spines persist in the adult of the Mesonacidae and often the intergenal spines, but only in a modified manner. The intergenal spines are seen in a later geological period in the adult *Bronteus*,¹ where they might be considered as a reversion to a character of their Cambrian ancestors. *Hydrocephalus*² appears to have an intergenal spine and in all of the *Proparia* [Beecher, 1897, p. 198] the "genal spine" is attached to the space within the facial sutures, and is in fact the prolongation of one of the fused segments of the cephalon, and corresponds in this respect to the intergenal spine of the Mesonacidae. Some of the species of the genus *Agnostus* also show spines that suggest the intergenal spine, notably *A. granulatus* Barrande and *A. rex* Barrande.³

Number of segments in the cephalon.—The question of the number of segments represented in the cephalon is one that cannot be fully discussed here.⁴ The presence of a palpebral segment that appears to also form the larger part of the anterior glabellar lobe

¹ Barrande, 1872, pl. 9, figs. 12 and 13; and pl. 11, figs. 13 and 14.

² Barrande, 1852, pl. 49.

³ Barrande, 1852, pl. 49.

⁴ The student is referred to a paper by H. M. Bernard on the "Systematic Position of the Trilobites," Quart. Journ. Geol. Soc., London, Vol. 50, 1894, pp. 411-432; also to C. E. Beecher's paper on the "Larval Stages of Trilobites," American Geologist, Vol. 16, 1895, pp. 166-197.

in the young of *Elliptocephala* [pl. 25, figs. 9 and 10], *Pædeumias* [pl. 25, fig. 22], and *Olenellus* [pl. 36, figs. 11-14], and the posterior portion of the same lobe in *Olenellus logani* [pl. 41, fig. 6], is evidence that there are six, if not seven, clearly defined segments in the cephalon; these include the occipital ring, the four segments represented by the glabellar lobes, and the ocular or eye-bearing segment; the expansion of the latter may form the anterior portion of the first glabellar lobe as indicated in *Olenellus logani* [pl. 41, fig. 6], where the furrows on the glabella in advance of the palpebral segment apparently outline the segment. In all trilobites where the cheeks carry the visual surface of the eye, the cheeks may be considered as an expansion of the ocular segment, and probably of a segment in advance of it, and the genal spines are the outward termination of the ocular segment. The anterior and second segments of the glabella do not appear to terminate in spines, but the third or fourth segment may be extended into the intergenal spines [pl. 25, figs. 9, 10, and 22; pl. 39, fig. 6].

It is not improbable that a seventh segment more anterior than the ocular segment existed in the primitive cephalon of the Mesonacidae; this is indicated by the antero-lateral spines of the young of *Olenellus gilberti* [pl. 36, figs. 11-14] and the larval-like cephalon of *Olenelloides* [pl. 40, figs. 2 and 3] and by the cephalon of *Calavia bicensis* [pl. 41, fig. 9] where there are two pairs of furrows in front of the palpebral ridge.

The preceding brief outline of the segments included in the cephalon may be tabulated as follows:

1. Anterior border segment, the reflected margin of which supports the hypostoma.
2. Ocular segment carrying the visual surface of the eye.
3. Palpebral or first glabellar segment from which the large anterior lobe of the glabella was largely developed, also the so-called "ocular" ridge, and the palpebral lobe.
4. Second glabellar segment which is usually extended beyond the end of the third glabellar segment in the adult cephalon.
5. Third glabellar segment which may or may not be extended so as to appear in the interpalpebral space.
6. Fourth glabellar segment. This segment in the young [pl. 25, figs. 9, 10, 13, and 22; pl. 36, fig. 12] may be continued as an intergenal spine.
7. Occipital segment, the extensions of which terminate against the intergenal spines [pl. 25, figs. 9, 10, and 22].

Eye.—The changes in the eye lobes vary in different genera. All agree in having a proportionally very long eye lobe in the youngest stages, such as those represented by figs. 9 and 10, pl. 25, of *Elliptoccephala*; figs. 20-22, pl. 25, of *Pædeumias*, and figs. 5-8, pl. 31, of *Wanneria*. The elongated eye lobes remain during life in most of the species of all of the genera, excepting *Wanneria*. In this latter genus the eye lobe is very long in the young [pl. 31, figs. 8, 7, 5, and 4] and short in the adult [pl. 31, figs. 1, 3; pl. 30, figs. 1 and 2]. Two species of the genus *Olenellus* have short eye lobes: *O. fremonti* [pl. 37] and *O. canadensis* [pl. 38]. The eye of *O. fremonti* is unique in that it is larger in the adult [pl. 37, figs. 1, 2, 3, and 6] than in the young stages of growth [figs. 8-12]. This is one of the characters that leads me to consider that the species is one that is descendent from a species that had attained, as far as the eye was concerned, the most advanced stage of development of any species of the Mesonacidæ, and then through reversion developed the long eye lobe in the adult. This stage might be represented by the small-eyed *O. canadensis*.

In one species I have been so fortunate as to find the outer faceted surface preserved [pl. 43, figs. 5 and 6]. This surface is perforated by minute rounded, hexagonal openings arranged in oblique transverse rows which gives them a more or less quincunx order. The interstitial spaces between the openings are narrow, rounded ridges. There is no trace of a corneal covering, and the surface is so much like that of the outer surface of the eye of *Limulus* that I cannot avoid the conclusion that they are of the same type [compare figs. 4 and 5, pl. 43], and "inward projections of the outer cuticle" [Bernard, 1894, p. 422]. Bernard concludes that the eye of *Limulus* is more primitive than that of *Apus*. This may be a correct view, but I strongly suspect that the primitive phylopods of the type of *Apus* will be found to have developed earlier than the trilobites.

Dr. A. S. Packard [1880, p. 508], after comparing the eye of *Limulus* with the sections of the eye of some Ordovician trilobites, notably *Asaphus* and *Bathyrurus*, came to the conclusion that the hard parts of the eye of the trilobites and of *Limulus* were throughout identical, and that the trilobite's eye was organized on the same plan as that of *Limulus*. Dr. G. Lindström, in his *Researches on the Visual Organs of the Trilobites* [1901, pp. 26-27], found that there were several types of eyes among the trilobites:

- I. Genera with compound eyes having :
 - (a) prismatic plano-convex cornea facets ;
 - (b) round or bi-convex transversely elongate lenses ;
- II. Genera with aggregate eyes of bi-convex lenses ; and
- III. Genera with isolated eyes, one or several stemmata at the extremity of a straight facial ridge.

He says [1901, p. 27] of the statement of Packard: "This statement is altogether wrong, and as I hope to show the trilobites have had eyes entirely different from those of *Limulus*, and instead agree with those of the *Isopoda* and perhaps also with a few other Crustacea."

At the time Dr. Lindström wrote he was unacquainted with the visual surface of the eye of *Olenellus* and contended [1901, p. 9] that all Cambrian trilobites were blind in not having eyes on the upper surface of the cephalon. He thought that they might have been provided with visual organs on the hypostoma. The discovery of the faceted surface of the eye of *Olenellus gilberti* clearly negatives the broad conclusion of the absence of a visual organ on the upper surface of the cephalon and indicates that with sufficiently well-preserved specimens the visual surface will be found on all Cambrian trilobites with eyes. That it has not been found long ago is probably due to the fact that the roughened visual surface without a corneal covering adheres to the matrix and is broken off with it. I do not wish to assert that the eyes of *Olenellus* and *Limulus* are constructed on the same plan, but I do think that the outward appearance of the surface of the eye of the young specimens shows that they were similar [pl. 43, figs. 4 and 5].

Dr. Lindström [1901, p. 71] found maculæ on the hypostoma of 136 species of 39 genera of trilobites, on 36 species of which it was possible to study the structure of the maculæ through sections. He states that while the structure that often characterizes the maculæ as a visual organ is very rudimentary, there is no doubt that it subserved the purpose of the visual organ, even where there is no trace of any definite structure that is preserved in the fossil state. In final conclusion he says [1901, p. 74] :

We find the maculæ of the trilobites present from the oldest Cambrian times and we find also in them a progressive evolution, in some to a high degree, lenses and facets, perfectly identical with those of the eyes on the head shield, converting them into true eyes. . . . But there are, no doubt, still more facts to adduce for filling up extant lacunæ in the knowledge of these matters.

I have not been able to find maculæ showing any definite structure on the hypostoma of any species of the Mesonacidæ. I see, however, no *a priori* reason why such structures should not be present.

From the structure and probable habits of the trilobite, as a mud-burrowing animal more or less allied to *Limulus*, it does not at first appear what special purpose was subserved by having visual organs on the hypostoma. While thinking of this, I was led to revert to observations that I made when collecting trilobites showing ventral appendages. These notes [Walcott, 1875, p. 159] state that of 1,160 specimens of *Ceraurus* noted on the under surface of a thin layer of limestone, 1,110 were lying on their backs when buried in the sediment and but 50 presented the dorsal surface upward. Prof. Alexander Agassiz in describing the habits of young *Limulus* says [1878, pp. 75-76]:

Mr. C. D. Walcott has called attention to the fact that when collecting fossils he finds large numbers of trilobites on their back¹; from this he argues that they died in their natural position, and that when living they probably swam on their backs. He mentions, in support of his view, the well-known fact that very young *Limulus* and other crustacea frequently swim in that position. I have for several summers kept young horse-shoe crabs in my jars, and have noticed that besides thus often swimming on their backs, they will remain in a similar position for hours, perfectly quiet, on the bottom of the jars where they are kept. When they cast their skin it invariably keeps the same attitude on the bottom of the jar. It is not an uncommon thing to find on beaches, where *Limulus* is common, hundreds of skins thrown up and left dry by the tide, the greater part of which are turned on their backs. An additional point to be brought forward to show that the trilobites probably pass the greater part of their life on their back, and die in that attitude, is that the young *Limulus* generally feed while turned on their back; moving at an angle with the bottom, the hind extremity raised, they throw out their feet beyond the anterior edge of carapace, browsing, as it were, upon what they find in their road, and washing away what they do not need by means of a powerful current produced by their abdominal appendages.

My object in calling attention to the above facts in relation to the habit of trilobites and *Limulus* is to suggest that in all probability the eyes of the hypostoma were of service when the trilobite was lying on its back on the sand or mud, and it was on this account that they were thus developed. It is highly probable that the adult trilobite crawled about the bottom and did not swim freely in the water to the extent that it would be necessary for it to be able to see the bottom. Its habits must have been very much like those of *Limulus* when in search of food. That the trilobite burrowed and pushed

¹ Ann. Lyceum Nat. Hist. New York, Vol. 11, 1875, pp. 155-159.

its way through the mud and soft sands in a manner similar to that of *Limulus* is proven by the trails and burrows left by it which we now designate as *Cruziana* [Walcott, 1891, pls. 64-66].

Facial sutures.—The facial sutures are rarely represented, even by elevated lines on the exterior surface or depressed lines on the interior surface of the cephalon. If we accept Beecher's view that the sutures are in a condition of symphysis [Beecher, 1897, p. 191], and that the elevated and depressed lines represent the suture between the cranidium and free cheeks, the latter bear the visual surface of the eye. In my hurried study of the *Olenellus* fauna in 1886 and 1891 I permitted facial suture lines to be represented in front of the eye in a specimen referred to *Olenellus gilberti* [Walcott, 1886, pl. 20, fig. 1h; 1891, pl. 86, fig. 1h] on evidence that now appears to me to be insufficient, as the line may have been formed by a fracture in the test.

In one specimen of *Pædeumias transitans* [pl. 33, fig. 1] an elevated line having the usual curvature of the posterior facial suture starts from the base of the eye at its posterior third and extends with a gentle sigmoid curve outward and backward to the posterolateral angle of the cheek where it fades away. It is not probable that this line represents the facial suture that has been lost in the development of the cephalon, but it suggests that conclusion.

Prof. R. P. Whitfield [1884, p. 151, pl. 15, fig. 1] describes and illustrates the curve of facial sutures in *Olenellus thompsoni*.¹ The curve assigned to the sutures back of the eye is certainly incorrect, as, from many specimens, we know that the elevated lines run to the intergenal angles, and I strongly suspect that the suture as outlined in front of the eye is based on a crack in the test, as the specimen is flattened in the arenaceous shale.

Anterior glabellar lobe.—The anterior or first lobe of the glabella in the young stages of growth is small and a part of the palpebral segment of the cephalon [pl. 25, figs. 9, 10, and 22]. In what I consider to be the most primitive genus of the Mesonacidae, *Nevadia* [pl. 23], the first lobe is small and not at all expanded as in *Olenellus* [pl. 37]. In *Callavia* [pls. 27 and 28] the first lobe is also small, although the genus occurs at a much higher horizon than *Nevadia*. We find that *Holmia weeksi* [pl. 29] which is associated with *Nevadia* has an expanded first glabellar lobe. That the small, contracted first lobe of *Nevadia* is a primitive character is shown by its occurring in the youngest stages of growth of all the genera of

¹ Referred in this paper to *Pædeumias transitans*.

the Mesonacidae of which we have the young cephalon. The small first glabellar lobe of *Callavia* is an illustration of the survival of a primitive character in the adult of a later genus or it may be an instance of reversion to a primitive character. The anterior glabellar lobe of *Pædeumias* [pl. 34] and *Olenellus* [pls. 34-39] is expanded and convex when found in a matrix favorable to preserving the convexity. Most specimens have been found in shales which accounts for the flattening of the lobe and the fracturing of the test not only of the lobe but of the adjoining parts of the cephalon. The expansion of the anterior lobe of the glabella in the genera *Mesonacis*, *Elliptocephala*, *Holmia*, *Wanneria*, *Pædeumias*, and *Olenellus* indicates that these genera are of later origin than *Nevadia*, and this conclusion is strengthened by the evidence afforded by a comparison of the thorax of the genera. *Callavia* has the primitive glabella, but its thorax indicates a later origin than the genera *Nevadia*, *Mesonacis*, and *Elliptocephala*.

Another interesting character of the anterior lobe is the presence in *O. logani* [pl. 41, fig. 9] of a faint furrow that extends inward a short distance from the point where the anterior margin of the palpebral ridges joins the anterior glabellar lobe; this pair of furrows indicates that the lobe is formed of two segments of the original primitive cephalon.¹ The palpebral segment is beautifully shown by the young of *Elliptocephala asaphoides* [pl. 25, figs. 9 and 10].

Hypostoma.—The hypostoma has a convex central body that is narrowed posteriorly by grooves that separate the body from a transverse posterior portion on which maculæ may be present. It may be attached directly to the anterior doublure of the cephalon or by a narrow process [pl. 34, figs. 5-7]. Minute specimens of the hypostoma of *Wanneria halli* [pl. 31, fig. 9] show a perforated, flattened marginal border on the posterior and postero-lateral sides. As the hypostoma increases in size the outer rim disappears and the test between the lobes forms a denticulated margin as in *Pædeumias transitans* [pl. 34, fig. 7]. The next development is the absorption of the thickened points and the formation of true spines [pl. 34, fig. 5]. This type of hypostoma is found in *Elliptocephala asaphoides* [pl. 24, fig. 8], *Holmia kjerulfi* [pl. 27, fig. 7], *Wanneria halli* [pl. 31, fig. 9], *Pædeumias transitans* [pl. 34, figs. 5 and 6], *Olenellus gilberti* [pl. 36, fig. 5], *Olenellus fremonti* [pl. 37, figs. 21 and 22],

¹This anterior pair of furrows is shown for *Paradoxides* by Barrande's illustrations of *P. spinosus* [Barrande, 1852, pl. 12, figs. 2, 3, and 6; and pl. 13, fig. 1] and *P. pusillus* [Barrande, 1872, pl. 9, fig. 23].

Olenellus lapworthi [pl. 39, fig. 7], and *Olenellus claytoni* [pl. 40, fig. 9].

The absorption of the spines and the resultant smooth margin appears to have been accomplished in *Callavia bröggeri* [pl. 27, fig. 2], *C. crosbyi* [pl. 28, fig. 6], *Olenellus canadensis* [pl. 38, figs. 2 and 3], *Holmia lundgreni* [pl. 40, fig. 6], and *Mesonacis torrelli* [pl. 26, figs. 9 and 10].

The hypostoma of *Olenellus* has the maculae clearly indicated, but none of the specimens are sufficiently well preserved to permit of making thin sections to determine its structure.

Thorax.—As shown by adult specimens, the development of the thorax from *Nevadia* to *Olenellus*, inclusive, may be divided into six stages.

1. *Nevadia* stage: In *Nevadia* the thoracic segments of a uniform character follow each other from the first to the seventeenth. At the eighteenth segment an abrupt change occurs [pl. 23, figs. 1, 2, and 4]. The grooved pleural lobe disappears and a spinose extension of the same general character as that attached to the anterior pleural lobes is attached directly to the side of the axial lobe of the posterior eleven segments. The dorsal shield is terminated by a very small and simple pygidium.

2. *Mesonacis* stage: In *Mesonacis* [pl. 26, fig. 1] the thoracic segments are fully developed from the first to the fourteenth. The third segment is enlarged and the fifteenth segment has a large median spine and the ten posterior segments form a distinct subordinate series of small but typical segments. The smaller posterior segments are more advanced in development than the posterior segments of *Nevadia*, but not as much so as the anterior segments anterior to the fifteenth segment.

3. *Elliptocephala* stage: In *Elliptocephala* the third segment is relatively larger during the earlier stages of growth in which it has been observed [pl. 24, figs. 3-5], but this disappears in the adult [pl. 24, fig. 1], leaving the segments of a uniform character back to the fourteenth where there is a series of five short segments with long median spines. Most of the series of small segments of *Nevadia* and *Mesonacis* have disappeared.

4. *Holmia* stage: In *Holmia* the 16 segments are in orderly succession and of a similar character; the pygidium remains relatively small and more or less rudimentary. This is best shown by *Holmia kjerulfi* [pl. 27, fig. 7] and *H. rowei* [pl. 29, figs. 3 and 4]. In *Wammeria walcottanus* a short, slender spine appears on the four-

teenth segment in fully matured dorsal shields [pl. 30, figs. 10-12] ; otherwise the segments are of the same character, except as they decrease uniformly in size to the pygidium. In *Callavia bröggeri* [pl. 27, fig. 1] the seventeenth and eighteenth segments are relatively smaller, in this respect resembling the shorter posterior segments of *Mesonacis* and *Elliptocephala*.

5. *Pædeumias* stage: In *Pædeumias transitans* [pl. 33] we find the transition stage between the stages represented by *Mesonacis* [pl. 26], *Elliptocephala* [pl. 24], and *Olenellus thompsoni* [pl. 35]. There are fourteen fully developed segments with the third segment enlarged and the fifteenth segment developed into a strong, long spine with the pleural lobes of the segment absent. Beneath and back of the large spine there are from two to six rudimentary segments without pleural lobes, and a simple plate-like pygidium.

6. *Olenellus* stage: Fourteen fully developed segments, a large third segment, and the fifteenth segment a strong terminal telson ; posterior rudimentary segments and true pygidium of the *Pædeumias* stage absorbed [pl. 35, fig. 1] or the rudimentary segments and pygidium have disappeared and the large median spine of *Pædeumias* has become the telson of *Olenellus*.

Olenellus is the last genus of the *Olenellus* branch of the Mesonacidæ to develop, and from *Pædeumias transitans* we find evidence that it has passed through the *Holmia* stage [pl. 32, figs. 2 and 3] and the *Fædeumias* stage [pl. 33] before becoming a true *Olenellus*.

The enlarged third segment of *Olenellus* [pl. 35, fig. 1] also occurs in *Mesonacis* [pl. 26, fig. 1] and in the younger stages of growth of *Elliptocephala* [pl. 24, figs. 3-5]. In *Olenelloides* [pl. 40, fig. 3] both the third and sixth segments are enlarged. The cause of the enlargement and prolongation of the third segment is unknown. In *Paradoxides* the pleuræ of the second segment are elongated in small specimens of several species [Barrande, 1852, pl. 10, fig. 25 ; pl. 12, figs. 5-7 ; and pl. 13, fig. 16].

Peachella.—We know nothing of the thorax of *Peachella* [pl. 40, figs. 17-19], but from the cephalon it is probable that it was of the *Olenellus* type.

Olenelloides.—The thorax and large cephalon of *Olenelloides* [pl. 40, fig. 3] indicates a degenerate type and a stage of growth beyond which the animal could not develop. For the present it may be placed as a degenerate of the *Olenellus* stage of development.

Pygidium.—The pygidium is a simple transverse plate in the protaspis stage and it is not strongly developed in any genus and

species of the Mesonacidae. It is very small, essentially rudimentary, and its segmentation is limited to one transverse ring on the median lobe [pl. 29, fig. 11].

The telson of *Olenellus* is not considered to be a true pygidium. It resembles the telson of *Limulus*, but this resemblance does not necessarily indicate that *Olenellus* was the ancestor of *Limulus*; its origin does, however, indicate the manner in which the telson of *Limulus* may have originated.

DELIMITATION OF GENERA

The cephalon in all genera of the Mesonacidae is so nearly similar that only specific differences appear to be present, except in *Nevadia* and *Callavia*, which have a small anterior glabellar lobe. The modifications of the thorax are largely taken as the basis for generic separation. The pygidium is essentially the same in all of the genera.

Nevadia.—*Nevadia* [pl. 23] is characterized by the presence of small, simple segments (primitive segments) on the posterior portion of the thorax that have not been developed to the same degree as the segments anterior to them. In the type *Nevadia wecksi* the posterior eleven primitive segments have only the axial lobe and a spinose continuation on each side [pl. 23, figs. 1, 2, and 4]; the grooved pleural lobe of the seventeen more specialized anterior segments is not present. The spinose extensions of the posterior segments are proportionally much rounder and smaller than those of the anterior seventeen segments. As far as known the posterior thoracic spines of *Elliptocephala* [pl. 24, figs. 1 and 9] and the great spine of the fifteenth segment of *Wanneria* [pl. 30, fig. 11] and *Mesonacis* [pl. 26, fig. 1] were not developed in *Nevadia*.

The only species referred to *Nevadia* is *N. wecksi* Walcott.

Mesonacis.—This form [pl. 26, fig. 1] is essentially the same as *Elliptocephala*, but it has an enlarged third segment in the adult and a strong spine on the fifteenth segment. The posterior contracted segments are also of a different character. In *Mesonacis* they are similar to those anterior to the fifteenth segment, while in *Elliptocephala asaphoides* they lose the long-curved pleura so characteristic of the anterior thirteen segments.

The posterior ten segments may be said to be [pl. 26, figs. 1, 2, and 3] less developed, proportionally than the anterior segments, although possessing a well-defined furrowed pleural lobe. A trace of this character is also preserved in *Callavia bröggeri* [pl. 27, fig. 1] where the two posterior thoracic segments are proportionally smaller than the anterior segments.

The species referred to *Mesonacis* are: *M. vermontana* (Hall), *M. mickwitzii* (Schmidt), and *M. torrelli* (Moberg).

Elliptocephala.—In *Elliptocephala* [pl. 24, figs. 1, 2, and 9] the posterior five segments are more highly developed than the primitive segments of *Nevadia*, but not as much so as the segments anterior to them. The abrupt narrowing of the thorax of *Elliptocephala* is of the same type as that shown by *Mesonacis* [pl. 26, fig. 1], but it does not have the large third segment in the adult stage or the great spine on the fifteenth segment.

The one species referred to *Elliptocephala* is *E. asaphoides* Emmons.

Callavia.—*Callavia* [pl. 27, fig. 1; pl. 28, figs. 4 and 8] has a trace of the constricted pleuræ of the posterior portion of the thorax in the two last segments; these are of the same type as the anterior segments. The broad thorax of *Callavia* with the falcate extensions of the pleuræ are quite unlike the narrow thorax of *Holmia* [pl. 27, fig. 7] with its spinose pleural extensions. There are differences of importance in the cephalon as compared with *Holmia*. The glabella of *Callavia* is narrower and more primitive and its intergenal spine is less primitive. The pleural furrow of *Callavia* is narrow and oblique like that of *Paradoxides*, while the pleural furrow of *Holmia* and *Wanneria* [pl. 30] is broad and straight like that of all other known genera of the Mesonacidae. It is doubtful if *Callavia* should precede *Holmia*, but from its primitive glabella and the retaining of two shortened thoracic segments it appears to be nearer *Elliptocephala* than does *Holmia*.

The species referred to *Callavia* are: *C. bicensis* Walcott, *C. bröggeri* (Walcott), *C. burri* Walcott, *C. callavei* (Lapworth), *C. cartlandi* (Raw), *C. crosbyi* Walcott, and *C. nevadensis* Walcott.

Holmia.—*Holmia* [pl. 27, fig. 7] with its uniform series of segments and simple plate-like pygidium appears to represent a stage in the development of the Mesonacidae that followed the *Elliptocephala-Mesonacis* stages. It has lost the rudimentary thoracic segments of *Nevadia*, it is without the large third segment of the adult *Olenellus* and *Mesonacis*, and it is not known to have had an enlarged third segment at any stage of growth. The posterior segments do not show the restricted character of those posterior to the fifteenth spine bearing segment of *Mesonacis*, or the rudimentary form of the posterior segments of *Pædumias*.

The species referred to *Holmia* are: *H. kjerulfi* (Linnarsson), *H. lundgreni* (Moberg), and *H. rozei* Walcott.

Wanneria.—*Wanneria* [pl. 30] has a uniform series of thoracic segments with the pleuræ terminating in broad falcate extensions beyond the body line [pl. 30, fig. 1] instead of spinose ends as in *Holmia* [pl. 27, fig. 7]. It has a great median spine on the fifteenth segment, much like that of *Mesonacis* [pl. 26, fig. 1] and *Pædeumias transitans* [pl. 33]. The posterior segments are not rudimentary as in the latter species. For comparison with *Callavia* see above.

The species referred to *Wanneria* are: *W. walcottanus* (Wanner), *W. gracile* Walcott, and *W. halli* Walcott.

Pædeumias.—The posterior rudimentary thoracic segments of *Pædeumias transitans* [pl. 33] appear to be the result of the absorption of the posterior segments of a many segmented ancestor and are unlike the rudimentary posterior segments of *Nevadia*, which I think are the originally less developed segments and which record a stage in the early evolution of the Mesonacidae that has not been found in any other known species. The pygidium is also rudimentary. The distinctive characters of the genus are in the presence of the rudimentary segments and pygidium.

The only species referred to *Pædeumias* is *P. transitans* Walcott.

Olenellus.—That *Olenellus* [pls. 37-39] should result from the great development of the median spine on the fifteenth segment and the absorption of the posterior rudimentary segments and pygidium of its *Mesonacis* stage of development [pl. 33] is of great interest, as it proves it to be the last phase of development of this line of the Mesonacidae. *Olenellus thompsoni* passes through a *Holmia* [pl. 32, figs. 1-3] and *Pædeumias* stage [pl. 33] before becoming a true *Olenellus*.

The American species referred to *Olenellus* are: *O. thompsoni* Hall and its variety *crassimarginatus* Walcott. *O. gilberti* Meek and an undetermined variety. *O. fremonti* Walcott, *O. canadensis* Walcott, *O. claytoni* Walcott, *O. argentus* Walcott, and *O. walcotti* (Shaler and Foerste).

The European species are: *O. gigas* Peach, *O. lapworthi* Peach, *O. reticulatus* Peach, and *Olenellus* 2 sp. undt.

Peachella.—*Peachella* [pl. 40, figs. 17-19] is known only by its cephalon. This indicates a type related to *Wanneria gracile* [pl. 38, figs. 21 and 22] or the younger stages of growth of *Olenellus canadensis* [pl. 38, fig. 6]. It is probable that the thorax and pygidium will be found to be much like that of *Olenellus*.

The only species known is *P. iddingsi* (Walcott).

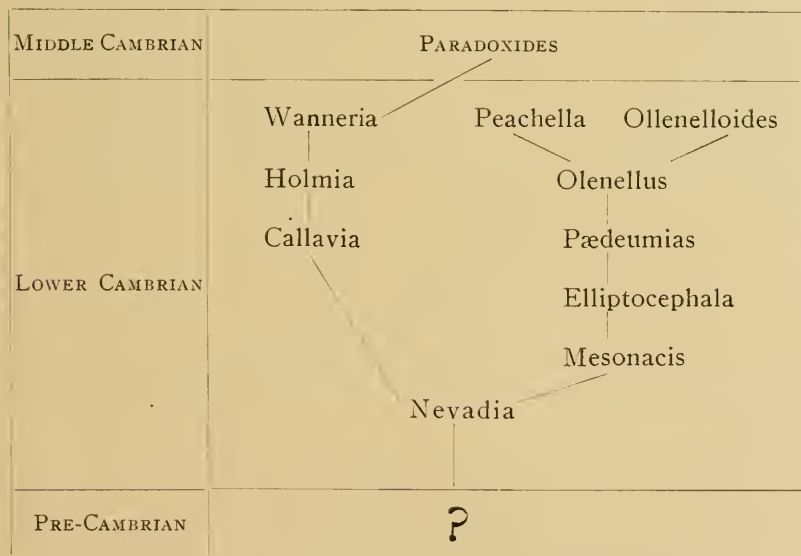
Olenelloides.—*Olenelloides* is clearly defined by its large cephalon and primitive thorax and pygidium.

DEVELOPMENT OF MESONACIDÆ

The development of the Mesonacidæ from some annelidian-like ancestor by the gradual combination of segments to form the cephalon and pygidium is indicated by the examples cited of *Nevadia*, *Elliptocephala*, *Holmia*, and *Pædeumias*. The cephalon, as we know it, was developed in pre-Cambrian time, also the pleural lobes of the thorax. The compact, strong pygidium, made up of many segments, does not occur in the Mesonacidæ, and is unknown in any trilobite from the beds of the Lower Cambrian in which the simplest form of the Lower Cambrian trilobites (*Nevadia weeksi*) occurs.

With my present information I am inclined to think that *Paradoxides* descended through the *Callavia-Wanneria* line, rather than the *Mesonacis-Olenellus* line. The latter line expended its force and became extinct in Lower Cambrian time, leaving no descendant to pass into the Middle Cambrian.

Diagrammatically represented my present conclusion as to the development of the known genera of the Mesonacidæ is as follows, beginning with *Nevadia* at the base.



The presence of a *Holmia*-like species (*H. rowei*) with *Nevadia* in the oldest known horizon of the Mesonacidæ indicates that more primitive forms of the *Nevadia* type existed at an earlier epoch before *Holmia* was developed by the absorption of the simple posterior segments of its *Nevadian* progenitor.

Mesonacis occurs in association with *Olenellus*, but I think that *Mesonacis*-like forms developed at an early epoch and that *Mesonacis vermontana* is a survival of a stage in the evolution of *Olenellus* that preceded *Elliptocephala* and *Pædeumias*. One of the conclusions resulting from this study of the Mesonacidae is that we know only a few of the representatives of the family, and of these only a very few showing the younger stages of growth, and the entire dorsal shield.

MESONACIDÆ AND PARADOXINÆ

The family Mesonacidae is distinguished from the Paradoxinae mainly by the presence in the latter of free cheeks separable on the line of the facial sutures from the cranium. In the Mesonacidae the facial sutures are in a state of symphysis and the free cheeks and cranium are frequently not to be distinguished.

STRATIGRAPHIC POSITION OF THE GENERA AND SPECIES

All of the known species of the Mesonacidae occur in the Lower Cambrian or Georgian terrane. At the type locality in the town of Georgia, Vermont, *Olenellus* and *Mesonacis* occur in the same beds, and as far as known to me all known species of *Olenellus*, as restricted, are from the upper zones of the Georgian terrane.

In the accompanying table of genera and species the Lower Cambrian is arbitrarily divided into four divisions or zones, as follows:

D = *Olenellus*, or upper zone.

C = *Callavia* zone.

B = *Elliptocephala* zone.

A = *Nevadia*, or lower zone.

In the *Nevadia* zone (A) we find the genus *Nevadia* [pl. 23] with one species, also a species that is referred to *Holmia*, *H. rozvei* [pl. 29].

In zone "B" which is above zone "A" *Elliptocephala* occurs, also, doubtfully, *Wanneria* and *Olenellus*.

In zone "C" which is high up in the Lower Cambrian, but not the upper zone, *Callavia* is represented by five species, *Mesonacis* by two, *Holmia* by two, *Olenellus* by one, and two are doubtfully referred to this horizon.

In zone "D" *Olenellus* is represented by eleven species, *Pædeumias* by one, *Wanneria* by two, *Callavia* by one, and *Mesonacis* by one.

GENERA AND SPECIES.	LOWER CAMBRIAN.			
	A ¹	B ¹	C ¹	D ¹
<i>Nevadina</i> , new genus.....	T			
<i>wicksi</i> , new species.....	x			
<i>Elliptoccephala</i> Emmons.....		T		
<i>asaphoides</i> Emmons.....		x		
<i>Mesonacis</i> Walcott.....			x	T
? <i>mickwitzii</i> (Schmidt).....			x?	
<i>torelli</i> (Moberg).....			x	
<i>vermontana</i> (Hall).....				x
<i>Holmia</i> Matthew.....	x		T	
<i>kjerulfi</i> (Linnarsson).....			x	
<i>lundgreni</i> (Moberg).....			x	
<i>rosvæi</i> , new species.....	x			
<i>Callavia</i> Matthew.....			T	x
<i>bröggeri</i> (Walcott).....			x	
<i>burri</i> , new species.....			x	
<i>callævi</i> (Lapworth).....			x	
<i>cartlandi</i> (Raw) (MSS.).....			x	
<i>crosvyi</i> , new species.....			x	
<i>nevadensis</i> , new species.....				x
<i>Wanneria</i> , new genus.....		x?		T
<i>gracile</i> , new species.....		x?		
<i>halli</i> , new species.....				x
<i>walcottanus</i> (Wanner).....				x
<i>Pædeumias</i> , new genus.....				x
<i>transitans</i> , new species.....				x
<i>Olenellus</i> Hall.....		x?	x	T
<i>argenteus</i> , new species.....		x?		
<i>canadensis</i> , new species.....				x
<i>claytoni</i> , new species.....		x?		
<i>freemonti</i> , new species.....			x	
<i>gigas</i> Peach.....				x
<i>gilberti</i> Meek.....				x
<i>gilberti</i> var. undt.....				x
<i>lapworthi</i> (Peach).....				x
<i>logani</i> , new species.....				x
<i>reticulatus</i> Peach.....				x
<i>thompsoni</i> Hall.....				x
<i>thompsoni crassimarginatus</i> , new variety.....				x
? <i>walcotti</i> (Shaler and Foerste).....			x?	
? sp. undt. (Sweden).....			x?	
? sp. undt. (Scotland).....				x
<i>Peachella</i> , new genus.....				x
<i>iddingsi</i> (Walcott).....				x
<i>Olenelloides</i> Peach.....				x
<i>armatus</i> Peach.....				x

¹ See page 250, opposite, for the explanation of these symbols.

ABRUPT APPEARANCE OF THE MESONACIDÆ

I will not discuss at length the question of the abrupt appearance of the Mesonacidæ fauna¹ in this paper as it will be the subject of a paper on the Abrupt Appearance of the Cambrian Fauna of North America,² to be read before the International Geological Congress at Stockholm in August, 1910.

I have been gradually coming to the conclusion that the most natural explanation of the absence of the traces of a distinct pre-Cambrian fauna is that the North American continent in pre-Cambrian time was at such an elevation above the sea that there is now no record of the sediments deposited about the continental area at that time. This presupposes that the great series of pre-Cambrian Algonkian sediments in the Rocky Mountain region were deposited in an inland mediterranean, or a series of great lakes and flood plains such as existed in Tertiary times.³ The same applies to the Lake Superior, Texas, Arizona, and all of the later pre-Cambrian Algonkian formations.

On this hypothesis the evolution of the pre-Cambrian fauna was taking place in waters contiguous to the continental area, and their remains, buried in the sediments then accumulating, have not been found, owing to the fact that those sediments are now probably off the coast lines of the continent buried beneath the sea. That such a condition existed is suggested by the almost total absence of any traces of life in the pre-Cambrian sediments now existing on the continent.

GEOGRAPHIC DISTRIBUTION

Olenellus, as now restricted, has been found on both the western and eastern sides of North America and the northwest of Scotland. *Olenellus canadensis*, *O. gilberti*, and *O. fremonti* occur in the northern section of the Cordilleran Province in Alberta and British Columbia, and the two latter extend far to the south in Nevada and California. In the Appalachian Province *O. thompsoni*

¹ This name will be used by me in the future as the genus *Olenellus* is now limited to the upper zone of my *Olenellus* Fauna of 1891 [Walcott, 1891, pp. 515-597].

² This will be published as No. 1 of Vol. 57 of the Smithsonian Miscellaneous Collections.

³ The crustacean and annelid fossils described [Walcott, 1899, p. 238] might quite as well have been fresh water as marine forms. There is nothing as far as known to indicate that they were necessarily limited to a marine habitat.

and the closely related *Pædeumias transitans* range from Alabama to Lake Champlain and down the St. Lawrence valley to the south-eastern end of Labrador in the Atlantic Province. On the eastern side of the Atlantic *Olenellus lapworthi* is abundant in northwest Scotland on Loch Maree.

Olenellus has a wide distribution, and it may in the future be found in Siberia and far to the north within the Arctic Circle on both North America and Asia and adjacent islands.

Holmia has both an extended geographic and stratigraphic range, especially if we consider with it the closely related *Callavia* and *Wanneria*. *Holmia rowei* in the lower portion of the known Lower Cambrian horizon of Nevada is unknown elsewhere, and *H. kjerulfi* is limited to the Scandinavian area, but probably will be found to extend eastward into Russia and possibly Siberia. *Callavia* is essentially an Atlantic Province genus as the one species from Nevada, *C. ? nevadensis*, is a more or less doubtful reference.

Elliptocephala and *Nevadia* are each limited to a single species and a narrow distribution and stratigraphic range. *Mesonacis vermontana* occurs in western Vermont on Lake Champlain, and it will probably be found in the St. Lawrence River area. *Mesonacis ? mickwitzii* is probably a *Mesonacis*, but this awaits further proof.

Nothing is known of the Mesonacidæ on the Asiatic continent, and the evidence for the presence of any of its forms in Australia or elsewhere than as described in this paper is not sufficiently conclusive to justify my accepting it. I am prepared to learn that undoubted specimens have been found in Siberia and Australia, and possibly Sardinia and to the north in Spain and France.

With our present information, the Mesonacidæ is confined to western Europe and North America. The immediate descendants of the family are probably *Paradoxides* about the Atlantic Basin, and *Redlichia* [Walcott, 1905, p. 25] in eastern Asia, northern India, and Australia.

TRANSITION FROM THE MESONACIDÆ TO THE PARADOXINÆ

The question of the transition from the Lower Cambrian fauna to the Middle Cambrian fauna is one that has not been fully worked out. That all of the genera of the Mesonacidæ should disappear before the undoubted appearance of *Paradoxides* is a very significant fact and to me indicates that there was a transition fauna in the Atlantic Province, and that in most instances owing to shifting shore

lines and irregular deposition of sediments the record is incomplete. Both in England [Cobbold, 1910, pp. 19, 42, and 47] and New Brunswick [Walcott, 1900, pp. 302 and 320-322] the *Protolenus* fauna [Matthew, 1895, pp. 101-153] has been found beneath the horizon of the *Paradoxides* fauna and above the horizon of the Lower Cambrian fauna. The *Protolenus* fauna has a commingling of generic types common to both the Lower and Middle Cambrian faunas, but as yet nothing has been found that could be construed to be a connecting link between the Mesonacidae and Paradoxinae. In the western Pacific Province fauna of China, India, and Australia the genus *Redlichia* [Walcott, 1905, pp. 24-25] appears to be a form that combines characteristics of both families, and it may be that *Albertella* [Walcott, 1908a, pls. 1 and 2] may be found to have retained some of the characters of the Mesonacidae; also *Zacanthoides* [Walcott, 1908a, pl. 3]. The genus *Albertella* occurs in the passage beds between the Lower and Middle Cambrian or in beds at the top of the Lower Cambrian above *Olenellus canadensis*.

A specimen of the cephalon of *Paradoxides* was found by Mr. George Edson [1907, p. 209], of St. Albans, Vermont, in the St. Albans shales just west of the City of St. Albans. The St. Albans shales are argillaceo-arenaceous and carry lentiles of limestone that are more or less fossiliferous. The *Paradoxides* occurs in the shale and in a limestone lentile. Fig. 10 is taken from a compressed cephalon in the shale, and fig. 11 from a cephalon occurring in the limestone lentile along with *Agraulos*. As far as can be determined from the specimens of the cephalon the species is identical with *Paradoxides harlani* Green from the Braintree quarries near Boston, Massachusetts.

Mr. H. W. Shimer¹ identified under the name "*Olenellus (Holmia) bröggeri* (Shimer)" a crushed cephalon found in association with *Paradoxides harlani* Green. Through the courtesy of Dr. T. A. Jaggard, of the Massachusetts Institute of Technology at Boston, I have been able to study and photograph the specimen identified by Mr. Shimer and it is here reproduced as fig. 12. Beside it [fig. 13] is an undoubted cephalon of *P. harlani* from the same quarry. The Shimer specimen is compressed laterally so as to narrow the glabella and crowd the palpebral lobe inward and out of shape. I find among specimens of the cephalon of *P. harlani* considerable variation in the length of the palpebral lobe. In some it continues up to the side

¹ American Journ. Sci., 4th ser., Vol. 24, 1907, p. 177.

of the anterior lobe of the glabella and in others there is scarcely a trace of the ridges connecting the lobe above the eye, and the anterior glabellar lobe. There is no special reason why *Holmia* should not have continued on into *Paradoxides* time, but I do not think it is proven to have done so by the specimen described by Mr. Shimer.



FIG. 10.



FIG. 11.



FIG. 12.



FIG. 13.

FIG. 10. Cephalon of *Paradoxides* compressed in the St. Albans shale just west of the city of St. Albans, Franklin County, Vermont. U. S. National Museum.

11. Cephalon of *Paradoxides* from lentile of limestone in the St. Albans shale, at the same locality as fig. 10. U. S. National Museum.

12. Specimen identified by H. W. Shimer [1907, p. 177] as "*Olenellus (Holmia) bröggeri*." It should be compared with fig. 13.

13. Cephalon of *Paradoxides harlani* Green from the Middle Cambrian at Braintree, Massachusetts. U. S. National Museum.

DESCRIPTION OF GENERA AND SPECIES

NEVADIA, new genus

Dorsal shield broad, ovate. Cephalon large, semicircular in outline, about one-third the length of the dorsal shield; genal angles extended into spines; facial sutures rudimentary or in a condition of symphysis; eyes crescentic, with ridges uniting them with the anterior lobe of the glabella; glabella elongate, with a relatively small anterior lobe and three posterior transverse lobes; strong occipital ring.

Thorax with twenty-eight segments; body of pleuræ nearly straight; pleural furrow broad and parallel to the transverse axis of the pleuræ; pleuræ terminating in long, curved spines that are much shorter on the posterior eleven segments in the type species which are without a distinct, furrowed pleural lobe.

Pygidium small, without pleural lobes and transverse furrows.

Surface minutely granular and with irregular network of fine, irregular, anastomosing ridges.

Genotype.—*Nevadia wecksi*, new species.

The generic name is given after the State of Nevada, in which the specimens were found.

Stratigraphic range.—Lower Cambrian: Silver Peak group where the type species ranges through a band of arenaceous shale and quartzitic sandstone 222 feet in thickness. In the Barrel Spring section [Walcott, 1908, p. 189, 12 of section] the species was placed under the genus *Holmia*.

Geographic distribution.—Sixteen miles south and 10 miles northwest of Silver Peak, Esmeralda County, southwestern Nevada.

Observations.—*Nevadia* is probably the most primitive form of the Mesonacidae. The strong ridge uniting the eye lobe and the frontal lobe of the glabella in the adult is a marked feature of the young of *Elliptoccephala asaphoides* [pl. 24, figs. 3, 6, 7; pl. 25, figs. 9, 10, 11]; *Olenellus fremonti* [pl. 37, figs. 9, 10, 11]; and, as a case of reversion, in *Olenellus thompsoni* [pls. 34, 35] and similar forms of *Olenellus* from the upper portion of the Lower Cambrian terrane.

Nevadia appears to be the more primitive type and it occurs much deeper down in the Cambrian section than *Mesonacis vermontana* and *Elliptoccephala asaphoides*.

The elongate thorax of many segments; spinose extensions of the pleuræ; narrowing of the pleural lobes and their absence on the ten posterior segments; and the very small, simple pygidium without

pleural lobes are all primitive characters indicating a nearer approach to an annelidian ancestor than any other form of the Mesonacidae.

Nevadia differs from *Elliptoccephala* Emmons [pl. 24] in the more primitive character of the eye lobe in the adult and in the character of the posterior rudimentary segments.

Nevadia differs from *Mesonacis* Walcott [pl. 26] in the absence of an enlarged third thoracic segment in the adult and in the character of the ten posterior rudimentary thoracic segments.

NEVADIA WEEKSI, new species

PLATE 23, FIGS. 1-7, TEXT FIGS. 14 AND 15

Holmia weeksi WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, No. 5, p. 189. (Name given in list of fossils occurring in 12 of the section; the species does not occur in 3, 6, or 11 of the same section, nor in 2j of the Waucoba section [p. 187]. The specimens identified with this species from 3 of the section are referred in this paper to *Wanneria gracile*; those from 6 are referred to *Olenellus fremonti*; those from 11 are not specifically identified; and those from 2j of the Waucoba section are referred to *Olenellus fremonti*.)

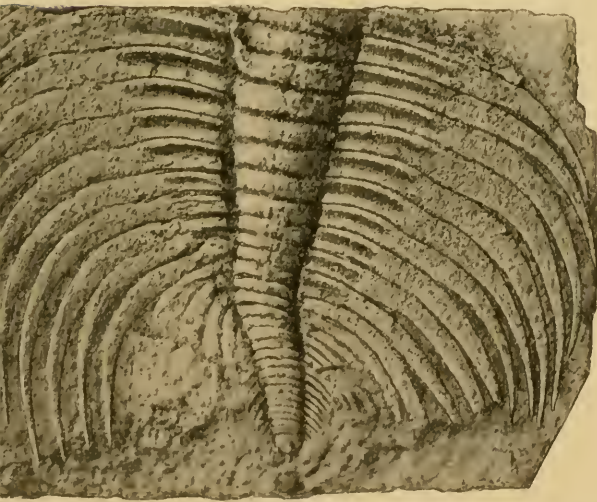


FIG. 14.



FIG. 15.

Nevadia weeksi, new species.

FIG. 14. Posterior portion of the dorsal shield preserving 18 rudimentary segments and the pygidium. Locality No. 1f, south of Silver Peak, Esmeralda County, Nevada. U. S. National Museum, Catalogue No. 56792i.

15. Anterior portion of dorsal shield associated with the specimen represented by fig. 14. U. S. National Museum, Catalogue No. 56792j.

Dorsal shield large; gently convex as preserved in the arenaceous shales; broadly ovate in outline. Cephalon transversely semicircular in outline, one-third the length of the adult dorsal shield; bordered by a narrow, wire-like rim that is extended at the genal angles into a slender spine; intergenal angles distinctly shown in adult specimens [fig. 3, pl. 23]. Glabella about four-fifths of the length of the cephalon; it narrows from the occipital segment towards the frontal lobe, as shown by figs. 2 and 3; in a small specimen of the cephalon 3.75 mm. in length it is almost cylindrical, with the sides converging slightly toward the front; the anterior lobe is about two-fifths the length of the glabella and narrower than the lobes posterior to it; it was evidently convex before being flattened in the shale, and narrowed toward the front; the three posterior transverse lobes decrease in size from the front to the posterior lobe, and slope from each side gently backwards toward the center; the glabellar furrows are narrow and in the specimens available for study are united at the center by a shallow groove. Occipital segment transverse, stronger than the posterior segment of the glabella and separated from it by a narrow, clearly defined furrow.

Eye lobe long, crescentiform, broad at the base and extending from opposite the back portion of the anterior lobe of the glabella back to nearly opposite the occipital furrow; it is united, even in large adult specimens, by a strong ridge to the frontal lobe of the glabella [fig. 3], very much in the same manner as in small cephalons of *Elliptocephala asaphoides* [pl. 24, figs. 3, 4, 6, and 7]; the posterior end of the eye lobe is rather close to the dorsal furrow between it and the glabella. Cheeks broad, large, and beautifully marked on the interior surface by a system of irregular canals extending from the base of the eye lobe toward the outer margin [fig. 6].

Thorax elongate, tapering gently from the cephalon to the pygidium. It has twenty-eight segments, the anterior seventeen of which are progressively smaller, but otherwise uniform in character; these may be designated as the normal segments of this species; the posterior eleven segments have only the curved spinose extension of the segment beyond the axial lobe, the body portion of the pleural lobe not appearing back of the seventeenth segment. In a small dorsal shield with a cephalon 3.75 mm. in length the pleural lobes disappear beside the axial lobe at about the tenth segment from the cephalon. Unfortunately, the posterior segments are broken off. The axial lobe is convex; less than one-half the width of the pleural

lobes with their spinose extensions. On large specimens an elongate node occurs at the posterior center of each segment; it is not known if the posterior eleven segments had median spines of the type occurring on *Elliptoccephala asaphoides* [pl. 24, fig. 1]. The pleural lobes of the anterior seventeen segments gradually become shorter until at the seventeenth there is only a trace of the lobe and its median furrow; each pleura has a broad, strong furrow that is nearly the full width of the segment at its union with the axial lobe, from whence it narrows gradually to the base of the spinose extension of the pleura; the latter are elongate and gently curved backward near the cephalon; from whence they increase in length and curvature to the seventeenth segment, where their length and backward curvature are so great that they extend a considerable distance back of the posterior eleven segments and pygidium; the posterior eleven segments of the axial lobe have a backward extending lateral spine attached directly to them [pl. 23, fig. 4] without any intervening grooved pleural lobe.

Pygidium apparently a continuation of the axial lobe without pleural lobes or spines; it is small and, as far as can be determined from compressed specimens, it is a simple plate of about equal length and breadth that narrows toward the posterior margin.

Surface minutely granular and with very narrow raised lines or ridges that unite to form an irregular network over glabella and the central portions of the thoracic segments. On the broad cheeks the ridges radiate more or less irregularly from the base of the eye toward the margins of the cephalon.

Dimensions.—A dorsal shield 41 mm. in length that is flattened in arenaceous shale has the following dimensions. (Two thoracic segments are crowded up beneath the cephalon):

<i>Cephalon:</i>	<i>mm.</i>
Length	13.25
Width at base.....	31.5
Length of eye lobe.....	5.
Length of glabella.....	9.
Width of glabella at base.....	7.
Width of glabella at front.....	4.
<i>Thorax:</i>	
Length	26.
Width at anterior segment, including spinose extension of pleuræ	33.
Width at seventeenth segment, including spinose extension.....	30.
Width at twenty-eighth segment, including spinose extension.....	24.

Width of axial lobe, anterior segment.....	6.5
Width of axial lobe, seventeenth segment.....	3.
Width of axial lobe, twenty-seventh segment.....	1.5
Width of pleural lobe, anterior segments.....	6.5
Width of pleural lobe, seventeenth segment.....	1.

Pygidium:

Length	about 1.75
Width at front.....	1.5

The preceding description is based on specimens compressed in an arenaceous shale that has had sufficient distortion to flatten the dorsal shield and widen it. The normal form of the cephalon is probably nearest to that of the cephalon represented by fig. 5. The largest dorsal shield found indicates a total length of 126 mm.

Observations.—This species is one of the most primitive known to me. The form of the anterior lobe of the glabella is primitive, and its twenty-eight segments with posterior eleven so very simple indicate a closer approach to annelidian progenitors than any of its associates in the Lower Cambrian, Georgian, fauna; it has three more thoracic segments than *Mesonacis vermontana* (Hall) [pl. 26, fig. 1] and the posterior eleven are more primitive in form.

Nevadia wecksi differs from *Elliptoccephala asaphoides* [pl. 24] in so many ways that it is not necessary to describe them. The points of generic similarity are in the cephalon where the general characters are similar; in the thorax where the segments are of the same type back to the rudimentary segments; and the pygidium appears to be similar, although relatively much smaller in *N. wecksi*.

This species was identified and named *Holmia wecksi*, new species, and the name used in the Barrel Spring geological section [Walcott, 1908, pp. 188-189], and in the Waucoba Springs section [*Idem*, pp. 186-187].

The specific name is in recognition of the excellent work of Mr. F. B. Weeks, formerly of the United States Geological Survey.

FORMATION AND LOCALITY.¹—Lower Cambrian: Silver Peak Group in hard arenaceous shales at the following localities: (1f) in No. 12 of the Barrel Spring section [Walcott, 1908c, p. 189], 3 miles (4.8 km.) northeast of Barrel Spring, which is 10 miles (16 km.) south of the town of Silver Peak; and (174b) 10 miles (16 km.) northwest of Silver Peak on ridge north of Red Mountain; both in Esmeralda County, Nevada.

¹ The type locality is given in italics, when there is more than one locality. The locality numbers in heavy-face type are the numbers assigned to the specimens in the collections of the United States National Museum.

Genus MESONACIS Walcott

- Barrandia* HALL (in part), 1860, Thirteenth Ann. Rept. New York State Cab. Nat. Hist., p. 115. (Described and discussed. As described the genus includes forms now referred to both *Mesonacis* and *Olenellus*. Beginning with the 5th paragraph the text is a description of "*Barrandia thompsoni*.")
- Barrandia* HALL (in part), 1861, Report on the Geology of Vermont, Vol. 1, p. 369. (Copy of Hall, 1860, p. 115; the reference includes species referred to both *Mesonacis* and *Olenellus*. Beginning with the 5th paragraph the text is a description of the species "*Barrandia thompsoni*"; this is also copied from the preceding reference.)
- Olenellus* FORD (in part), 1881, American Journ. Sci., 3d ser., Vol. 22, p. 251. (As discussed in this paper the genus *Olenellus* includes forms now referred to *Elliptocephala*, *Mesonacis*, and *Olenellus*.)
- Mesonacis* WALCOTT, 1885, American Journ. Sci., 3d ser., Vol. 29, pp. 328-330. (Discussed as a new genus.)
- Mesonacis* WALCOTT, 1886, Bull. U. S. Geol. Survey, No. 30, p. 158. (Merely gives its position in the classification of the trilobites.)
- Olenellus* HOLM (in part), 1887, Geol. Fören. i Stockholm Förhandl., Bd. 9, Häfte 7, pp. 498-499. (Described in Swedish. As described and discussed throughout the paper, the genus includes many of the forms now placed in the family Mesonacidae.)
- Elliptocephalus* (*Schmidtia*) MARCOU (in part), 1890, American Geologist, Vol. 5, p. 363. (*Schmidtia* is proposed as a new subgenus to include forms that are now referred to *Mesonacis mickwitzii*, *Mesonacis vermontana*, and *Zacanthoides typicalis*.)
- Not *Schmidtia* VOLBORTH [1860] = Brachiopod.
- Not *Schmidtia* BALS-CRIV. = Protozoan.
- Olenellus* (*Mesonacis*) WALCOTT, 1891, Tenth Ann. Rept. U. S. Geol. Survey, p. 637. (*Mesonacis* is here placed as a subgenus of *Olenellus*. The forms referred to the subgenus are now placed under both *Mesonacis* and *Elliptocephala*.)
- Mesonacis* COLE, 1892, Natural Science, Vol. 1, pp. 342 and 344. (Discussed. In the legend of figure 2, p. 343, *Mesonacis* is placed as a subgenus of *Olenellus*.)
- Mesonacis* PEACH and HORNE (in part), 1892, Quart. Journ. Geol. Soc. London, Vol. 48, p. 236. (As defined this genus includes forms now referred to both *Elliptocephala* and *Mesonacis*.)
- Mesonacis* (*Olenellus*) PEACH, 1894, Idem, Vol. 50, pp. 671-674. (As discussed in these pages this genus includes forms now referred to both *Elliptocephala* and *Mesonacis*.)
- Elliptocephala* (*Mesonacis*) BEECHER, 1897, American Journ. Sci., 4th ser., Vol. 3, p. 192. (*Mesonacis* is stated to be probably of only subgeneric value under *Elliptocephala*.)
- Mesonacis* MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, p. 318. (Described in Swedish. The genus is discussed frequently on pages 309-320 of the paper.)
- Schmidtia* MOBERG, 1899, Idem, p. 319 and footnote. (Discussed in Swedish.)

Mesonacis WELLER, 1900, Ann. Rept. Geol. Survey, New Jersey, for 1899, pp. 50-51. (Discussed.)

Schmidtellus MOBERG, in Moberg and Segerberg, 1906, Meddelande från Lunds Geologiska Fältklubb, Ser. B, No. 2 (Aftryck ur Kongl. Fysiografiska Sällskapets Handlingar, N. F., Bd. 17), p. 35, footnote. (Proposed as a new genus by Moberg for *Schmidtia* Marcou, preoccupied.)

Type of the genus *Mesonacis vermontana* Hall. The description of the genus is incorporated with that of the type species [Walcott, 1886, pp. 158-162], and its relations are discussed in this paper under observations on the Mesonacidae (pp. 244, 246, and 250).

MESONACIS MICKWITZI (Schmidt)

PLATE 26, FIG. 4, TEXT FIGS. 16 AND 17.

Olenellus mickwitzi SCHMIDT, 1888, Mém. Acad. Imp. Sci. St.-Pétersbourg, 7th ser., Vol. 36, No. 2, pp. 13-19, pl. 1, figs. 1-25. (Described and discussed. Figure 1, with the exception of the cephalon which was added from other specimens, is copied in his paper, pl. 26, fig. 4.)

Olenellus mickwitzi SCHMIDT, 1889, Mélanges Géol. et Paléontol. tirés du Bull. Acad. Imp. Sci. St.-Pétersbourg, N. S., Vol. 1 (33), pp. 191-195, 10 text figures on page 193. (Described and discussed, giving additional details. Figures 1 and 9 are copied in this paper as text figures 16 and 17, p. 263.)

Elliptoccephalus (*Schmidtia*) *mickwitzi* (Schmidt), MARCOU, 1890, American Geologist, Vol. 5, p. 363. (The subgenus *Schmidtia* is proposed for this and other species.)

Olenellus (*Mesonacis*) *mickwitzi* (Schmidt), WALCOTT, 1891, Tenth Ann. Rept. U. S. Geol. Survey, p. 634, pl. 93, fig. 1. (Merely refers the species to *Mesonacis* and copies Schmidt's restoration [1888, pl. 1, fig. 1].)

Mesonacis mickwitziae PEACH, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, p. 672, text fig. B, p. 673. (Mentioned. The text figure is copied from a part of one of Schmidt's figures.)

Olenellus (*Mesonacis*) *mickwitzi* FRECH, 1897, Additional plates inserted in 1897 in Lethæa geognostica, Pt. 1, Lethæa palæozoica, Atlas, pl. 1a, fig. 8. (Figure 8 is copied from Schmidt, 1888, pl. 1, fig. 1.)

Schmidtia mickwitzi (Schmidt), MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, pp. 319-320, pl. 13, figs. Va-c. (Described and discussed; figure Va is copied from Schmidt [1888, pl. 1, fig. 1] and figures Vb and Vc are copied from Schmidt [1889, figs. 1 and 9, p. 193].)

Schmidtellus mickwitzi MOBERG, in Moberg and Segerberg, 1906, Meddelande från Lunds Geologiska Fältklubb, Ser. B, No. 2 (Aftryck ur Kongl. Fysiografiska Sällskapets Handlingar, N. F., Bd. 17), p. 35, footnote. (Merely proposes the new generic name *Schmidtellus* for this species, *Schmidtia* Marcou being preoccupied.)

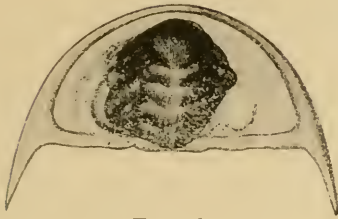


FIG. 16.

Mesonacis mickwitzii (Schmidt).

FIG. 16. Cephalon, copied from Schmidt, 1889, fig. 1, p. 193.

17. Pygidium, copied from Schmidt, 1889, fig. 9, p. 193.



FIG. 17.

This species is known only by fragments that have been most fully described and illustrated by Schmidt [1888 and 1889]. Dr. Schmidt's restoration of the posterior portions of the thorax is copied on pl. 26, fig. 4. The similarity to *Mesonacis vermontana* is shown by figs. 1 and 2, pl. 26. Schmidt [1889] says that the pygidium shows a slight notch on the back edge. He also observed traces of transverse furrows on the axis and very faintly on the lateral lobes. The fragments of the hypostoma indicate that the general form is similar to that of *Olenellus*.

The cephalon of *M. mickwitzii* is much like that of *M. vermontana*, and the pygidium, posterior thoracic segments, and the great spine on the sixth (?) segment from the pygidium are also of the same type. Dr. Moberg [1899, footnote, p. 319] thinks that as the generic name *Schmidtia* is already in existence, and that as the type species is so imperfectly known it would be well to retain *Schmidtia* for it, and not refer it to *Mesonacis*. These reasons do not appeal strongly to me, and as *Schmidtia* was preoccupied by Volborth in 1860, I think it is best to refer the species to *Mesonacis* and retain it there until further information of it is obtained. Dr. Moberg [1906] proposed *Schmidtellus* to take the place of *Schmidtia*, but, as stated above, I think it best to retain the species under *Mesonacis* until more is known of it.

FORMATION AND LOCALITY.—Lower Cambrian: The following localities are given by Schmidt, 1888, p. 19: (1) lower layers of the Fucoid sandstone¹ on Jaggowal Brook; (2) at the same horizon near the cement works on Kunda Brook; and (3) glauconitic sandstone at the base of the section in Streitberg; all near Reval, Government of Esthonia, Russia.

¹ Esthonia formation of Marcou [1890, pp. 360-361].

MESONACIS TORELLI (Moberg)

PLATE 26, FIGS. 5-18

Olenellus torelli MOBERG, 1892, Om Olenellusledet i sydliga Skandinavien, p. 3. (Specimens exhibited at 14th meeting of Scandinavian naturalists at Copenhagen discussed.)

Schmidtia ? torelli MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, pp. 330-338, pl. 15, figs. 1-17. (Described and discussed in Swedish. Figures 1b, 4, 6, 7, 8, 10, 12, 15, and 16 of Moberg are copied in this paper, pl. 26, figs. 5a, 7, 9, 17, 16, 18, 14, 11, and 15 respectively. Plaster casts of the specimens represented by figures 1a, 6, and 14 of Moberg are figured in this paper, pl. 26, figs. 5, 10, and 10a, and 8 respectively.)

Dr. Joh. Chr. Moberg gives a very full description of this interesting species as represented by numerous fragments of the cephalon and thorax and entire specimens of the pygidium. Dr. Moberg very kindly sent me casts of the specimens he used for illustration, also a few natural specimens. From the casts and specimens a few figures have been made that will serve to indicate the principal characters of the species.

The generic reference is based on the general similarity of the cephalon and pygidium to that of *Mesonacis vermontana* [pl. 26, fig. 1], the presence of a thoracic segment bearing a large spine, and the fact so well stated by Dr. Moberg that the central lobe of the thorax was about as wide as half the width of the thorax, this indicates a slender thorax similar to that of *M. vermontana*.

Obolella lindströmi Walcott, *O. mobergi* Walcott, and a *Hyalithes* like *H. degeeri* Holm occur with fragments of *M. torelli*.

FORMATION AND LOCALITY.—Lower Cambrian: (312v) bluish-gray sandstone, along the coast near Björkelunda, south from Simrishamn, Province of Kristianstad, Sweden [Moberg, 1899, p. 337].

The species is doubtfully identified by Moberg [1899, p. 337] in sandstone occurring between Sularp and Norrtorp, near Fogelsång, Province of Malmöhus, Sweden.

MESONACIS VERMONTANA (Hall)

PLATE 26, FIGS. 1-3

Olenus vermontana HALL, 1859, Twelfth Ann. Rept. New York State Cab. Nat. Hist., pp. 60-61, fig. 2, p. 60. (Described and discussed as a new species.)

Olenus vermontana HALL, 1859, Nat. Hist. New York, Paleontology, Vol. 3, pt. 1, p. 527, text figure. (Copy of the preceding reference.)

Barrandia vermontana HALL, 1860, Thirteenth Ann. Rept. New York State Cab. Nat. Hist., p. 117, text figure. (Discussed. The figure is copied from Hall, 1859, fig. 2, p. 60.)

Paradoxides vermonti EMMONS, 1860, Manual of Geology, 2d ed., p. 280, note A. (Note on the stratigraphic position of the species.)

Paradoxides vermontana BARRANDE, 1861, Bull. Soc. Géol. de France, 2d ser., Vol. 18, pp. 277-278, pl. 5, fig. 8. (Translates into French the description given by Hall [1859, pp. 60-61] and copies Hall's outline figure [1859, fig. 2, p. 60].)

? *Paradoxides vermontana* (Hall), BILLINGS, 1861, Geol. Survey Canada, Paleozoic Fossils, p. 11. (Mentions presence of heads representing this species at Anse au Loup. In view of the close similarity between the heads of several of the forms now referred to the different genera of the Mesonacidae the occurrence of this species at the locality mentioned must be regarded as doubtful.)

Barrandia vermontana HALL (in part), 1861, Report on the Geology of Vermont, Vol. 1, p. 370, first 6 paragraphs. (Copies the paragraph given by Hall [1860, p. 117] and describes the species. The text includes reference to figures given by Hall [1862, pl. 13] which are referred in this paper to *Paedeumias transitans*.)

Barrandia vermontana HALL (in part), 1862, Report on the Geology of Vermont, Vol. 2, pl. 13, fig. 2 (not figs. 4 and 5, referred in this paper to *Paedeumias transitans*). (Figure 2 is copied from Hall, 1860, text figure, p. 117; figures 4 and 5 appear to represent forms more like *Paedeumias transitans* than *Mesonacis vermontana*.)

Olenellus vermontana HALL, 1862, Fifteenth Ann. Rept. New York State Cab. Nat. Hist., p. 114. (Generic name *Olenellus* proposed.)

Olenellus vermontana BILLINGS, 1865, Geol. Survey Canada, Paleozoic Fossils, Vol. 1, p. 11. (Reprinted from Billings, 1861a, p. 11, substituting *Olenellus* for *Paradoxides*.)

Olenellus vermontanus FORD, 1881, American Journ. Sci., 3d ser., Vol. 22, fig. 13, p. 258. (Figure 13 is copied from Hall, 1859, fig. 2, p. 60.)

Not *Olenellus vermontana* WHITFIELD, 1884, Bull. American Mus. Nat. Hist., Vol. 1, No. 5, pp. 152-153, pl. 15, figs. 2-4. (Referred in this paper to *Paedeumias transitans*.)

Mesonacis vermontana WALCOTT, 1885, American Journ. Sci., 3d ser., Vol. 29, pp. 328-330, figs. 1 and 2, p. 329. (Discussed. Figures 1 and 2 are outline drawings of the specimen figured in this paper, pl. 26, figs. 1 and 2.)

Mesonacis vermontana (Hall), WALCOTT, 1886, Bull. U. S. Geol. Survey, No. 30, pp. 158-162, pl. 24, figs. 1, 1a-b. (Copies the original description given by Hall, 1859, pp. 60-61, and describes and discusses the species. Figure 1 is copied from Hall, 1859, fig. 2, p. 60; and figures 1a and 1b are drawn from the specimen figured by Walcott, 1885, text figs. 1 and 2, p. 329. This specimen is the one illustrated in this paper, pl. 26, figs. 1 and 2.)

- Olenellus vermontana* (Hall), HOLM, 1887, Geol. Fören. i Stockholm Förhandl., Bd. 9, Häfte 7, pp. 515-516. (Described in Swedish. The species is frequently mentioned also in the discussion of "*Olenellus kjerulfi*.")
- Elliptocephalus (Schmidtia) vermontana* MARCOU, 1890, American Geologist, Vol. 5, p. 363. (The subgenus *Schmidtia* is proposed for this and other species.)
- Olenellus (Mesonacis) vermontana* (Hall), WALCOTT, 1891, Tenth Ann. Rept. U. S. Geol. Survey, p. 637, pl. 87, figs. 1, 1a-b. (No text reference. Figure 1 is copied from Hall, 1859, fig. 2, p. 60; and figures 1a and 1b are copied from Walcott, 1886, pl. 24, figs. 1a and 1b.)
- Olenellus (Mesonacis) vermontana* (Hall), COLE, 1892, Natural Science, Vol. 1, pp. 340 and 341, fig. 2, p. 343. (Discussed. The figure is an outline drawing of the figure given by Walcott, 1886, pl. 24, fig. 1a.)
- Mesonacis vermontana* MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, p. 318, pl. 13, fig. 4. (Mentioned at several places in the text. The figure is copied from Walcott, 1886, pl. 24, fig. 1a.)

A detailed description of this species was given in 1886 [Walcott, 1886, p. 158]. Nothing has been added to our information of it since that date and no additional specimens have been discovered. The finding of a specimen of *Pædeumias transitans* in association with *Mesonacis vermontana* at Georgia, Vermont, in which three rudimentary segments and a *Mesonacis*-like pygidium occur beneath the telson [pl. 33, fig. 1] corroborated the view held in 1886 [Walcott, 1886, p. 166] that the body of *Mesonacis* was shortened by the absorption of the posterior segments and the spine on the fifteenth segment became the elongate telson of *Olenellus*. At first I was inclined to refer the form with the three rudimentary segments to *Mesonacis*, but with the discovery at York, Pennsylvania, by Prof. Atreus Wanner, of numerous specimens with from two to six rudimentary segments, and that all the rudimentary segments were unlike those of *Mesonacis vermontana*, I decided finally to include such specimens in a new genus *Pædeumias*, and to retain in *Mesonacis* only those specimens that have only normal thoracic segments posterior to the fifteenth spine-bearing segment.

FORMATION AND LOCALITY.—Lower Cambrian: (25) *siliceous shale just above Parkers quarry, near Georgia, Franklin County, Vermont.*

Specimens corresponding to the cephalon of this species occur at Bonne Bay, Newfoundland, and L'Anse au Loup, on the north side of the straits of Belle Isle, Labrador.

Genus ELLIPTOCEPHALA Emmons

- Elliptocephala* EMMONS, 1844, Taconic System, p. 21, legend of fig. 1. (Characterized.)
- Elliptocephala* EMMONS, 1846, Nat. Hist. New York, Agriculture, Vol. 1, pt. 5, p. 65, legend of fig. 1. (Copy of preceding reference.)
- Olenus* HALL, 1847, Nat. Hist. New York, Paleontology, Vol. 1, p. 256, footnote. (Places "*Elliptocephalus*" as a synonym of *Olenus*.)
- Elliptocephalus* EMMONS, 1849, Proc. American Assoc. Adv. Sci., First meeting, p. 18. (Notes on the genus as distinct from *Olenus* and *Paradoxides*.)
- Elliptocephalus* EMMONS, 1855, American Geology, Vol. 1, pt. 2, pp. 114-115. (Discussed.)
- Elliptocephalus* (Emmons), MARCOU, 1860, Proc. Boston Soc. Nat. Hist., p. 371. (Considers "*Elliptocephalus*" to be a true *Paradoxides*.)
- Olenellus* (*Elliptocephalus*) FORD, 1877, American Journ. Sci., 3d ser., Vol. 13, pp. 265-272. (A very full description of the type species *O. (E.) asaphoides*.)
- Olenellus* FORD, 1878, American Journ. Sci., 3d ser., Vol. 15, p. 130, footnote. (Discusses the generic relations of *Olenellus*, as represented by *O. asaphoides*, and *Paradoxides* as represented by *P. aculeatus* and *P. kjerulfi*.)
- Olenellus* FORD (in part), 1881, American Journ. Sci., 3d ser., Vol. 22, pp. 250-259. (As discussed throughout the paper the genus *Olenellus* includes forms now referred to *Elliptocephala*, *Mesonacis*, and *Olenellus*.)
- Olenellus* WALCOTT (in part) [not HALL], 1886, Bull. U. S. Geol. Survey, No. 30, pp. 162-166. (Described and discussed. As discussed the genus includes forms now referred not only to *Olenellus* but to *Elliptocephala*, *Callavia*, and *Peachella*. On pages 622-623 are given reasons for rejecting *Elliptocephala* as a generic name.)
- Olenellus* HOLM (in part), 1887, Geol. Fören. i Stockholm Förhandl., Bd. 9, Häfte 7, p. 498-499. (Described in Swedish. As described and discussed throughout the paper this genus includes many of the forms now placed in the family *Mesonacidae*.)
- Ebenezeria* MARCOU, 1888, Mem. Boston Soc. Nat. Hist., Vol. 4, p. 123. (Proposed as a new genus to replace "*Elliptocephalus*" because of the similarity of the latter genus to *Ellipsocephalus* Zenker.)
- Elliptocephalus* (Emmons), MARCOU, 1890, American Geologist, Vol. 5, p. 362. (Argues that "*Elliptocephalus*" has right of priority over *Olenellus*.)
- Olenellus* (*Mesonacis*) WALCOTT (in part), 1891, Tenth Ann. Rept. U. S. Geol. Survey, p. 637. (Merely uses *Mesonacis* as a subgenus; the forms referred to the subgenus are now placed with *Elliptocephala* and *Mesonacis*.)
- Elliptocephala* COLE, 1892, Natural Science, Vol. 1, p. 340. (Discussed.)
- Mesonacis* PEACH and HORNE (in part), 1892, Quart. Journ. Geol. Soc. London, Vol. 48, p. 236. (As defined this genus includes forms now referred to both *Elliptocephala* and *Mesonacis*.)

- Olenellus* BERNARD, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, pp. 415-416. (Discusses evidence afforded by this genus as to the systematic position of the trilobites.)
- Mesonacis* (*Olenellus*) PEACH (in part), 1894, Idem, pp. 671-674. (As discussed in these pages this genus includes forms now referred to both *Elliptocephala* and *Mesonacis*.)
- Elliptocephala* (Emmons), BEECHER, 1897, American Journ. Sci., 4th ser., Vol. 3, pp. 191 and 192. (Name used in discussion of genera of the *Olenidae*.)
- Georgiellus* MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, p. 317. (Proposed as a new genus to replace *Elliptocephala*.)
- Elliptocephala* (Emmons), MATTHEW, 1899, American Geologist, Vol. 24, p. 59. (In review of Moberg's paper [1899] considers that *Elliptocephala* should be retained.)
- Olenellus* (*Georgiellus*) POMPECKJ, 1901, Zeitschr. Deutschen geol. Gesellschaft, Vol. 53, Heft 2, p. 16. (Emmons' species is merely mentioned as "*O. (Georgiellus) asaphoides*" in the discussion of the relations between *Olenopsis* and various genera of the *Mesonacidae*.)
- Olenellus* LINDSTRÖM, 1901, Kongl. Svenska Vet.-Akad. Handlingar, Vol. 34, No. 8, pp. 12-18, and 24. (A discussion of the development of the *Olenellidae* is almost entirely based upon features exhibited by the type species of the genus *Elliptocephala*.)

The characters of the genus are outlined in the description of the genotype, *E. asaphoides*, which is the only known species. Observations on *Elliptocephala* are also made in the section on *Mesonacidae* (pp. 244 and 247).

Genotype.—*Elliptocephala asaphoides* Emmons.

Stratigraphic range.—Lower Cambrian: Greenwich formation¹ in shales and interbedded limestones and sandstones of unknown thickness, but as far as known not over 300 feet.

Geographic distribution.—On the eastern side of the Hudson River valley, in Washington and Rensselaer counties, New York.

Young stages.—Reference is made to the younger stages of growth of this genus in the description of the development of the individual of the family *Mesonacidae*, p. 236. This, with the illustrations on plates 24 and 25, will give the student the means of comparison with the young stages of other genera. The specimens in the Ford collection are now in the New York State Museum at Albany, New York.

¹ Mr. T. Nelson Dale [1904, p. 29] gives a section of the Lower Cambrian series exposed in Rensselaer County, and part of Columbia County, New York. On pages 43 and 50 he states that this series is regarded as equivalent to the Greenwich formation of Washington County, New York, and Rutland County, Vermont. The series is also regarded as equivalent to the Vermont formation and is mapped on plate I of the same paper under the heading "Greenwich slate,

Observations.—*Eliptocephala* appears to be a more advanced form of the Mesonacidæ than *Mesonacis*. It has seven less segments in the thorax and the stage of large third segment is passed in the young and is lost in the adult. The five small posterior segments of *Eliptocephala* suggest that they are rudimentary segments by reversion, as in *Padeumias* [pl. 33], and not rudimentary as the result of non-development, as in *Nevadia* [pl. 23]. From its stratigraphic position and associated fossils it is probably somewhat older than *Mesonacis vermontana* Hall.

ELLIPTOCEPHALA ASAPHOIDES Emmons

PLATE 24, FIGS. 1-10; PLATE 25, FIGS. 1-18

Eliptocephala asaphoides EMMONS, 1844, Taconic System, p. 21, figs. 1, 2, and 3. (Characterized in description of figure 1.)

Eliptocephala asaphoides EMMONS, 1846, Nat. Hist. New York, Agriculture, Vol. 1, p. 65, figs. 1, 2, and 3. (Copy of preceding reference.)

Olenus asaphoides (Emmons), HALL, 1847, Nat. Hist. New York, Paleontology, Vol. 1, pp. 256-257, pl. 67, figs. 2a-c. (Describes species and redraws the three specimens illustrated by Emmons [1844, p. 21, figs. 1, 2, and 3].)

Olenus asaphoides (Emmons), FITCH, 1849, Trans. New York State Agric. Soc. for 1849, p. 865. (Occurrence mentioned.)

Eliptocephalus asaphoides EMMONS, 1849, Proc. American Assoc. Adv. Sci., First Meeting, p. 18. (Discussed with particular reference to the generic distinction between *Eliptocephalus*, *Paradoxides*, and *Olenus*.)

Eliptocephalus asaphoides EMMONS, 1855, American Geology, Vol. 1, pt. 2, p. 114, figs. 1, 2, and 3; and pl. 1, fig. 18. (Described. Figures 1, 2, and 3 are copied from Emmons, 1844, figs. 1, 2, and 3, p. 21.)

Not *Paradoxides asaphoides* EMMONS, 1860, p. 87 = *Olenellus thompsoni*.

Not *Paradoxides macrocephalus* EMMONS, 1860, fig. 70, p. 88, and p. 280 = *Olenellus thompsoni*. (In the first edition of the Manual of Geology this figure was labeled *Paradoxides brachycephalus*.)

Not *Eliptocephalus* (*Paradoxides*) *asaphoides* EMMONS, 1860, p. 280 = *Olenellus thompsoni*.

Paradoxides asaphoides (Emmons), BARRANDE, 1861, Bull. Soc. Géol. de France, 2d ser., Vol. 18, pp. 273-276, pl. 5, figs. 4 and 5. (Translates into French the legend of figures 1 and 2 of Emmons [1844, p. 21] and copies figure 1 of the same paper in fig. 4, pl. 5. Figure 5 of Barrande's paper is copied from Emmons [1855, pl. 1, fig. 18]. Barrande also translates into French the description and discussion given by Hall [1847, p. 256].)

Not *Paradoxides macrocephalus* BARRANDE, 1861, Idem, pl. 5, fig. 7 = *Olenellus thompsoni*.

Vermont formation." This is apparently the first use of the term "Greenwich slate," the previous mention of the series, to which Mr. Dale refers on page 50 being the table opposite page 178 of his paper in the 19th Annual Report of the U. S. Geological Survey [1899] where no formation names are used.

- Olenellus (Olenus) asaphoides* (Emmons), FORD, 1871, American Journ. Sci., 2d ser., Vol. 2, p. 33. (Gives name in list of species from rocks at Troy, N. Y.)
- Olenellus (Olenus) asaphoides* (Emmons), FORD, 1871, Canadian Naturalist, new ser., Vol. 6, p. 210. (Copy of preceding reference.)
- Olenellus (Elliptocephalus) asaphoides* (Emmons), FORD, 1877, American Journ. Sci., 3d ser., Vol. 13, pp. 265-272, pl. 4, figs. 1-10. (Described and discussed in detail, both young and adult specimens being illustrated.)
- Olenellus asaphoides* (Emmons), FORD, 1878, American Journ. Sci., 3d ser., Vol. 15, pp. 129-130. (Note on the development of the young and on the generic relations of the species.)
- Olenellus asaphoides* (Emmons), FORD, 1881, American Journ. Sci., 3d ser., Vol. 22, pp. 250-259, figs. 1, 2, and 3, p. 251. (Observations on the generic relations and larval stages of the species. Figure 3 is an outline drawing of the figure given by Ford [1877, pl. 4, fig. 5].)
- Olenellus asaphoides* (Emmons), WALCOTT, 1884, Monogr. U. S. Geol. Survey, Vol. 8, pp. 36-37, pl. 21, figs. 10, 11, and 12. (Young stages of growth referred to. Figure 10 is an outline drawing based on Ford's figure [1877, pl. 4, fig. 2b], and figures 11 and 12 are similar drawings based on the cephalons of the figures given by Ford [1881, figs. 1 and 2, p. 251].)
- Olenellus asaphoides* (Emmons), WALCOTT, 1886, Bull. U. S. Geol. Survey, No. 30, pp. 168-170, pl. 17, figs. 3-8 and 10; pl. 20, figs. 3, 3a-b; and pl. 25, fig. 8. (Described and discussed. The specimen represented by fig. 3, pl. 17, is redrawn in this paper, pl. 25, fig. 18; figures 5 and 6, pl. 17, are copied in this paper, pl. 25, figs. 9 and 10; fig. 7, pl. 17, is copied from Ford, 1877, pl. 4, fig. 5; fig. 8, pl. 17, is copied from Ford, 1881, fig. 1, p. 251; figs. 3a-b, pl. 20, are copied from Walcott, 1884, pl. 21, figs. 10, 11, and 12, respectively; and fig. 8, pl. 25, is copied in this paper pl. 24, fig. 10.)
- Olenellus asaphoides* (Emmons), HOLM, 1887, Geol. Fören. i Stockholm Förhandl., Bd. 9, Häfte 7, p. 515. (Described in Swedish. The species is frequently mentioned also in the discussion of "*Olenellus kjerulfi*.")
- Elliptocephalus asaphoides* (Emmons), MARCOU, 1888, American Geologist, Vol. 2, p. 12. (Discussed.)
- Ebenezeria asaphoides* MARCOU, 1888, Mem. Boston Soc. Nat. Hist., Vol. 4, p. 123. (Merely proposes the new generic name for the species because of the close similarity between "*Elliptocephalus*" Emmons and *Ellipsocephalus* Zenker.)
- Olenellus asaphoides* (Emmons), LESLEY, 1889, Geol. Survey Pennsylvania, Report P4, Vol. 2, p. 489, 10 text figures. (Figures 3, 5, 6, 7, 8, and 10 are copied without change in number from Walcott, 1886, pl. 17; and figs. 3, 3a, and 3b are copied in the same manner from Walcott, 1886, pl. 20.)
- Olenellus (Mesonacis) asaphoides* (Emmons), WALCOTT, 1890, Proc. U. S. National Museum, Vol. 12, p. 41. (Mentions discovery of entire specimens of the dorsal shield.)

- Olenellus asaphoides* (Emmons), MATTHEW, 1891, American Geologist, Vol. 8, p. 289 and footnote. (Suggests that the species is from a different horizon from that of "*Olenellus thompsoni*" and "*Olenellus (Mesonacis) vermontana*," and believes that *Elliptoccephala* should be retained as the generic reference.)
- Olenellus (Mesonacis) asaphoides* (Emmons), WALCOTT, 1891, Tenth Ann. Rept. U. S. Geol. Survey, pp. 637-638, pl. 86, figs. 3, 3a-b; pl. 88, figs. 1, 1a-g; pl. 89, figs. 1, 1a; and pl. 90, figs. 1, 1a. (Discussed. Figures 3, 3a-b, pl. 86, are copied from Walcott, 1884, pl. 21, figs. 10, 11, and 12 respectively; figs. 1 and 1a, pl. 88, are copied from Walcott, 1886, pl. 17, figs. 5 and 6; fig. 1d, pl. 88, is redrawn from the specimen illustrated by Ford, 1877, pl. 4, fig. 5; figs. 1b, 1c, 1d, and 1e, pl. 88, are copied in this paper, pl. 24, figs. 3, 4, 5, and 10 respectively; the specimen represented by figure 1f, pl. 88, is redrawn in this paper, pl. 24, fig. 6; fig. 1g, pl. 88, is redrawn in this paper, pl. 24, fig. 8; figs. 1 and 1a, pl. 89, are copied in this paper, pl. 24, figs. 1 and 2 respectively; and fig. 1a, pl. 90, is copied in this paper, pl. 24, fig. 9.)
- Elliptoccephala asaphoides* (Emmons), COLE, 1892, Natural Science, Vol. 1, pp. 340-341. (Notes on use of name.)
- Olenellus asaphoides* (Emmons), BERNARD, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, pp. 415-416 and 423-424; fig. 3, p. 415; figs. 4a-c and 5, p. 416; and fig. 9, p. 423. (Discusses evidence afforded by this species as to the systematic position of the trilobites. Figure 3 is copied from Walcott, 1886, pl. 17, fig. 5; figures 4a-c are copied from Walcott, 1884, pl. 21, figs. 10, 11, and 12, outline drawings which were based on Ford's figures [1877, pl. 4, figs. 2, 3, and 4]. Figure 5 is copied from Walcott, 1891, pl. 88, fig. 1b; and figure 9 is a diagrammatic restoration of the cephalon figured by Walcott, 1891, pl. 90, fig. 1.)
- Mesonacis (Olenellus) asaphoides* PEACH, 1894, Idem, p. 671; text fig. c, p. 673; and pl. 32, fig. 11. (Mentioned. The figures are copied from drawings or parts of drawings given by Walcott [1891, pls. 88 and 89].)
- Olenellus (Mesonacis) asaphoides* (Emmons), BEECHER, 1895, American Geologist, Vol. 16, p. 176, figs. 6, 7, and 8, p. 175. (Larval stages discussed. Figure 7 is copied from Walcott, 1884, pl. 21, fig. 10, an outline drawing which was based on Ford's figure [1877, pl. 4, fig. 2b] and figure 8 is an outline drawing of the figure given by Walcott [1886, pl. 17, fig. 5].)
- Georgiellus asaphoides* (Emmons), MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, p. 316, pl. 13, figs. 1a and 1b. (The species is referred to *Georgiellus*, a new genus replacing *Elliptoccephala* and the figures are copied from Walcott, 1891, figs. 1 and 1a, pl. 89.)
- Not *Olenellus (Mesonacis) asaphoides* ? GRABAU, 1900, Occasional papers, Boston Soc. Nat. Hist., No. 4, Vol. 1, pt. 3, pp. 667-669, pl. 34, figs. 2a-b. (Referred in this paper to *Callavia crosbyi*.)
- Not *Olenellus (Mesonacis) asaphoides* BURR, 1900, American Geologist, Vol. 25, p. 45. (Referred in this paper to *Callavia crosbyi*.)
- Olenellus (Georgiellus) asaphoides* (Emmons), POMPECKJ, 1901, Zeitschr. Deutschen geol. Gesellsch., Vol. 53, Heft 2, p. 16. (Name used in the discussion of the relation between *Olenopsis* and various genera of the Mesonacidae.)

Olenellus asaphoides (Emmons), LINDSTRÖM, 1901, Kongl. Svenska Vet.-Akad. Handl., Vol. 34, No. 8, pp. 12-18, text figs. 1-10, p. 13. (Development of cephalon discussed. Figs. 2 and 3 are copied from Walcott [1886, pl. 17, figs. 5 and 6]; figs. 5, 6, and 7 are copied from Ford, [1877, pl. 4, figs. 1, 2, and 3]; fig. 10 is drawn from the cephalon of the figure given by Ford [1877, pl. 4, fig. 5]; and figs. 8 and 9 are drawn from the cephalons of the figures given by Ford [1881, figs. 1 and 2, p. 251].)

Olenellus (Mesonacis) asaphoides (Emmons), CLARKE and RUEDEMANN, 1903, Bull. New York State Museum, No. 65, pp. 730-732. (A list of the specimens (hypotypes) collected by Ford in the collection of the New York State Museum.)

Dorsal shield broad ovate, moderately convex. Cephalon large, semicircular in outline, about two-fifths the length of the dorsal shield; genal angles extended into spines; facial suture rudimentary or in a condition of synthesis; eyes elongate, crescentic, with ridges uniting the palpebral lobes to the anterior lobe of the glabella in the young, and in the adult a narrow furrow serves to cut off the palpebral ridge from the glabella; glabella elongate, increasing gradually in width from the occipital furrow to the greatest width on the anterior lobe; anterior lobe large, convex, broader than the posterior lobes, even in the earliest known stage of growth in which it is defined [pl. 25, fig. 9]; the three posterior lobes are subequal in size, nearly transverse and separated by distinct, short lateral furrows that are united by a shallow transverse furrow. In the young the furrows are much deeper proportionally. Occipital ring strong and well defined, when not flattened in shale it has a small median node.

Thorax with eighteen segments; body of pleuræ nearly straight, and with a broad furrow that extends out to the geniculation at the base of the strong falcate extension of the pleuræ. The five posterior segments terminate on the line of the body of the pleuræ in blunt, rounded ends that curve backward at the posterior margin; the pleural furrows are narrow and shallow. The anterior thirteen segments have a small median node near the posterior margin of their axial lobe, and each of the posterior five segments has a long, strong, tapering spine that extends back over the pygidium.

Pygidium small, transverse, and with only a trace of an anterior segment.

Surface finely granulated, and with narrow, irregular raised ridges that unite to form an irregular network over the glabella, axial, and pleural lobes of the thorax; on the cheeks and frontal limb of the cephalon the ridges radiate from the base of the eyes and the

glabella to the outer rim; on the outer rim and spines and on the falcate spinous extension of the pleuræ the ridges are subparallel to the margins.

Hypostoma elongate ovate in outline, strongly convex; anterior margin arched to conform to the outline of the interior margin of the doublure of the cephalon to which it was attached; posterior margin and side margins to the antennal groove denticulated or with six or more short, blunt projections on each side of the median line; antennal groove on the lateral margins in front of the thickened round rim and back of the subtriangular anterior lateral extension of the body along the anterior margin. The oval body is outlined posteriorly by a strong furrow on each side that extends obliquely inward and backward from the antennal furrow, and a very shallow transverse furrow that unites the posterior ends of the oblique furrows; a short, shallow, transverse furrow occurs on the space between the furrow described and the denticulated posterior margin.

It is rarely that the denticulated margin can be worked out of the hard limestone matrix. This led Ford [1877, pl. 4, fig. 6] and Walcott [1886, pl. 17, fig. 10] to represent the hypostoma with a smooth posterior margin. A denticulated margin was illustrated but not described by Walcott in 1891, pl. 88, fig. 1g.

Dimensions.—A dorsal shield 126 mm. in length that is flattened in the shale has the following dimensions:

<i>Cephalon:</i>	<i>mm.</i>
Length	50
Width at base.....	98
Length of eye lobe.....	24
Length of glabella.....	40
Width of glabella at base.....	24
Width of glabella at front.....	31
<i>Thorax:</i>	
Length	70
Width at anterior segment, including spinose extension of the pleuræ	79
Width at thirteenth segment, including spinose extension.....	63
Width at eighteenth segment, including spinose extension.....	14
Width of axial lobe, anterior segment.....	24
Width of axial lobe, thirteenth segment.....	13
Width of axial lobe eighteenth segment.....	9
Width of pleural lobe, anterior segments.....	20
Width of pleural lobe, eighteenth segment.....	3
<i>Pygidium:</i>	
Length	about 6
Width at front.....	13

The preceding description is based on adult flattened specimens of *E. asaphoides* Emmons, as shown by fig. 1, pl. 24. In uncompressed cephalons and dorsal shield from a limestone matrix [figs. 3-7, pl. 24], the convexity is greater and the relief of the surface stronger.

FORMATION AND LOCALITY.—Lower Cambrian: Greenwich formation [Dale, 1904, pp. 29, 43, and 50, and pl. I] in thin-bedded limestones interbedded in siliceous shales at the following localities: (35b)¹ adjoining the house of D. W. Reed on the roadside near the Old Reynolds Inn, 1 mile (1.6 km.) west of North Greenwich; (35) western side of D. W. Reed's farm, 1.5 miles (2.4 km.) north of Bald Mountain; (36a) on the roadside about 3 miles (4.8 km.) northeast of North Greenwich; (33) on the roadside near Rock Hill Schoolhouse No. 8 in Greenwich Township; (33b) 1.5 miles (2.4 km.) east-southeast of North Greenwich; (34) a little west of the bridge over the Poultney River at Low Hampton; (45b) on the roadside 70 rods east of Bristol's house at Low Hampton; (36) 1 mile (1.6 km.) south of Shushan in the town of Jackson, 3.5 miles (5.6 km.) north of Cambridge; (38) .25 mile (.4 km.) north of John Hulett's farmhouse, 3 miles (4.8 km.) west of South Granville; (38a) 2 miles south of North Granville on the road which turns south from the road running between that village and Truthville; and (37) 1.5 miles (2.4 km.) south of Salem; all in Washington County, New York.

(29a) limestone 1 mile (1.6 km.) below the New York Central Railroad depot at Schodack Landing; and (27) even-bedded and conglomerate limestones on the ridge in the eastern suburb of Troy; both in Rensselaer County, New York.

(32) sandstone on the south slope of Stissing Mountain, Dutchess County, New York.

Genus CALLAVIA Matthew

Olenellus WALCOTT (in part) [not HALL], 1866, Bull. U. S. Geol. Survey, No. 30, pp. 162-166. (Described and discussed. As discussed the genus includes forms now referred not only to *Olenellus*, but to *Callavia*, *Elliptocphala*, and *Peachella*.)

Olenellus WALCOTT (in part) [not HALL], 1891, Tenth Ann. Rept. U. S. Geol. Survey, pp. 633-635. (As discussed the genus includes forms now referred to both *Olenellus* and *Callavia*.)

Cephalacanthus LAPWORTH (in part) [not LACÈPÈDE], 1891, Tenth Ann. Rept. U. S. Geol. Survey, by Chas. D. Walcott, p. 641. (Proposed as a new genus to include *Olenellus kjerulfii*, *O. bröggeri*, and *O. callavici*. The name was, however, preoccupied by Lacèpède, 1802, Hist. Nat. Poiss., Vol. 3, p. 323.)

¹ This is the Reynolds Inn locality of Emmons and Fitch.

Cephalacanthus LAPWORTH (in part), 1891, Geological Magazine, Dec. 3, Vol. 8, p. 531. (Gives reasons for proposing the genus. The reference to the original place of publication of *Cephalacanthus* is given as "Geol. Mag., 1888, p. 641" it should be "Tenth Ann. Rept. U. S. Geol. Survey, by Chas. D. Walcott, 1891, p. 641.")

Holmia PEACH and HORNE (in part), 1892, Quart. Journ. Geol. Soc. London, Vol. 48, p. 236. (As defined this genus includes forms now referred to both *Holmia* and *Callavia*.)

Holmia (*Olenellus*) PEACH (in part), 1894, Idem, Vol. 50, pp. 671-674. (As discussed in these pages this genus includes forms now referred to both *Holmia* and *Callavia*.)

Callavia MATTHEW, 1897, American Geologist, Vol. 19, p. 397, footnote. (Generic name proposed to include "*Olenellus bröggeri*" Walcott and "*Olenellus callavii*" Lapworth on account of the glabella differing from that of "*Olenellus* (*Holmia*) kjerulfi.")

Holmia MOBERG (in part), 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, pp. 314 and 318. (As characterized the genus includes two species now placed under *Callavia*.)

Dorsal shield broad ovate, moderately convex; cephalon broad, semicircular; marginal rim broad and continued into genal spines; posterior margin with a strong, short intergenal spine just within the genal angle and the rudimentary facial suture.

Facial sutures rudimentary or in a condition of synthesis back of the eye, but not observed in front of the eye. Eye lobes narrow, elongate-crescentiform. Glabella clavate-elongate, with the large anterior lobe contracting toward the front. The three posterior lobes are not strongly defined, the occipital ring has a strong median spine extending back over the thorax.

Hypostoma convex, broad in front, narrowing to the broadly rounded, smooth posterior margin; crossed within the narrow posterior margin by a sulcus subparallel to the margin, also a flattened ridge anterior to which a strong groove is outlined on each side; antennal furrows, α α , fig. 2, pl. 27, gently arched inward on the lateral margins.

Thorax with fifteen to eighteen segments. Axial lobe convex, with an elongate node or spine at the center. Pleural lobes broad and passing gradually into the broad, curved extensions of each segment; pleural furrows extending from the side of the axial lobe out to the beginning of the curved terminations of the pleuræ.

Pygidium small, transverse, and with a transverse groove near the anterior margin; lateral lobes not developed.

Surface minutely granular and with irregular network of very narrow, irregular anastomosing ridges.

Genotype.—*Olenellus* (*Holmia*) *bröggeri* Walcott.

Stratigraphic range.—Lower Cambrian (Georgian) terrane in a zone about 75 feet thick that is 270 feet below the zone of *Paradoxides hicksi* [Walcott, 1891, pp. 260-261]. *Callavia bröggeri* occurs in numbers 2 and 4 of the section.

Geographic distribution.—Atlantic Coast Province, *Callavia bröggeri* occurs about the head of Conception Bay, Newfoundland, and *C. crosbyi* and *C. burri* in eastern Massachusetts near Weymouth. *Callavia callavei* Lapworth is from central Shropshire, England.

Observations.—Moberg [1899, p. 318, footnote] called attention to the variation of *Holmia bröggeri* Walcott, *H. callavei* Lapworth, and *H. lundgreni* Moberg from *Holmia kjerulfi* Linnarsson, and raised the question as to whether they should not form a new genus or subgenus. With the new material furnished by *Callavia crosbyi*, a form closely related to *C. bröggeri* Walcott, formerly referred to *Holmia*, and by *Holmia rowei* Walcott, I decided to group *Olenellus (Holmia) bröggeri* Walcott [1891], *Olenellus callavei* Lapworth [1891, pp. 530-536], and the two species described in this paper as *Callavia crosbyi* and *C. burri* under a new genus. Later I found (hidden away in a footnote¹) that Dr. G. F. Matthew had proposed the name *Callavia* to include the same species on account of the character of the glabella.

Callavia bröggeri [pl. 27, fig. 1] differs from *Holmia kjerulfi* Linnarsson [pl. 27, fig. 7], the genotype of *Holmia*, in having the first lobe of the glabella constricted in front instead of expanded; in the presence of a strong occipital spine, and in having broad, sickle-shaped extensions of the pleuræ [fig. 6] instead of sharp, spine-like terminations as in *H. kjerulfi* [fig. 7].

The glabella appears to be of a more primitive type than that of *Holmia*, in this respect resembling the glabella of *Nevadia* [pl. 23, fig. 3], and that of the young of *Elliptocephala* [pl. 25, figs. 13 and 14].

Callavia has the intergenal spines in the adult close to the genal spines, and forming a part of the posterior margin of the cephalon, instead of a distinct spine crossing it half way between the glabella and genal spine, as in *Holmia*.

Comparing *Callavia* and *Holmia* as to the stages of development shown by their various parts, we find that the glabella of *Callavia* is more primitive, the intergenal spine and pleuræ less primitive.

The comparisons between *Callavia* and *Wanneria* are made under observations on the former genus [p. 247].

Matthew, 1897, p. 397, footnote.

CALLAVIA BICENSIS, new species

PLATE 41, FIGS. 9, 9A

Cephalon longitudinally, broadly semi-elliptical; strongly convex, with the eye lobes and front lobe of the glabella rising abruptly from the cheeks; marginal border slightly rounded and separated from the cheeks by a shallow, rounded groove; it broadens somewhat at the genal angles, where it is prolonged into spines; the posterior marginal border is narrow and convex beside the occipital ring, from whence it flattens out and broadens before uniting with the border at the genal angle; an oblique thickening occurs where the low ridge extending from the posterior end of the eye crosses the margin.

Glabella with a large, convex anterior lobe that rises abruptly from the narrow space between it and the anterior marginal border; this lobe has two short and slightly defined furrows on each side that originate near the front margin of the palpebral ridge; the posterior of the two furrows extends inward on a line almost directly across the lobe and the anterior furrow extends inward subparallel to the rounded lateral margin of the lobe; a narrow, low ridge extends all about the front of the lobe very much in the same manner as a similar ridge in *Callavia crosbyi* [pl. 28, fig. 1]; the posterior lateral angles of the lobe are connected to the palpebral lobe by a strong, rounded ridge; the second glabellar lobe is narrow and arched slightly backward at each end so as to nearly enclose the ends of the third lobe, which is thus shortened, but it is still transversely longer than the fourth lobe; the fourth lobe is transversely shorter than the second and third, also a little wider; the second, third, and fourth lobes all arch backward, and are very faintly defined across the center of the glabella. The glabella is narrow at the base, expanding to where it unites with the palpebral lobe, from whence it contracts toward its front margin; this gives an outline somewhat similar to that of *Callavia bröggeri* [pl. 27, fig. 1]. Occipital ring about the same width and length as the fourth glabellar lobe; it is marked by a small median node that rises from its highest point at the posterior margin. Palpebral lobes narrow, elevated, and gently arched from their connection to the first glabellar lobe to opposite the glabellar furrow between the occipital ring and fourth glabellar lobe; the posterior end of the lobe is about as far from the side of the glabella as the width of the fourth glabellar lobe; the palpebral lobes, although elevated, do not rise to the level of the

median line of the glabella; they slope rather abruptly inward to the nearly flat interpalpebral area. Visual surface of eye narrow and arching around beneath the outer margin of the palpebral lobe. Cheeks of medium width and sloping rapidly, with a gentle curvature, from the base of the eye and the anterior glabellar lobe to the intermarginal furrow; a facial suture is indicated back of the eye by a narrow ridge extending from the posterior end of the eye obliquely outward and backward so as to cross the posterior marginal border obliquely about two-thirds of the distance from the occipital ring to the genal angle.

The portions of the thorax preserved show that the thoracic segments had a strongly arched axial lobe with a median spine on each segment; the pleural lobes are relatively short and of the same character as those of *Callavia crosbyi* [pl. 28, fig. 4]; the pleural furrow is rather broad next to the axial lobe, from whence it narrows out to the rather short falcate termination. The segments shown on the specimen illustrated belong to the middle portion of the thorax; several of the other segments have been crowded up beneath the cephalon, as shown by the breaking away of a portion of the cheek.

Surface of the cephalon and of thoracic segments ornamented by an extremely fine network of raised ridges, such as characterize the surface of *C. crosbyi* [pl. 28, fig. 7]. There is also a series of very fine irregular ridges radiating from the base of the eye and anterior lobe of the glabella outward to the intermarginal furrow.

Dimensions.—The type specimen of a cephalon has a length of 13 mm., with a width of 19 mm. The proportions of other parts of the cephalon are illustrated by fig. 9, pl. 41, which is based on a photograph enlarged two diameters.

Observations.—This species is described from a single specimen found in the conglomerate limestone at Bic. It shows an entire cephalon and several of the middle segments of the thorax. The illustration is drawn from a cast made in the natural matrix from which the specimen was broken in breaking the limestone. Numerous fragments of large thoracic segments similar to those of *Callavia bröggeri* were found in the same boulder of limestone, but there were no traces of the cephalon except bits of the cheeks and palpebral lobes. The ends of the pleuræ are illustrated by figs. 10 and 10a, pl. 41.

Callavia bicensis differs from *C. crosbyi* in the outline of the cephalon and glabella, proportions of palpebral lobes, glabella, and cheeks. It does not have the great occipital spine of *C. bröggeri* or the tapering, conical glabella of *C. burri* [pl. 28, fig. 9].

The associated fossils are *Micromitra nesus* Walcott, *Botsfordia calata* (Hall), *Hyolithes*, *Discinella*, fragments of large species of *Callavia*, and *Protypus* sp. (?)

FORMATION AND LOCALITY.—Lower Cambrian (2r) a limestone boulder enclosed in a conglomerate of probable Upper Cambrian age, in a railroad cut 2 miles (3.2 km.) west of the railroad station at Bic, Province of Quebec, Canada.

CALLAVIA BRÖGGERI Walcott

PLATE 27, FIGS. 1-6

Olenellus bröggeri WALCOTT, 1888, Name proposed at exhibition of specimens at the International Geological Congress, London.

Olenellus bröggeri WALCOTT, 1888, *Nature*, Vol. 38, p. 551. (Name used in geologic section.)

Olenellus (Mesonacis) bröggeri WALCOTT, 1889, *American Journ. Sci.*, 3d ser., Vol. 37, pp. 378-380. (Description of localities and horizon in geological section.)

Olenellus (Mesonacis) bröggeri WALCOTT, 1890, *Proc. U. S. National Museum*, Vol. 12, p. 41. (Describes species and compares it with other species of *Olenellus*.)

Holmia ? bræggeri (Walcott), MARCOU, 1890, *American Geologist*, Vol. 5, pp. 370-371. (Contends that this species is not a true *Olenellus*, and refers it tentatively to *Holmia*.)

Olenellus (Holmia) bröggeri WALCOTT, 1891, *Tenth Ann. Rept. U. S. Geol. Survey*, pp. 638-640, pl. 91, fig. 1; pl. 92, figs. 1, 1a-h. (Described and discussed. Figure 1, pl. 92, is copied in this paper, pl. 27, fig. 1, and pl. 44, fig. 4. Figures 1c, 1d, 1e (in part), 1g, and 1h, pl. 92, are copied in this paper, pl. 27, figs. 5, 6, 2, 4, and 3 respectively.)

Cephalacanthus bröggeri LAPWORTH, 1891, *Tenth Ann. Rept. U. S. Geol. Survey*, by Chas. D. Walcott, p. 641. (Compared with "*Cephalacanthus callavei*.")

Callavia bröggeri MATTHEW, 1897, *American Geologist*, Vol. 19, p. 397, footnote. (New genus proposed.)

Olenellus (Holmia) bræggeri (Walcott), POMPECKJ, 1901, *Zeitschr. Deutschen geol. Gesellsch.*, Vol. 53, Heft 2, pl. 1, fig. 10. (Mentioned frequently on pages 14-17 in a discussion of the relations between *Olenopsis* and various genera of the Mesonacidae. Figure 10 is copied from Walcott, 1891, pl. 91, fig. 1.)

Olenellus bröggeri (Walcott), BERNARD, 1894, *Quart. Journ. Geol. Soc. London*, Vol. 50, p. 423. (Calls attention to the occipital spine as a modification of the "dorsal organ" of *Apus*.)

Holmia bröggeri (Walcott), PEACH, 1894, *Idem*, pp. 672 and 673. (Refers to this species in discussion of *Olenellus*.)

Not *Olenellus (Holmia) bröggeri* BURR, 1900, *American Geologist*, Vol. 25, pp. 43-45. (Referred in this paper to *Callavia crosbyi*.)

Not *Olenellus (Holmia) bröggeri* GRAEAU, 1900, *Occasional Papers, Boston Soc. Nat. Hist.*, No. 4, Vol. 1, pt. 3, pp. 662-664, pl. 33, figs. 1a-j. (Referred in this paper to *Callavia crosbyi*.)

The new material of this species that has been added to our collection since the specific description was published in 1891 [Walcott, pp. 638-641] shows that the intergenal spines of a small cephalon 5 mm. in length are long and slender, and extend a little beyond the points of the genal spines. The glabellar furrows are very faint and the occipital spine slender. The generic relations of the species have been discussed under the genus *Callavia* [p. 276].

FORMATION AND LOCALITY.—Lower Cambrian: (41) sandstone¹ in a railroad cut 1 mile (1.6 km.) west of the Manuels Brook railway bridge; (?) a decomposed arenaceous limestone 1,200 feet (366 m.) west of the railway bridge mentioned in 41; in railway cuts 300 feet (91 m.) west (5p), 1 mile (1.6 km.) west (5s), and 1.5 miles (2.4 km.) west (5r) of Manuel Station; (41a) a compact, thin-bedded limestone beneath Topsail Head; (42) a horizon nearly corresponding to the base of the Manuels Brook section, on Brigus Head; and at (5t and 5u) slightly different horizons² on Redrock Point, near Chapple Cove, Hollywood Point; all on Conception Bay, Newfoundland.

(5n) shale on Smith Point in Smith Sound, Trinity Bay, Newfoundland.

CALLAVIA BURRI, new species

PLATE 28, FIGS. 9-10

Olenellus sp. BURR, 1900, American Geologist, Vol. 25, p. 45. (Notes occurrence of an unidentified species of *Olenellus*.)

Olenellus sp. GRABAU, 1900, Occasional Papers, Boston Soc. Nat. Hist., No. 4, Vol. 1, pt. 3, pp. 665-667, pl. 34, figs. 1a-b. (Described as possibly belonging to a new subgenus of *Olenellus*. The specimen represented by figure 1a is redrawn in this paper, pl. 28, fig. 9.)

Cephalon semicircular in outline, moderately convex in its fine, quartzitic sandstone matrix; bordered by a moderately broad, slightly convex rim that is separated from the cheeks by a faintly defined furrow; genal angles, as now known, extended in small, short, flattened spines; posterior border narrow and rounded next to the occipital ring and gradually widening to where it curves into the outer border at the genal angle; it has a slight undulation midway of its length, but is not interrupted by the crossing of the ridges of intergenal spines; intermarginal furrow narrow and slightly de-

¹ See the section given by Walcott [1891b, pp. 260-261] for the stratigraphic position of the species in the section on Manuels Brook.

² Locality No. 5u is about 175 feet higher than 5t, which is 20 feet above the base of the section.

pressed. Glabella convex, conical, and strongly lobed; dorsal furrow shallow and interrupted about the anterior lobe by a very narrow second furrow that separates a narrow ridge from the glabella; the anterior lobe of the glabella tapers from the base toward the narrowly rounded front and its base is broadly wedge shaped, owing to the backward slope of the anterior pair of furrows; the second and third lobes are united about the ends of the second pair of furrows, while the fourth lobe is clearly defined by the occipital furrow; occipital ring convex, of uniform width, and without a median node or spine. Palpebral lobe united to the postero-lateral base of the anterior glabellar lobe by a narrow ridge; it is about one-third the length of the cephalon, and at its posterior end it is distant about one-half of its length from the glabella; opposite its posterior end and adjoining the dorsal furrow next to the end of the fourth glabellar lobe a small prominent tubercle breaks the surface of the area within the palpebral lobe. Checks gently convex and divided only by a narrow intergenal ridge that extends from the base of the palpebral lobe diagonally outward to the posterior marginal border about midway of its length.

Surface.—The surface is similar to that of *Callavia crosbyi*, except that the meshes of the reticulated network of narrow ridges are somewhat finer and more like those of the right side of fig. 7, pl. 28, than the meshes on the left side.

Dimensions.—A cephalon 24 mm. in length has a width at the base of 47 mm. Length of glabella 17 mm.; width of glabella at base 10 mm. Width of glabella at base of anterior lobe inside the narrow outer ridge 7 mm. Length of palpebral lobe 8 mm. Distance of palpebral lobe from glabella at anterior end 2 mm.; at posterior end 6 mm.

Observations.—Of this species only a few specimens of the cephalon are known. Its outline is similar to that of *Callavia crosbyi*, except that in the specimens thus far seen the genal spines are very much smaller, and there is no evidence of an intergenal spine. The marginal rim is less distinctly defined than in *C. crosbyi*; the palpebral lobes are shorter; and the glabella proportionally shorter, more conical, and more distinctly lobed.

Callavia burri differs from *C. bröggeri* as it does from *C. crosbyi*, and it does not have the great occipital spine of the former species.

FORMATION AND LOCALITY.—Lower Cambrian: (9n) associated with *Callavia crosbyi* in the dark, purplish siliceous shale of the Weymouth formation on Pearl Street, North Weymouth, Norfolk County, Massachusetts.

CALLAVIA CALLAVEI (Lapworth)

PLATE 42, FIGS. 1-2

Olenellus callavei LAPWORTH, 1888, Geological Magazine, new series, Dec. 3, Vol. 5, p. 485. (Name proposed.)

Olenellus callavei LAPWORTH, 1888, Nature, Vol. 39, p. 212. (Copy of preceding reference.)

Olenellus (Holmia) calcei (Lapworth), WALCOTT, 1891, Tenth Ann. Rept. U. S. Geol. Survey, p. 635. (Refers species to *Holmia* as result of having seen specimens of it.)

Cephalacanthus callavei LAPWORTH, 1891, Tenth Ann. Rept. U. S. Geol. Survey, by Chas. D. Walcott, pp. 640-641. (Compared with "*Cephalacanthus bröggeri*" and "*C. kjerulfi*.")

Olenellus (Holmia) callavei LAPWORTH, 1891, Geological Magazine, Dec. 3, Vol. 8, pp. 530-536, pl. 14, figs. 1-25, and pl. 15. (Described and discussed, with special reference to its relations to *Olenellus kjerulfi* and *O. bröggeri*.)

Olenellus (Holmia) callavei (Lapworth), COLE, 1892, Natural Science, Vol. 1, pp. 344 and 345. (Discussed.)

Callavia callavii MATTHEW, 1897, American Geologist, Vol. 19, p. 397, footnote. (New genus proposed.)

Dr. Lapworth gives a very full description and illustration of the fragments representing this species, and a diagrammatic restoration based apparently on my restored figure of *C. bröggeri* [Walcott, 1891, pl. 91, fig. 1].

Callavia callavei differs from *C. bröggeri* in its stronger genal and intergenal spines and shorter occipital spine, form of the glabella, and lateral extensions of the pleuræ. It may be that other differences will appear if better specimens become available for comparison, or as the two species are very closely related, it may be found that they are specifically more nearly identical than now seems probable.

FORMATION AND LOCALITY.—Lower Cambrian: near the base of the Comley sandstone (Hollybush series) in a purplish-red arenaceous limestone, Comley quarry, on the flanks of Little Caradoc, near Church Stretton, Central Shropshire, England.

CALLAVIA CARTLANDI Raw, MSS.

PLATE 42, FIGS. 3-4

Olenellus (Holmia?) cartlandi RAW, 1909, MSS. received from Mr. Frank Raw, University of Birmingham, England, December 17, 1909.

This species is founded on a single specimen found loose in the quarry at Comley in Shropshire. It occurs on a characteristic piece of chocolate and green limestone of the *Callavia callavei* bed of the quarry that has been subjected to considerable abrasion and weath-

ering. The two photographs of the specimen show the characters of the species, and as Mr. Raw will soon publish a detailed description, I will only quote from his manuscript the comparisons made with the closely allied and associated species *C. callavei* Lapworth to show how it differs from the latter species:

Head.

- (1) The head is much broader in proportion.
- (2) It is greatly produced in a postero-lateral direction, this part of the cheeks being very extensive.
- (3) The posterior margin of the cheeks are wavy in outline, quite different from the simple sigmoid curve of *O. (H.) callavei*.
- (4) The occipital furrows are stronger and less oblique.
- (5) There is no indication of a strong occipital spine such as in *O. (H.) callavei* modifies so greatly the occipital ring.

Thorax.

- (6) The trilobation in the thorax gives vastly different proportions between axis and limbs, the former being less than half the width of the latter, the contrast being due to a great lateral extension of the pleuræ in this form.
- (7) The outline—wavy—of the pleuræ is quite different, as is also their initial directions (somewhat forwards) from the axial rings.
- (8) The falcate extremities of the pleuræ are much longer and more backwardly directed.

Of these distinguishing characters, the most striking are the great relative breadth due to an extension of the limbs throughout and showing itself especially in the entirely different proportion of the thoracic pleuræ—slender, instead of thick-set, and the shape of the pleuræ—wavy, of 3 curves, and starting from the axis somewhat forwards, instead of simply sigmoid and starting backwards.

Callavia cartlandi is similar to *C. burri* [pl. 28, fig. 9] in not showing an occipital spine, or intergenal spines in its broad postero-lateral cheek, and in the narrowing of the glabella. It is not improbable that these two species will be found to represent a distinct form that may, with the discovery of better specimens, be placed under a new subgenus or genus.

Callavia cartlandi differs strongly from *Wanneria walcottanus* [pl. 30, fig. 2] in the form of the anterior lobe of the glabella and the furrows on the pleuræ of the thoracic segments.

I am indebted to Mr. Frank Raw, of Birmingham University, England, for casts of the type specimens and for the opportunity to read his preliminary manuscript notes on the species.

FORMATION AND LOCALITY.—Lower Cambrian: near the base of the Comley sandstone (Hollybush series) in a purplish-red arenaceous limestone, Comley quarry, on the flanks of Little Caradoc, near Church Stretton, Central Shropshire, England.

CALLAVIA CROSBYI, new species

PLATE 28, FIGS. 1-8

Olenellus (Holmia) bröggeri BURR, 1900, American Geologist, Vol. 25, pp. 43-44. (Specimens from North Weymouth described and discussed.)

Olenellus (Mesonacis) asaphoides BURR, 1900, Idem, p. 45. (Distorted specimens of the cephalon found at North Weymouth are doubtfully identified with this species and characterized.)

Olenellus (Holmia) bröggeri GRABAU, 1900, Occasional Papers Boston Soc. Nat. Hist., No. 4, Vol. 1, pt. 3, pp. 662-664, pl. 33, figs. 1a-j. (Described and discussed.)

Olenellus (Mesonacis) asaphoides ? GRABAU, 1900, Idem, pp. 667-669, pl. 34, figs. 2a-b. (Identification based on distorted cephalons of *Callavia crosbyi*.)

Metadoxides magnificus ? GRABAU, 1900, Idem, p. 670, pl. 34, figs. 4-6. (Fragments of spines referred to the species with reservation.)

*Callavia crosbyi** is so similar to *C. bröggeri* that the description of the latter, except where the two forms differ in details, will suffice. These differences are: the stronger posterior marginal border; the presence of a narrow, clearly defined ridge about the anterior glabellar lobe in *C. crosbyi*; a stronger, broader pleural furrow in the thorax; and a relatively shorter extension of the pleuræ beyond the end of the furrow. The pygidium of *C. crosbyi* is not well known, as the only specimen showing it is crushed and poorly preserved. The hypostomæ [pl. 28, fig. 6, and pl. 27, fig. 2] are similar as far as known.

Callavia crosbyi differs from *C. burri* in the outline and details of the glabella, larger palpebral lobes, and proportions of the glabella and cheeks.

The surface is finely granular and beautifully ornamented with a network of fine, irregular, anastomosing ridges, as shown by fig. 7, pl. 28. On the left side the elongate meshes of the network are seen as they occur on the broad margin of the cephalon and on the right side the fine network of the cheek below the eye; this surface extends over the glabella, the posterior border of the cephalon, and the thoracic segments, except on the curved extensions of the pleuræ where the meshes are coarser.

The longest cephalon in the collection has a length of 58 mm. and width of 126 mm. This indicates that the dorsal shield attained a length of 32 cm. or more.

FORMATION AND LOCALITY.—Lower Cambrian: (9n) associated with *Callavia burri* in the dark, purplish siliceous shale of the Weymouth formation on Pearl Street, North Weymouth, Norfolk County, Massachusetts.

CALLAVIA ? NEVADENSIS, new species

PLATE 38. FIGS. 12-14.

Olenellus gilberti WALCOTT (in part) [not MEEK], 1884, Monogr. U. S. Geol. Survey, Vol. 8, p. 29, pl. 9, fig. 16, and pl. 21, fig. 13 (not fig. 16a, pl. 9, which is referred in this paper to *Olenellus fremonti*; nor figure 14, pl. 21, which is referred in this paper to *Olenellus gilberti*). (Described. Figures 16 and 13 are copied in this paper, pl. 38, figs. 12 and 14 respectively.)

Olenellus gilberti WALCOTT (in part) [not MEEK], 1886, Bull. U. S. Geol. Survey No. 30, pp. 170-180, pl. 19, figs. 2c, d, f, and g (not pl. 18, figs. 1, 1a-b; pl. 19, figs. 2, 2a, 2b, 2k; pl. 20, fig. 4; and pl. 21, figs. 1 and 1a = *Olenellus gilberti*; and not pl. 18, fig. 1c; pl. 19, figs. 2e, 2h, 2i; pl. 20, figs. 1, 1a-i, 1k-m; and pl. 21, figs. 2 and 2a = *Olenellus fremonti*). (The description and discussion given includes reference to specimens now referred to *Callavia nevadensis*. Figure 2d, pl. 19, is copied in this paper, pl. 38, fig. 13; figure 2c is copied from Walcott, 1884, pl. 21, fig. 13; and figure 2g is copied from Walcott, 1884, pl. 9, fig. 16.)

Olenellus gilberti WALCOTT (in part) [not MEEK], 1891, Tenth Ann. Rept. U. S. Geol. Survey, pl. 84, figs. 1e and 1g; pl. 85, figs. 1e and g (not pl. 84, figs. 1, 1a-c; pl. 85 figs. 1b-d; and pl. 86, fig. 4 = *Olenellus gilberti*; and not pl. 84, figs. 1d and 1f; pl. 85, figs. 1, 1a, and 1f; and pl. 86, figs. 1, 1a-i, 1k-m = *Olenellus fremonti*). (No text reference. Figures 1e and 1g, pl. 84, are copied from Walcott, 1886, pl. 19, figs. 2d and 2f; fig. 1e, pl. 85, is copied from Walcott, 1886, pl. 19, fig. 2g; and fig. 1g, pl. 85, is copied from Walcott, 1884, pl. 21, fig. 13.)

Of this species only fragments of the cephalon and thorax are known. These I referred to *Olenellus gilberti* [1884, 1886, and 1891], but in restricting the latter species to the characters shown by the type specimens [pl. 36, figs. 1-3] the specimens from Prospect Mountain are separated and now referred to *C. nevadensis*. They are distinguished from *O. gilberti* by the broader space between the glabella and frontal rim, short eye lobes, and converging sides of the glabella, particularly those of the large frontal lobe. The glabella is similar to that of *C. burri* [pl. 28, fig. 9], but the marginal borders differ materially in the two species.

Callavia nevadensis is associated with numerous fragmentary specimens of *Olenellus fremonti* [pl. 37] and *Peachella iddingsi* [pl. 36, fig. 17].

The reference to the genus *Callavia* is on account of the tapering glabella and slender anterior glabellar lobe.

FORMATION AND LOCALITY.—Lower Cambrian: Pioche formation at the following localities: (51 and 52) at the summit of Prospect Mountain, Eureka District, Eureka County; (30) on the west slope of the Highland Range, 8 miles (12.8 km.) north of Bennetts Springs and about 8 miles (12.8 km.) west of Pioche, Lincoln County; and

(313g) in the Groom Mining District, at the south end of the Timpanohute Range, near the line between Nye and Lincoln counties; all in Nevada.

Genus HOLMIA Matthew

- Paradoxides* FORD (in part), 1878, American Journ. Sci., 3d ser., Vol. 15, p. 130, footnote. (Discusses the generic relations of *Paradoxides* as represented by *P. kjerulfi* and *P. aculeatus* with *Olenellus* as represented by *O. asaphoides*.)
- Olenellus* HOLM (in part), 1887, Geol. Fören. i Stockholm Förhandlingar, Bd. 9, Häfte 7, pp. 498-499. (Described in Swedish. As described and discussed throughout the paper the genus includes many of the forms now placed in the family Mesonacidæ.)
- Gen ? MATTHEW, 1888, Canadian Record Sci., Vol. 3, pp. 75-76. (Linnarsson's species, *Paradoxides kjerulfi*, is discussed as the representative of a new genus intermediate between *Paradoxides* and *Olenellus*, and Matthew says: "It is to be hoped that his countrymen will see reason to connect Holm's name with this new genus.")
- Holmia* MARCOU, 1890, American Geologist, Vol. 5, pp. 365-366. (Linnarsson's species is discussed and Marcou accepts Matthew's suggestion [1888, p. 76] and places the species under *Holmia*.)
- Holmia* MATTHEW, 1890, Trans. Roy. Soc. Canada, Vol. 7, Sec. 4, p. 160, footnote. (Points out differences between *Olenellus kjerulfi* and the American species of *Olenellus*, and proposes the generic name *Holmia*.)
- Cephalacanthus* LAPWORTH (in part) [not LACÉPÈDE], 1891, Tenth Ann. Rept. U. S. Geol. Survey, by Chas. D. Walcott, p. 641. (Proposed as a new genus to include *Olenellus kjerulfi*, *O. bröggeri*, and *O. callavici*. The name, however, was preoccupied by Lacépède, 1802, Hist. Nat. Poiss., Vol. 3, p. 323.)
- Cephalacanthus* LAPWORTH (in part), 1891, Geol. Mag., Dec. 3, Vol. 8, p. 531. (Gives reasons for proposing the genus. The reference to the original place of publication of *Cephalacanthus* is given as "Geol. Mag., 1888, p. 641" it should be "Tenth Ann. Rept. U. S. Geol. Survey, by Chas. D. Walcott, 1891, p. 641.")
- Holmia* COLE, 1892, Natural Science, Vol. 1, p. 344. (Discussed. In the legend of figure 3, p. 343, *Holmia* is placed as a subgenus of *Olenellus*.)
- Holmia* PEACH and HORNE (in part), 1892, Quart. Journ. Geol. Soc. London, Vol. 48, p. 236. As defined this genus includes forms now referred to both *Holmia* and *Callavia*.)
- Holmia* (*Olenellus*) PEACH (in part), 1894, Quart. Journ. Geol. Soc. London, Vol. 50, pp. 671-674. (Compares certain characters of *Holmia* with those of *Olenellus* and *Mesonacis*. As discussed in these pages, however, the genus includes forms now referred to both *Holmia* and *Callavia*.)
- Holmia* BEECHER, 1897, American Journ. Sci., 4th ser., Vol. 3, p. 191. (Considers facial sutures of *Holmia* as in a condition of synthesis. Places *Holmia* in family *Paradoxina*.)
- Holmia* FRECH, 1897, Lethæa geognostica, pt. 1, Lethæa Palæozoica, Bd. 2, p. 41. (Considers *Holmia* and *Olenopsis* Bornemann as identical.)

- Holmia* MOBERG (in part), 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, p. 318. (Briefly characterizes genus. As characterized the genus includes species now referred to *Callavia*.)
- Holmia* MATTHEW, 1899, American Geologist, Vol. 24, p. 59. (Reviews Moberg's paper [1899] and notes two types placed under *Holmia*.)
- Holmia* WELLER, 1900, Ann. Rept. Geol. Survey New Jersey for 1899, pp. 50-51. (Discussed.)
- Holmia* POMPECKJ, 1901, Zeitschr. Deutschen geol. Gesellsch., Vol. 53, Heft 2, pp. 14-17. (*Olenopsis* is compared with *Holmia* and other genera of the Mesonacidae.)
- Holmia* LINDSTRÖM, 1901, Kongl. Svenska Vet.-Akad. Handlingar, Bd. 34, No. 8, p. 24. (Considers *Holmia* an eyeless trilobite, with beginning suture.)

Holmia is characterized by intergenal spines in the adult, a uniform series of thoracic segments and a small more or less transverse pygidium with only traces of transverse furrows indicating segments in the median lobe.

Genotype.—*Paradoxides kjerulfi* Linnarsson, 1871.

The only American species of the genus I recognize is *Holmia rowei* Walcott.

Stratigraphic range.—Lower Cambrian. In Scandinavia the *Holmia kjerulfi* zone is just beneath the *Paradoxides* bearing strata. In Sweden it is overlain by the *Paradoxides tessini* zone [Holm, 1887, p. 514], and in Norway by the *P. ölandicus* zone [*Idem*, p. 514].

Holmia rowei Walcott occurs low down in the Lower Cambrian in association with *Nevadia weeksi* Walcott.

Geographic distribution.—Scandinavia in Europe; southwestern Nevada in the United States.

Observations.—The generic relations and position of *Holmia* in the Mesonacidae are considered in observations on the Mesonacidae [p. 247].

From the occurrence of *Holmia kjerulfi* just beneath the *Paradoxides* zone in Scandinavia with associated genera closely allied to those in the *Paradoxides* fauna it is probable that the genus occurs in the upper portion of the Lower Cambrian in western Europe. In the southwestern United States, in Nevada, *Holmia rowei* is found over 4,500 feet below the zone of *Olenellus gilberti*. I strongly suspect that there is a lost interval in the Scandinavian section between the zone of *Holmia kjerulfi* and *Paradoxides ölandicus* that may represent a portion of the section between *Olenellus* and *Holmia* in Nevada. That *Olenellus* is not found in Scandinavia also strengthens this view, as *Olenellus* is very characteristic of the higher beds of the Lower Cambrian in both eastern and western North America.

Holmia [pl. 27, fig. 7] differs from *Callavia* [pl. 27, fig. 1] in having an expanded frontal glabella lobe; in its spinose extensions of the pleura; and small occipital spine. From *Wanneria* [pl. 30, figs. 2 and 6] it varies in not having a great spine on the fifteenth segment, and in having spinose extensions of the pleuræ. The latter character is similar to that in the thorax of *Elliptoccephala* [pl. 24, fig. 1] and *Mesonacis* [pl. 26, fig. 1].

Holmia follows *Mesonacis* and *Callavia* in the scheme of classification of the Mesonacidæ because it is considered that the thorax indicates a stage of development slightly more advanced than in those genera. The latter still retain the partially developed posterior segments that appear to have disappeared in *Holmia*.

Dr. G. F. Matthew [1899, p. 59] in his review of Moberg's paper [1899, pp. 309-348] mentions that there are two types under *Holmia* as arranged by Moberg [1899, pp. 314 and 318], the first two species mentioned after *Holmia kjerulfi* being distinguished from the genotype by a difference in the number of the segments in the thorax, and possessing a conical in place of a club-shaped glabella. The species are *H. bröggeri* Walcott and *H. callavei* Lapworth. These forms are now included in the genus *Callavia*.

HOLMIA KJERULFI Linnarsson

PLATE 27, FIG. 7

- Paradoxides kjerulfi* LINNARSSON, 1871, Öfversigt af Kongl. Vet. Akad. Förhandlingar, pp. 790-792, pl. 16, figs. 1-3. (Described and discussed.)
- Paradoxides kjerulfi* (Linnarsson), KJERULF, 1873, Om grundfjeldets og sparagmitfjeldets mægtighed i Norge. 2. Sparagmitfjeldt, p. 83, text figs. 1-5. (No text reference.)
- Olenellus kjerulfi* (Linnarsson), BRÖGGER, 1878, Nyt Mag. for Naturvid., Bd. 24, p. 44. (Mentioned.)
- Paradoxides kjerulfi* FORD, 1878, American Journ. Sci., 3d ser., Vol. 15, p. 130, footnote. (Discusses generic relations of *Paradoxides* as represented by *P. kjerulfi* with *Olenellus* as represented by *O. asaphoides*.)
- Paradoxides ? kjerulfi* (Linnarsson), FORD, 1881, American Journ. Sci., 3d ser., Vol. 22, pp. 255-258, text fig. 10, p. 256. (Gives a diagrammatic figure of the cephalon, and discusses the relation of the species to *Olenellus asaphoides* and of *Paradoxides* to *Olenellus*.)
- Olenellus kjerulfi* LINNARSSON, 1883, Sveriges Geol. Unders., Ser. C, No. 54, pp. 18-20, pl. 3, figs. 12-17. (Describes and illustrates specimens from Andrarum.)
- Paradoxides kjerulfi* (Linnarsson), WALCOTT, 1886, Bull. U. S. Geol. Survey, No. 30, p. 178, pl. 20, fig. 2. (Compares ocular ridge and facial suture back of the eyes with those features in *Olenellus gilberti*. Figure 2 is an outline drawing of the figure given by Linnarsson [1871, pl. 16, fig. 2].)

- Olenellus* (?) *kjerulfi* (Linnarsson), MATTHEW, 1886, American Journ. Sci., 3d ser., Vol. 31, pp. 472-473. (Identifies species from Newfoundland and expresses doubt as to generic reference.)
- Olenellus kjerulfi* (Linnarsson), HOLM, 1887, Geol. Fören. i Stockholm Förhandl., Vol. 9, Häfte 7, pp. 493-522 (499-512 in particular). (Described and discussed in Swedish, figuring a complete restoration of the dorsal shield [pl. 14, fig. 2] which has been widely copied, see pl. 27, fig. 1 of this paper.)
- Paradoxides* (Gen. ?) *kjerulfi* MATTHEW, 1888, Canadian Record Sci., Vol. 3, pp. 75-76. (The species is discussed as the representative of a new genus intermediate between *Paradoxides* and *Olenellus* and Matthew says: "It is to be hoped that his countrymen will see reason to connect Holm's name with this new genus.")
- Holmia kjerulfi* (Linnarsson), MARCOU, 1890, American Geologist, Vol. 5, pp. 365-366. (The species is discussed and Marcou accepts Matthew's suggestion [1888, p. 76] and places the species under *Holmia*.)
- Olenellus* (*Holmia*) *kjerulfi* (Linnarsson), WALCOTT, 1891, Tenth Ann. Rept. U. S. Geol. Survey, p. 635, pl. 86, fig. 2; and pl. 93, fig. 2. (The figure on plate 86 is copied from Walcott, 1886, pl. 20, fig. 2; figure 2, pl. 93 is copied from Holm, 1887, pl. 14, fig. 2.)
- Cephalacanthus kjerulfi* LAPWORTH, 1891, Tenth Ann. Rept. U. S. Geol. Survey, by Chas. D. Walcott, pp. 640-641. (Compared with "*Cephalacanthus callavei*.")
- Olenellus* (*Holmia*) *kjerulfi* (Linnarsson), COLE, 1892, Natural Science, Vol. 1, p. 343, text fig. 3. (Gives outline figure of the restoration of the dorsal shield by Holm, 1887, pl. 14, fig. 2.)
- Holmia* (*Olenellus*) *kjerulfi* PEACH, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, p. 671, pl. 32, fig. 12. (Mentioned. Figure 12 is copied from Holm, 1887, pl. 14, fig. 2.)
- Olenellus kjerulfi* (Linnarsson), KOKEN, 1896, Die Leitfossilien, p. 7, text fig. 2. (Reproduces restoration of dorsal shield by Holm [1887, pl. 14, fig. 2]. On page 352 the species is placed under *Mesonacis*.)
- Olenellus* (*Holmia*) *kjerulfi* (Linnarsson) FRECH, 1897, Additional plates inserted in 1897 in Lethæa geognostica, pt. 1, Lethæa Palæozoica, Atlas, pl. 1a, fig. 13. (Figure 13 is copied from Holm, 1887, pl. 14, fig. 2.)
- Holmia kjerulfi* (Linnarsson), MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, p. 318, pl. 13, fig. 3. (Mentioned at several places in the text. The figure is copied from Holm, 1887, pl. 14, fig. 2.)
- Holmia kjerulfi* LINDSTRÖM, 1901, Kongl. Svenska Vet.-Akad. Handlingar, Vol. 34, No. 8, p. 57. (Calls attention to the "maculæ" on the hypostoma.)

Dr. Holm's memoir [1887, pp. 493-522] on this species is so comprehensive and so well illustrated that I shall not attempt to reproduce it further than to illustrate his restoration of the dorsal shield [pl. 27, fig. 7].

The most nearly related species is *Holmia lundgreni* Moberg [pl. 40, figs. 4-7]. It differs from the latter in many details and, as

pointed out by Moberg [1899, p. 321], the two species belong to different stratigraphic horizons. *H. kjerulfi* is found in the "grey-wacke" below the zone containing *Paradoxides ölandicus* Sjogren. *H. lundgreni* Moberg has been found only in the Lower Cambrian sandstone.

The only American species, *Holmia rowei* [pl. 29], differs in so many characters that it is unnecessary to make comparisons between the two species.

The associated fossils at Tomten are *Obolella mobergi* Walcott, *Obolella (Glyptias) favosa* Linnarsson, and *Arionellus*.

Dr. G. F. Matthew [1886, p. 472] identified "*Olenellus* (?) *kjerulfi*" from New Brunswick and Newfoundland. In his catalogue of species in the Cambrian Rocks of eastern Canada [1904, pp. 260-278] he does not record the "*O. (?) kjerulfi*" under *Olenellus* or *Holmia*. The specimens are not in the Matthew collection at the University of Toronto, Canada, and under date January 6 and March 18, 1910, Dr. Matthew writes that he doubts if there is any material representing *Holmia* in the collection in St. John, as his notes were based on fragments.

FORMATION AND LOCALITY.—Lower Cambrian: (1) [Holm, 1887, p. 512] at Andrarum and Gislöf, Province of Skåne, Sweden.

(2) [Linnarsson, 1871, p. 790] at Tomten in Ringsaker, near Lake Mjösen; and (3) [Holm, 1887, p. 512] at Kletten; both in Norway.

(4) [Holm, 1887, p. 512] below Kyrkberget, on the shore of Great Uman Lake, Parish of Stensele, Lapland.

HOLMIA LUNDGRENI Moberg

PLATE 40, FIGS. 4-7

Olenellus lundgreni MOBERG, 1892, Om Olenellusledet i sydliga Skandinavien, p. 3. (Specimens exhibited at 14th meeting of Scandinavian naturalists at Copenhagen discussed.)

Holmia lundgreni MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, pp. 321-329, pl. 14, figs. 1-14. (Described and discussed. A plaster cast of the specimen represented by figures 2a-b is figured in this paper, pl. 40, figs. 4 and 4a.)

Holmia lundgreni LINDSTRÖM, 1901, Kongl. Svenska Vet.-Akad. Handlingar, Vol. 34, No. 8, p. 57. (Calls attention to "maculæ" on hypostoma.)

Only fragments of this species have been found, but these fortunately include one nearly entire cephalon [pl. 40, fig. 4]. All the specimens occur in a hard, compact, fine-grained sandstone. Through the courtesy of Dr. Moberg I received casts of the typical specimens described by him, also a few good fragments, of which three are

illustrated by figs. 5, 6, and 7, pl. 40. By the aid of these specimens and the casts and Dr. Moberg's very detailed descriptions the following brief description is drawn up:

Cephalon semicircular, strongly convex. Width a little less than one-half the length; marginal rim broad, flattened and separated from the cheeks by a shallow furrow; it widens from the front toward the genal angles and is probably produced into strong, flattened genal spines; posterior marginal rim about as wide as the rim in front of the glabella; it is faintly defined by a narrow, shallow furrow. Glabella widening a little from the occipital ring to the anterior end of the eye lobes where it expands into the large anterior lobe; the latter rises abruptly from just within the marginal rim and curves over to the level plane along the median line of the glabella; the glabella is marked by three pairs of lateral furrows joined across the glabella by a fainter furrow. The size and position of the furrows and the glabellar lobes are shown by figs. 4 and 5. The occipital ring is subequal in width to the fourth lobe of the glabella; it has a small, pointed median tubercle at the posterior margin. The palpebral lobes start from the postero-lateral portion of the large anterior glabellar lobes, and arch backward to a point opposite the front of the occipital ring; they are elevated nearly to the plane of the median line of the glabella and leave a depressed space between them and the dorsal furrow beside the glabella; sometimes a small intergenal spine is indicated at the end of a narrow elevated line extending from about the end of the occipital furrow. Dr. Moberg states that approximately parallel to this line is another fainter line, which extends from the posterior part of the eye, that he is inclined to consider an obliterated facial suture. He also noted traces of a similar line in front of the eye. The cheeks rise rapidly from the furrow within the marginal rim to the base of the eye.

The hypostoma is shown by fig. 6. No traces of spines or tubercles are shown on any specimens I have seen of the back and lateral margins, and Dr. Moberg did not note any marginal spines.

The median lobe of the thoracic segments is distinctly separated from the pleural lobes; a strong median spine with an elongated base occurs on many of the fragments of the median lobe; on other specimens a small tubercle is all that is seen, Dr. Moberg draws the conclusion from this that the anterior segments had small, weak spines, and that the spines increased in strength on the middle segments; the pleural lobe of the middle segments extend out directly

for about one-half their length and then curve evenly outward and backward, and narrow gradually to a point; the pleuræ are thus distinguished sharply from those of *Holmia kjerulfi* [pl. 27, fig. 7]; pleural furrow oblique, clearly marked, and deepest near the interior end.

Pygidium with a nearly circular outline without transverse furrows; its marginal rim is narrow on its anterior end, increasing slightly in width toward the posterior side where it narrows rapidly to the posterior median line, and thus gives a notched appearance to the posterior margin.

The surface is marked by irregular, fine ridges that form a more or less irregular network.

The largest cephalon has a length of 28 mm., width 54 mm., convexity about 10 mm.

Observations.—This species is most closely related to *Holmia kjerulfi* [pl. 27, fig. 7]. It differs in the outline of the glabella, genal angles, pleuræ of thoracic segments, and hypostoma. The outline of the glabella is intermediate between that of *Holmia* [pl. 27, fig. 7] and that of *Callavia* [pl. 27, fig. 1].

The fossils found in association with this species are, according to Moberg [1899, p. 329], a patelloid shell and *Hyalithes degeeri* Holm.

FORMATION AND LOCALITY.—Lower Cambrian: a block of sandstone (390v) collected west of Tumbyholm, north-northeast of Smedstorp, west of Simrisham, Province of Kristianstad, Sweden [Moberg, 1899, p. 328].

Dr. Moberg [1899, p. 329] states that he also found this species south from Gladsax Church.

HOLMIA ROWEI, new species

PLATE 29, FIGS. 1-11

Holmia rowei WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, No. 5, p. 189. (Name used in No. 12 of section; the species does not occur in No. 3, nor in the Waucoba Spring section, pp. 187-188. The specimens identified with this species from 3 of the section are referred in this paper to *Olenellus argentus* and to *Olenellus gilberti*; those from 3d of the Waucoba section [pp. 187 and 188] are referred to *Wanneria gracile*; and those from 1d and 2j [p. 186] are not specifically identified.)

Dorsal shield elongate oval, rather strongly convex over the cephalon and less so over the thorax and pygidium. Cephalon semi-circular in outline, strongly convex, one-third the length of the dorsal shield; bordered by a strong, rounded rim that is continued

into strong, long genal spines that are nearly as long as the thorax; the posterior border is broad, but not as convex as the frontal border; it narrows toward the base of the glabella and shows a decided tendency to curve with a varying angle at the intergenal angle [figs. 1, 5, 6, and 10, pl. 29]; the intermarginal furrow is narrow and rounded inward on the sides and in front, and rather more distinctly impressed within the posterior border. Glabella convex, elongate, gradually expanding from the occipital segment to the widest portion of the anterior lobe, dorsal furrow deep on the sides and in front; the anterior lobe is transverse, widest near its base, gradually curving on the sides to the rather sharply rounded front margin; the anterior and third pair of furrows extend from the central third of the glabella obliquely forward and terminate at the dorsal furrow; the second pair terminate inside so that the second and third lobes unite and enclose it [fig. 6]; usually the space between the end of the glabellar furrow and the dorsal furrow is very narrow, and it is often broken through [figs. 1, 2]; occipital ring separated from the glabella by two lateral furrows that are similar, when the shell is not too much flattened, to the glabellar furrows; the occipital ring is broad, convex, and with a long, strong median spine that curves backward over the axial lobe of the thorax to about the sixth segment; the base of the spine is strong and, in large specimens, extends nearly across the occipital ring. The cheeks arch up from the intermarginal furrow to the base of the eye, broadening back of the eye and narrowing toward the front margin so as to form only a narrow space of slightly variable width in different specimens between the glabella and the intermarginal furrow. The palpebral lobes are narrow, elongate, and gently arched outward and backward from the dorsal furrow beside the posterior lateral margin of the first glabellar lobe; they terminate a short distance from the dorsal furrow opposite the occipital furrow, thus giving only a slight divergence between their anterior and posterior ends; they are elevated to about the same height as the center of the glabella and slope rapidly into the depressed interpalpebral area. the drop to the cheeks is very abrupt, and gives only a narrow space for the visual surface of the eye. The only trace observed of a facial suture is an elevated line on the cast of the interior of a flattened cephalon; the line starts at the posterior end of the palpebral lobe and extends backward a short distance before curving outward toward the marginal rim, which it crosses obliquely at about the same place as in *Callavia bröggeri* [pl. 27, fig. 1].

Thorax with sixteen segments of the same character; the body of the thorax lies well within the long genal spines, owing to the shortness of the spinous extensions of the pleuræ; its sides are subparallel back to the tenth segment, where they begin to arch inward toward the small pygidium; axial lobe convex, about the same width as the pleural lobes, and narrowing gradually in width, a small elongate, median node, with a base as long as the width of the segment, occurs on each segment, and there is a low, rounded elongate tubercle on each side that is much like that on the axial segment of *Holmia kjerulfi* [compare fig. 4, pl. 29, with fig. 7, pl. 27]; an elongate, subtriangular tubercle next to the dorsal furrow on the anterior side of the segment is also well shown by fig. 5; usually the elongate tubercles of the axial lobe have disappeared by compression of the test; pleural lobes nearly flat from the dorsal furrow out to their curved spinose extensions where they arch gently downward; each pleura has a broad, strong furrow that is broadest next to the dorsal furrow from whence it narrows very gradually to just within the curved terminal spinous extension of the pleuræ. The posterior margin of the spinous extension is arched forward from the posterior margin of the pleuræ, which gives a beaked or slightly hooked outline to the termination of the pleuræ.

Pygidium small; width at the anterior margin and length subequal; the sides extend slightly outward from the anterior margin and terminate in short spines; the posterior margin is slightly arched backward at the center and inward on each side toward the base of the postero-lateral spines; axial lobes with one anterior transverse ring that appears to bend backward along the outer margins and extend into the terminal spines; back of the transverse ring a subtriangular termination of the axial lobe, of equal width and length, occupies the central area; it does not reach the posterior margin, and it has no traces of transverse rings or furrows; with the possible exception of the rounded outer marginal rim there are no indications of pleural extensions of the rings across the smooth space between the axial lobe and outer margins; the anterior ring shown by fig. 11 is the forward extension of the first ring that slipped beneath the terminal segment of the thorax.

Surface strongly granular on the outer rim of the cephalon [fig. 7], finely granular over most of the test, and with irregular network of fine elevated ridges that may give a pitted appearance in some places [fig. 8] where the ridges are crowded, or an open pattern with elongate meshes on the checks and segments.

Dimensions.—A dorsal shield 44.75 mm. in length has the following dimensions:

<i>Cephalon:</i>	<i>mm.</i>
Length	16.
Length of glabella	13.
Length of eyelobe.....	6.5
Width at posterior margin.....	30.
Width of glabella at posterior margin.....	8.
Width of glabella at broadest part of anterior lobe.....	10.

<i>Thorax:</i>	
Length	26.
Width at first segment.....	23.
Width of axial lobe at first segment.....	9.
Width of axial lobe at last segment.....	2.5
Width of pleural lobe at first segment.....	7.

<i>Pygidium:</i>	
Length	2.75
Width	2.5

The preceding description is based on adult specimens from 40 mm. to 50 mm. in length. The largest cephalon in the collection has a length of 30 mm.; width 50 mm. This indicates a dorsal shield of about 85 mm. in length. One young stage of growth is partly illustrated by a broken cephalon 1.5 mm. in length in which the outline [fig. 9] is rounded; glabella cylindrical, with the base of the frontal lobe continuous with the strong palpebral segment; this may be compared with the stage of *Elliptocephala asaphoides* represented by fig. 14 of pl. 25.

Observations.—Fragments of this species occur abundantly in association with *Nevadia weeksi* in hard, shaly sandstones deep down in the Lower Cambrian (Georgian) section of southwestern Nevada. In America it is the oldest species of the genus *Holmia*, and in development its position in the Mesonacidae appears to be after the forms with imperfectly developed posterior thoracic segments: *Nevadia*, *Mesonacis*, and the slightly more specialized *Callavia*.

The generic relations of *Holmia rowei* to the genotype *H. kjerulfi* are very close as may be seen by comparing the illustrations on pl. 29 with fig. 7, pl. 27. The eye lobes are of the same character, as are the other parts of the cephalon; each species has sixteen thoracic segments that terminate in narrow arching spines; the pygidia are small and of the same type. The occipital spine of *H. rowei* is longer than that of *H. kjerulfi*. The specific differences are in the details of the cephalon, such as the relation of the anterior lobe of the glabella to the frontal border; the longer occipital and genal

spines and more arched pleural spines of *H. rowei* and the outlines of the pygidia.

FORMATION AND LOCALITY.—Lower Cambrian: (1f) arenaceous shales of the Silver Peak Group, forming No. 12 of the Barrel Spring section [Walcott, 1908c, p. 189], 3 miles (4.8 km.) north-west of Barrel Spring, which is 10 miles (16 km.) south of the town of Silver Peak, Esmeralda County, Nevada.

WANNERIA, new genus

Dorsal shield large, broadly oval in outline. Cephalon about two-fifths of the length of the dorsal shield, transversely semicircular in outline with genal angles extended into strong spines; marginal border strong; cheeks broad; glabella elongate, semicylindrical and with four lobes, the anterior being the largest and expanded slightly or not at all beyond the line of the sides of the glabella; palpebral lobe connected to the anterior lobe of the glabella; it is short and relatively small in the adult [pl. 30, fig. 2; pl. 31, fig. 3] and increasing in length with the decrease in the size of the cephalon [pl. 30, figs. 3, 4; pl. 31, figs. 3, 1, 2, 4, 7, 8; pl. 38, figs. 19, 22].

Thorax with seventeen segments; median lobe strongly convex; pleural lobe broad and with the pleuræ extended into falcate ends that curve more and more backward until the posterior pairs nearly enclose the pygidium; pleural furrow broad, next to the axial lobe, and extending out about one-half the length of the pleura.

A small median, elongate tubercle occurs on the axial lobe of each segment, that becomes a strong, long, median spine on the fifteenth segment in old, large specimens [fig. 11, pl. 30]. It is small in younger individuals [fig. 10, pl. 30].

Pygidium small, subcircular, transverse where it joins the thorax and notched at the posterior center.

Surface with irregular network of very fine, irregular ridges that form very fine meshes over the greater part of the outer surface of the dorsal shield and hypostoma; the meshes are elongated on the marginal border of the cephalon and genal spines subparallel to the margin, while on the doublure of the thoracic pleuræ the meshes are more or less transverse [pl. 31, fig. 12], also on the pygidium [pl. 30, fig. 8].

Dimensions.—Two of the species of the genus, *W. walcottanus* and *W. halli*, grow to a large size, equal to that of any species of the Mesonacidæ. The former species is known to have reached a length of 17.6 cm. with a width of 15 cm. at the genal angles. Fragments of *W. halli* indicate a length for the dorsal shield of 15 cm.

Young stages of growth.—Nothing is known of the younger stages of growth of the genotype, *W. walcottanus* [pl. 30], but of the closely related species, *W. halli* [pl. 31], there are examples of a number of the younger stages of growth of the cephalon. These show that in the youngest stage of growth known [pl. 31, fig. 8] the form is much like that of the young of *Pædeumias transitans* [pl. 32, fig. 1, pl. 25, fig. 22], and *Elliptocephala asaphoides* [pl. 25, fig. 10]. The most notable changes resulting from increase in size are the diminution in size and length of the palpebral lobes [pl. 31, figs. 8, 7, 4, 2, 1, 3], the separation of the genal from the intergenal spines [pl. 31, figs. 8, 6, 4, 1], and the widening of the glabella back of the first lobe [pl. 31, figs. 8, 5, 7, 4] until its sides are sub-parallel; the change in form of the first or anterior lobe of the glabella is shown by figs. 8, 5, 7, 4, 2, 1, of pl. 31. Due allowance should be made for the expansion or widening of the anterior convex lobe as the result of flattening by compression in the shale.

Genotype.—*Olenellus (Holmia) walcottanus* Wanner.

The generic name is given in honor of Prof. Atreus Wanner, of York, Pennsylvania, who first described the type species.

Stratigraphic range.—Lower Cambrian (Georgian). The genotype occurs in the York formation, *Olenellus* zone, in the upper portion of the Lower Cambrian terrane, and *W. halli* occurs in the same zone in the Montevallo shale. *W. gracile* is found about 2,000 feet down in the St. Piran formation of the Lower Cambrian of Alberta, Canada, and 1,450 miles to the south in Nevada it occurs 1,200 feet or more below the zone of *Olenellus gilberti*, which corresponds to about the horizon of *Wannuceria halli* and *W. walcottanus* in Alabama and Pennsylvania, respectively.

Geographic distribution.—The genotype occurs in an east and west belt across the central parts of York and Lancaster counties, Pennsylvania. *W. halli* is found in central Alabama, and *W. gracile* in Nevada and Alberta, Canada.

Observations.—The cephalon is similar in generic characters to that of *Elliptocephala*, *Mesonacis*, *Pædeumias*, *Olenellus*, and *Holmia*, but differs from that of *Callavia* in having a more expanded anterior glabellar lobe, and in not having a large occipital spine. The thorax has seventeen segments of the *Callavia bröggeri* type [pl. 27, fig. 1], in that the segments continue of a uniform width out to where the margins converge into a strong backward curving point, but they differ in having a broad pleural furrow of the *Olenellus thompsoni* type [pl. 35, fig. 1], instead of the narrow oblique furrow of *C. bröggeri*. The great spine of the fifteenth segment of the adult

[pl. 30, fig. 11] is not found in *Callavia* or *Holmia*. *Wanneria* also differs from *Holmia* in the character of the lateral extensions of the pleuræ. In *Holmia* the spinose extensions give quite a different aspect [pl. 27, fig. 7] from that of the extensions of *Wanneria* [pl. 30, fig. 1]. *Wanneria* differs from *Elliptocephala* [pl. 24, fig. 1], *Mesonacis* [pl. 26, fig. 1], *Nevadia* [pl. 23, fig. 1], in the characters of the thorax to such an extent that a statement of the differences is unnecessary in this place.

WANNERIA ? GRACILE, new species

PLATE 38, FIGS. 15-24

Holmia rowei WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, No. 5, pp. 187 and 188. (The specimens listed under this name in 3d of the Waucoba section are referred in this paper to *Wanneria gracile*.)

Holmia weeksi WALCOTT, 1908, Idem, p. 189. (The specimens listed under this name in 3 of the Barrel Spring section are referred in this paper to *Wanneria gracile*.)

Cephalon semicircular in outline, moderately convex; marginal border rounded, strong in the larger, narrow and wire-like in the smaller specimens, and continued backward at the genal angles into moderately strong spines; posterior marginal border rounded and narrow at the occipital ring and slightly broader where it merges into the strong outer rim at the genal angles. In a cephalon 17 mm. in length there are no traces of an intergenal angle [fig. 21], but in one 7 mm. in length a broad angle is present and the marginal rim is thickened by an oblique, obscure intergenal ridge that was undoubtedly an intergenal spine in younger specimens [fig. 22]. An unusual specimen of the cephalon, 8 mm. in length [fig. 23], has the outer margin curved inward very much as in a very young cephalon 2 mm. in length [fig. 24]; the ridge on the test from the base of the eye out to the margin indicates the position of the intergenal spine at x ; the genal spine is not shown on the specimen. Glabella convex, elongate, narrowing gradually from the occipital ring to the front of the first lobe; four strong furrows extend obliquely backward from each side nearly to the center where they are united by a very shallow transverse furrow; the very slight dorsal furrow about the glabella is crossed by the ocular ridges that join the anterior lobe of the glabella at its postero-lateral margins; the second, third, and fourth glabellar lobes are curved slightly backward and almost pass into the flat area within the palpebral lobe; the proportions of all the glabellar lobes and the occipital ring are shown by figs. 19

and 20, also the size and length of the palpebral lobes which are elevated and joined to the first glabellar lobe by a narrow ridge. The palpebral lobe [figs. 17, 19] is short and much like that of *Wanneria walcottanus* [pl. 30, fig. 1]. From the posterior end of the palpebral lobe a narrow furrow on the interior of the test curves backward and then outward and backward to the posterior margin, following in its course the position of the facial suture of *Paradoxides spinosus* Boeck [Barrande, 1852, pl. 12, fig. 1]. Occipital ring strong, rounded, and with a small median node near the posterior margin.

The hypostoma is of the same general character as that of *Callavia bröggeri* [pl. 27, fig. 2] and *C. crosbyi* [pl. 28, fig. 6], and differs from the hypostoma of *Wanneria* [pl. 31, fig. 9] in having a smooth, rounded frontal margin.

Surface known only from a few fragments of the test adhering to the specimens illustrated by figs. 20 and 23. These show the characteristic irregular, elevated ridges of the surface of *Holmia*, also fine, rather sharp granulations. A cephalon 2 mm. in length [fig. 24] is strongly convex and with unusually elevated prominent palpebral lobes that merge into the first glabellar lobe in a manner similar to those of the young of *Elliptocephala asaphoides* [pl. 25, fig. 10].

Dimensions.—These are shown for the cephalon by fig. 21, which is reproduced from a photograph, natural size.

Observations.—This is a very interesting species of the Mesonacidae, and it is to be regretted that there are no entire specimens of the dorsal shield. *Wanneria ? gracile* is distinguished by its slender conical glabella from *W. walcottanus*. It resembles the latter species in having short, elevated palpebral lobes connected with the first lobe of the glabella by a strong ocular ridge. Its slender glabella with the narrow first lobe is more like that of *Callavia* [pl. 27, fig. 1; pl. 28, figs. 3 and 8] than that of *Wanneria* [pl. 30, fig. 1; pl. 31, figs. 1, 5, 6], which has a rounded, expanded anterior lobe to the glabella. It is not known whether there was a large spine on the thorax as in *Wanneria* [pl. 30, fig. 11]. The absence of this information and the conical outline of the anterior lobe of the glabella renders it difficult to make a positive reference of the species to *Wanneria*. The strong marginal border of the cephalon, small eyes, and the absence of an occipital spine relate it more closely to that genus than to *Callavia*. It is not improbable that entire specimens will show it to be a form intermediate between *Callavia* and *Wanneria*.

The stratigraphic position of *W. ? gracile* is in the central portion of the Lower Cambrian terrane of western Nevada and southeastern California beneath the great Archæocyathus limestone. It is associated with *Olenellus fremonti* in the massive quartzitic sandstone series 2,500 feet above the horizon of *Nevadia weeksi*, and 1,200 feet or more below the upper beds of the Lower Cambrian carrying *Olenellus gilberti*. At Vermilion Pass, Alberta, numerous specimens of the cephalon of this species [pl. 38, figs. 17-20] occur in a hard, brownish-gray sandstone of the St. Piran formation, about 2,000 feet below the Mt. Whyte formation and 250 feet above the Lake Louise formation. With the cephalon for comparison, there do not appear to be specific differences between the specimens from Nevada and Alberta, localities 1,450 miles distant from each other.

Near Resting Springs (locality No. 14p) the following species are associated with *W. gracile*: Cystid plates, *Lingulella (Lingulepis) rowci* Walcott, *Billingsella birvia* n. sp., *Obolella vermillionensis* n. sp., and *Olenellus fremonti* Walcott; in Nevada (locality No. 1v): *Archæocyathus ?* sp., *Kutorgina cingulata* (Billings), *K. perugata* Walcott, *Siphonotreta ? dubia* n. sp., *Swantonina weeksi* Walcott, *Swantonina ?* sp., *Stenotheca cf. elongata* Walcott, *Stenotheca cf. rugosa* Walcott, *Ptychoparia* sp., and *Olenellus argenteus* Walcott; at Vermilion Pass (locality No. 60b): *Obolella vermillionensis* n. sp., *Orthotheca adamsi*, n. sp.

FORMATION AND LOCALITY.—Lower Cambrian: Silver Peak formation [see Walcott, 1908c, p. 185] at the following localities: (14p) quartzitic sandstones near Resting (Fresh Water) Springs, which is in the southwest corner of T. 21 N., R. 8 E., on the Armagosa River; (8) arenaceous shales and shaly sandstones 3 miles (4.8 km.) above Tollgate Canyon, White Mountain Range; (53) sandstones in the lower portion of 3d of the Waucoba Springs section [Walcott, 1908f, pp. 187 and 188], 1 mile (1.6 km.) east of Saline Valley, road about 2.5 miles (4 km.) east-northeast of Waucoba Springs; (176 and 178a) in arenaceous shales apparently lying between massive limestones carrying Archæocyathus, at the south end of the Deep Spring Valley, about 20 miles (32 km.) east-southeast of Big Pine in Owens Valley; and (177) shales in low hills 3 miles (4.8 km.) west of the Deep Spring Valley; all in Inyo County, California.

(1v) arenaceous shales 3 miles north of Valcalda Spring and 4 miles (6.4 km.) northwest of Drinkwater Mine. Silver Peak quadrangle, Esmeralda County, Nevada.

(60b) compact sandstones of St. Piran formation about 2,000 feet (610 m.) below the Mount Whyte formation and 200 to 300 feet (61-91 m.) above the Lake Louise shale, at Vermilion Pass, on the Continental Divide between British Columbia and Alberta, west-southwest of Castle on the Canadian Pacific Railway, Alberta, Canada.

WANNERIA HALLI, new species

PLATE 31, FIGS. 1-11

The cephalon, hypostoma, and fragments of the thoracic segments of this species are all that is known of it. The cephalon [pl. 31] has the same general outline and broad marginal border as that of *W. walcottianus* [pl. 30, figs. 1 and 2]. The cephalon of *W. halli* differs from that of the latter species in having a more narrow glabella in proportion to the width of the cheeks and a smaller anterior lobe. The genal angles of 27 specimens of the cephalon of *W. halli* are all advanced in the adult, and only in the young are they on a line with the posterior margin [figs. 5 and 6]. In the larger specimens [figs. 1 and 3] the intergenal angle is a right angle; this gradually changes as the cephalon grows smaller [figs. 2, 4, and 6] until the genal angles slope inward [figs. 5 and 7] and rest against the intergenal spines [fig. 8].

The palpebral lobe of the adult [fig. 3] is relatively small, less than one-third of the length of the cephalon, but with decrease in size of the cephalon the lobe increases in length [figs. 1, 2, 4, 7, and 8] until in the smallest cephalon [fig. 8] it is seven-twelfths of its length; this includes the strong, elevated ridge that unites the lobe with the anterior lobe of the glabella. The narrowing of the glabella at the posterior end of the anterior lobe is also a very striking feature of the young of *W. halli* [figs. 5, 7, and 8].

The associated hypostoma has an elongate oval body that narrows posteriorly to the neck, that connects it with the convex transverse posterior section. A deep, oblique, lateral furrow separates the body on each side from the narrow raised outer rim and the posterior section; the outer rim merges into the convex posterior section that arches about the posterior portion of the body and the posterior and lateral margins are bordered by a flattened margin that is perforated by twelve small, round holes that, when the outer edge is broken away, leave the interspaces as blunt points which form a denticulated margin. The perforated margin occurs on very small specimens and those up to 2 mm. in length. Larger specimens have a denticulated

margin, and in the still larger all traces of the perforations have disappeared, and true spines occur usually six on each side and two or four on the posterior margin, as in *Pædeumias transitans* [pl. 34, figs. 5, 6, and 7].

Fragments of thoracic segments associated with the cephalon indicate [figs. 10, 11, pl. 31] that the pleural lobes were broad, and that the pleuræ of each segment continued outward and curved gently backward, narrowing gradually to a sharp point, as in *W. walcottanus* [pl. 30, figs. 1, 10-12].

Surface very rarely preserved owing to the maceration and compression of the specimens in the fine arenaceous-argillaceous shale. The few traces of it left indicate that it was similar to that of *W. walcottanus* in having an irregular network of fine, irregular ridges over the greater part of the surface; this is shown for the latter species by figs. 12, 13, pl. 31, and for *W. halli* by figs. 10, 11, pl. 31.

Dimensions.—The largest fragment of the cephalon in the collection indicates a complete cephalon 60 mm. in length with a width of 110 mm. and a dorsal shield based on the proportions of *W. walcottanus* of about 150 mm. in length.

Reference to the younger stages of growth of this species may be found under the description of the development of the individual of the Mesonacidæ (pp. 236-243).

The specific name is given in honor of Prof. James Hall.

FORMATION AND LOCALITY.—Lower Cambrian: in the upper portion of the Montevallo formation at the following localities: (56c) *argillaceous-arenaceous shales about 1,000 feet (305 m.) northeast of town of Helena, on roadside just north of Buck Creek*; and (164c) 4 miles (6.4 km.) south of Helena on road to Montevallo; both in Shelby County, Alabama.

WANNERIA WALCOTTANUS (Wanner)

PLATE 30, FIGS. 1-12; PLATE 31, FIGS. 12 AND 13

Olenellus (Holmia) walcottanus WANNER, 1901, Proc. Washington Acad. Sci., Vol. 3, pp. 267-269, pl. 31, figs. 1, 2; pl. 32 figs. 1-4. (Described and discussed as a new species. The specimens represented by 1, 2, and 3, pl. 32 are redrawn in this paper, pl. 30, figs. 6, 5, and 7 respectively. The specimen represented by figure 2, pl. 31, is redrawn in this paper, pl. 31, fig. 12.)

This is one of the largest species of the Mesonacidæ, and like *Callævia bröggeri* (Walcott), *C. crosbyi* Walcott, and *C. burri* Walcott, occurs in the upper portion of the North American Lower Cam-

brian terrane. It is quite abundantly represented by fragments in the collections from York and Lancaster counties, Pennsylvania, and more rarely by entire specimens. Since the original description of the species [Wanner, 1901] Professor Wanner has found specimens that prove the existence of a median spine on the fifteenth segment that in old and large dorsal shields is as strong as in large dorsal shields of *Pædeumias transitans* [compare fig. 11, pl. 30, with figs. 3 and 4, pl. 33]. On smaller dorsal shields the median spine is proportionally much less developed [see pl. 30, figs. 10 and 12]. The median spine of the fourteenth segment is short and slender, but stronger in large dorsal shields than the pointed nodes on the other segments of the thorax and the occipital segment of the cephalon.

The palpebral lobe of the adult is small, about one-third of the length of the cephalon [fig. 2], but these specimens of younger stages of growth indicate that the lobe is progressively longer [figs. 3, 4] as the cephalon decreases in size. This character is finely shown in the young of *Wanneria halli* [pl. 31].

The presence of the great spine on the fifteenth segment indicates the approach of the *Mesonacis* stage of development and the tendency to acquire the adult character of *Olenellus thompsoni* of having a large terminal telson without segments and pygidium posterior to it. The adult *W. walcottanus* resembles *Callavia bröggeri* (Walcott) and *C. callavei* (Lapworth), but differs greatly in its smaller eyes, absence of occipital spine, and presence of a great spine on the fifteenth segment.

Dimensions.—A large somewhat flattened dorsal shield from 1 mile north of Rohrerstown, Lancaster County, Pennsylvania, has a length of 17.6 cm. and a width at the genal angles of the cephalon of 15 cm. The cephalon is 6.4 cm.; thorax 10.2 cm., and pygidium 1 cm. in length. The eye lobes vary slightly in length as compared with the length of the cephalon, but the average length is one-third of the length of the cephalon. The relative proportions of other parts of the dorsal shields are well shown by fig. 1, pl. 30.

The cephalons of *Olenellus thompsoni crassimarginatus* [pl. 35, figs. 8-10] recall those of *W. walcottanus* [pl. 30], except that the latter has small eyes and an expanded anterior glabellar lobe, while the former has large eyes and a narrower anterior lobe to the glabella.

This species differs from *Wanneria halli* [pl. 31] in having a wider anterior glabellar lobe, proportionally wider glabella, narrower cheeks, with the genal angles on a line with the posterior margin of the cephalon.

FORMATION AND LOCALITY.—Upper portion of the Lower Cambrian, in the York formation: (8q)¹ *calcareous shales 2 miles (3.2 km.) northwest of the city of York, Pennsylvania, and eastward in the same band of shales across York County to the Susquehanna River.*

(12w)² 2 miles (3.2 km.) north of the city of Lancaster, Pennsylvania, near Fruitville, and westward at various localities to the Susquehanna River, notably 1 mile (1.6 km.) north of Rohrerstown, on the farm of Noah L. Getz.

PÆDEUMIAS, new genus

(Παίδευμα = rudiment)

The description of *Pædeumias* is included in that of the genotype *P. transitans*. I began by placing this form as a variety of *Olenellus thompsoni*, but when I came to discuss its relations to *Olenellus* it appeared desirable to give it a distinct generic and specific name, as it is a transition stage between *Mesonacis* and *Olenellus*.

Pædeumias is a *Mesonacis* or an *Olenellus* with rudimentary thoracic segments and pygidium posterior to the fifteenth segment, as one may wish to consider it. The cephalon and first fourteen segments are generically the same in the three genera. Their differences are in the dorsal shield posterior to the fourteenth segment.

Mesonacis has a spine-bearing fifteenth segment [pl. 26] with ten smaller but typical thoracic segments and a pygidium characterized by postero-lateral spines.

Pædeumias has the fourteenth segment as a median spine posterior to which there are from two to six rudimentary segments, and a rudimentary pygidium [pl. 33].

Olenellus has the fifteenth segment as a terminal telson without segments or pygidium posterior to it.

Genotype.—*Pædeumias transitans* Walcott.

Stratigraphic range.—Lower Cambrian (Georgian) terrane, in upper portion, in association with *Olenellus thompsoni*.

Geographic distribution.—Typical locality Georgia, Franklin County, Vermont. It has been found on the south side of the St. Lawrence River at Bic, in the Province of Quebec; at Bonne Bay, in northwestern Newfoundland; in Labrador, at L'Anse au Loup, on the Straits of Belle Isle; south of Vermont, in Lancaster and York counties, Pennsylvania; near Cleveland, in eastern Tennessee; and in Shelby County, Alabama.

¹ Collected by Prof. Atreus Wanner.

² Collected by Prof. H. Justin Roddy.

PAEDEUMIAS TRANSITANS, new species

PLATE 24, FIG. 12; PLATE 25, FIGS. 19-22; PLATE 32, FIGS. 1-13; PLATE 33, FIGS. 1-5; PLATE 34, FIGS. 1-8; PLATE 44, FIG. 7

- ? *Paradoxides thompsoni* BILLINGS [not (HALL)], 1861, Geol. Survey Canada, Paleozoic Fossils, p. 11. (Mentions presence of a head representing *Olenellus thompsoni* at Anse au Loup. In view of the similarity between the heads of that species and *Paedeumias transitans*, and the fact that *Paedeumias transitans* has been identified from this locality in material loaned to me by the Geological Survey of Canada it is probable that the latter species is the one referred to by Mr. Billings.)
- ? *Barrandia vermontana* HALL (in part), 1861, Report on the Geology of Vermont, Vol. 1, p. 370, first 6 paragraphs. (Copies the paragraph given by Hall [1860, p. 117] and describes the species. The text includes reference to figures [see Hall, 1862, pl. 13, figs. 4 and 5 in following reference] now placed under *Paedeumias transitans*.)
- ? *Barrandia vermontana* HALL (in part), 1862, Report on the Geology of Vermont, Vol. 2, pl. 13, figs. 4 and 5 (not fig. 2 which is a true *Mesonacis vermontana*). (As stated under this reference in the synonymy of *Mesonacis vermontana*, the specimens represented by figures 4 and 5 appear to be more closely allied to *Paedeumias transitans* than to *Mesonacis vermontana*.)
- ? *Olenellus thompsoni* BILLINGS [not (HALL)], 1865, Geol. Survey Canada, Paleozoic Fossils, Vol. 1, p. 11. (Reprinted from Billings, 1861a, p. 11, substituting *Olenellus* for *Paradoxides*.)
- Olenellus thompsoni* WHITFIELD [not (HALL)], 1884, Bull. American Mus. Nat. Hist., Vol. 1, No. 5, pp. 151-153, pl. 15, fig. 1. (Described and discussed.)
- Olenellus vermontana* WHITFIELD [not (HALL)], 1884, Idem, pp. 152-153, pl. 15, figs. 2-4. (Discussed.)
- ? *Olenellus thompsoni* ? WELLER [not (HALL)], 1900, Ann. Rept. Geol. Survey New Jersey for 1899, pp. 49-51, pl. 1, figs. 9-10. (Described and discussed. Only the head of this species is figured but it appears to be referable to *Paedeumias transitans*.)

In 1892 Prof. Atreus Wanner, of York, Pennsylvania, called my attention to the presence of well-preserved specimens of what we considered to be *Olenellus thompsoni* (Hall) in argillaceous shales at York [Walcott, 1896, pp. 13 and 16, footnote]. Subsequently Dr. Charles Schuchert made a large collection for the National Museum from the localities discovered by Professor Wanner, and later the latter permitted me to study the material in his private collection, and recently sent a number of well-preserved specimens of the younger stages of growth that he had found during the past ten years. The study of all available material has resulted in discovering a curious and interesting series of changes between the protaspis

stage and the typical adult of *O. thompsoni*, that include characters of the adult forms of *Holmia*, *Mesonacis*, and *Olecnellus*, also that a form otherwise identical with *O. thompsoni* has rudimentary thoracic segments and a *Holmia*-like pygidium posterior to the fifteenth spine-bearing segment of the thorax. For this form the name *Pædumias transitans* is proposed. In my first notes I referred these forms to *Mesonacis*, but with better material it became evident that the rudimentary segments of *P. transitans* were quite unlike those of *Mesonacis* [compare fig. 12, pl. 24, with figs. 2 and 3 on pl. 26].

In many specimens of *P. transitans* from York two to six rudimentary segments and a small, plate-like pygidium occur beneath and posterior to the fifteenth telson-bearing segment. The rudimentary segments are very thin, without pleural lobes, and marked by a broad, simple, transverse furrow; the ends terminate abruptly with a very short spine at the posterior angle in some specimens.

The York specimens [pl. 33, figs. 2-5] are similar to those from Vermont [fig. 1, pl. 33, and fig. 1, pl. 34]. In the typical form of *Mesonacis vermontana* [pl. 26, figs. 1 and 3] there are well-defined pleural lobes back of the fifteenth segment of the thorax, and the spine on the fifteenth segment is a characteristic dorsal spine and not a terminal telson like that of *O. thompsoni* [pl. 34, fig. 9; pl. 35, fig. 1]. The spine of fig. 1, pl. 33, is nearing the last stage of the change from the *Mesonacis*-like dorsal spine to the telson of *Olecnellus*. A similar specimen to this was found by Mr. Noah L. Getz one mile north of Rohrerstown, Lancaster County, Pennsylvania.

Restricting *Mesonacis* to those forms in which the segments posterior to the spine-bearing fifteenth segment are normal thoracic segments, such as represented by figs. 1, 2, and 3, pl. 26, we then refer all with the short rudimentary segments posterior to the spine-bearing fifteenth segment to the *Pædumias* stage of development of the Mesonacidae as *Pædumias transitans*; this species includes not only the York specimens, but the large Vermont specimens represented by fig. 1, pl. 33, and fig. 1, pl. 34.

In two specimens collected by Professor Wanner the telson has broken away from its base so as to show the union of the rudimentary segment and the fifteenth segment [see pl. 33, figs. 2 and 5]. The telson was hollow on the under side and, when forced down on the thin, delicate rudimentary segments, pressed them out of shape, as shown in the illustrations.

The smallest known *P. transitans* from York, with rudimentary segments, has a length of 14 mm. to the end of the telson-like spine

and of 8 mm. to the fifteenth segment. This appears to have six rudimentary segments and pygidium. The largest specimen from York [fig. 10, pl. 32] has a length of 74 mm. to the end of the telson-like spine and of 47 mm. to the fifteenth segment. It has five rudimentary segments and pygidium. The largest specimen from Georgia, Vermont, has a length of 98 mm. to the fifteenth segment. The entire dorsal shield of this specimen is similar to that of *Olenellus thompsoni*, except that the fifteenth segment is not quite reduced to a telson, and three rudimentary segments and a pygidium occur back of the great median spine [pl. 33, fig. 1]. Another feature to be noted is that the surface characters of the rudimentary segments and pygidium are sharp, elevated subparallel lines, as in the genus *Paradoxides*, and unlike those of the great spine and the segments of the thorax [pl. 24, fig. 12] which form a network of irregular reticulating and inosculating elevated lines characteristic of the known adult forms of most of the Mesonacidae. Nearly all specimens of the thorax of *P. transitans* have a sharp, elongate, median node on the posterior four to six thoracic segments [fig. 10, pl. 32]. On some of the larger specimens there is a slender, sharp node or spine at the posterior margin of the segments from the first to the eighth, and back of the eighth the base of the node or spine becomes more elongate until it extends across the full width of the segment. The hypostoma has a denticulated or spinous postero-lateral and posterior margin. The spines are short and usually blunt [fig. 7, pl. 34], but they may be sharp [fig. 5]; there are five larger ones on each side and two or three smaller and shorter ones on the back margin that are usually broken off or obscure so as to give the effect of a clear space [fig. 5] without spines. This type of hypostoma is quite abundant at the York localities, and an almost similar form occurs in Alabama.

Young stages of growth of dorsal shield.—The youngest stage of growth collected by Professor Wanner is 1 mm. in length over the cephalon [fig. 1, pl. 32]. The next stage [pl. 32, fig. 2] is 1.5 mm. in length with cephalon, five thoracic segments and a *Holmia* pygidium. At this stage the thoracic segments do not show transverse furrows on the pleural lobes and in such specimens [figs. 2 and 3] the segments are rudimentary or have not reached the fully developed stages as seen in the adult [figs. 1 to 3, pl. 34]. This immature stage of the thoracic segment occurs in the posterior segments of the adult form of *Nevadia weeksi* [pl. 23, figs. 1, 2, and 4], and represents the earliest known or *Nevadia* stage of development of

the Mesonacidae. At the next stage recognized, fig. 6, there are ten thoracic segments, a *Holmia* pygidium, and an enlarged third thoracic segment that is typical of *Mesonacis* and *Olenellus*. In fig. 1, pl. 33, the fifteenth segment is almost a typical telson of *Olenellus thompsoni*, but there are three short rudimentary segments and a pygidium. With another slight change the segments and pygidium would disappear and a true *Olenellus thompsoni*, like that of pl. 34, fig. 9; pl. 35, fig. 1, would result.

The conclusion from the foregoing is that the thorax of *Pædeumias* passes through several stages of development of which we now have some information. These are:

First. Holmia stage.—A *Holmia* without large third segment or telson.

Second. Intermediate stage.—A form with large third segment, but without a dorsal spine on the fifteenth segment.

Third. Pædeumias.—A form with large third segment, large spine on fifteenth segment, and with segments and plate-like pygidium posterior to the fifteenth segment.

Nearly all the specimens of *Pædeumias* found at York have the typical cephalon of *P. transitans*, as shown on pl. 34, figs. 2-4. In all of these the anterior lobe of the glabella is some distance from the frontal rim of the head, while in typical *Olenellus thompsoni* [pl. 35] and *Mesonacis vermontana*, from Vermont [pl. 26, fig. 1] the anterior lobe touches the frontal rim. With this in view, all of the specimens with the rudimentary segments and pygidium from Vermont and York may be considered as the *Pædeumias* stage of development of the Mesonacidae. The *Pædeumias* segments of the York specimens are short and without defined pleural lobes [pl. 33, figs. 2 to 5], and in this respect are similar to those of the Vermont specimen represented by fig. 1, pl. 33, and fig. 12, pl. 24.

Notes on the young cephalon from Alabama.—Specimens from the vicinity of York are all more or less compressed and flattened in the shales. A fortunate find of uncompressed specimens of the cephalon of some of the younger stages of growth associated with the adult cephalon in the Montevallo calcareo-argillaceous shales near Montevallo, Alabama, made by Mr. Charles Butts and Mr. T. E. Williard in 1906, show some interesting characters of the species not shown by the York specimens. These are illustrated by figs. 18-22, pl. 25, and may be compared directly with the young cephalon of *Elliptocephala asaphoides* on the same plate: fig. 22 with figs. 9 and 10;

fig. 21 with fig. 2; fig. 19 with fig. 4; also with the young cephalon of *Wanneria halli*, as shown on pl. 31. These all prove the close family relationship of the young of *Pædeumias*, *Wanneria*, and *Elliptoccephala*. The description of the young cephalon drawn from the Montevallo specimens is as follows:

Description of cephalon.—Cephalon moderately convex, elongate, semicircular in outline; bounded by a narrow, wire-like, rounded rim that is continued at the genal angle into a short, slender spine; posterior border narrow and interrupted toward the genal angle by a short, sharp intergenal spine. No facial sutures are indicated on any of the specimens. Glabella about three-fourths the length of the cephalon, narrow, elongate, and with the frontal lobe about one-third of the total length; three posterior transverse lobes and an occipital ring are separated by slightly oblique furrows that penetrate nearly to the center. These three lobes and the posterior lobe or occipital ring are nearly of equal width, and each has a small central elevated node or tubercle at the posterior margin. The occipital ring is separated by a strong furrow from the narrow posterior marginal rim of the cephalon. Eye lobes elongate, extending from the large anterior lobe of the glabella to opposite the occipital ring. They arch outward so that the inner margin is about the width of the glabella from the outer margin of the glabella. The eye lobes are separated from the anterior lobe of the glabella by a narrow furrow, although, in one crushed specimen, shown by fig. 20, pl. 25, the frontal lobe of the glabella is pushed in by the strong eye lobe; the space between the outer margin and the glabella and eye lobe is broad, gently convex, and without traces of facial sutures.

A young specimen [fig. 22] about 2 mm. in length has a narrow occipital ring, three broad glabellar lobes, and with the anterior glabellar lobe almost joined to the eye lobes; the sides of the cephalon are rounded in so as to bring the genal angles within a vertical line drawn backward from the outer margin of the eye lobe. The three short lobes of the glabella appear to be extended on each side into small lateral lobes that, with the central lobe, give a segmented appearance to the cephalon. This is further increased by the eye lobes and the anterior lobe of the glabella; the side extension of the posterior lobe of the glabella is continued into large intergenal spines, nearly as long as the head, that arch outward and the curve inward. In the specimen represented by fig. 21 the tendency of the genal angles to draw in toward the base of the glabella is indicated,

also the development of the side lobes of the three posterior glabellar lobes. The tendency to segmentation of the cranidium is the same as that shown by the head of *Elliptoccephala asaphoides* [pl. 25, figs. 9 and 10].

Comparisons.—*Padeumias transitans* is represented both at York and in Alabama by a number of cephalons that suggest the cephalon of *Olenellus gilberti*, as found in the shales in Nevada [pl. 36, figs. 1-3]; also the cephalon of young specimens of *Elliptoccephala asaphoides* [pl. 25, figs. 11-13]. They differ from *E. asaphoides* in having a larger, longer eye lobe, narrower glabella, and in the decided difference in the younger stages of growth. The cephalon of the adult of *O. gilberti* [pl. 36, figs. 1-7] is very similar, but in the younger stages of growth [pl. 36, figs. 11-14] they differ materially from *P. transitans* [pl. 25, figs. 19-22; pl. 32, figs. 1-8].

FORMATION AND LOCALITY.—Upper portion of the Lower Cambrian: (25) dark siliceous shale at Parkers quarry, near Georgia, Franklin County, Vermont.

In the collections of the Geological Survey of Canada are specimens of this species from Bonne Bay, Newfoundland; and from L'Anse au Loup, on the northern shore of the Straits of Belle Isle, Labrador.

(8q) calcareo-argillaceous and arenaceous shales 2 miles (3.2 km.) northwest of the city of York; and (48a) at Cutkamps quarry north of Cottage Hill, north and northeast of the city of Troy, and eastward on the strike of the shales across York County to the Susquehanna River; all in York County, Pennsylvania.

(56l and 12w) 2 miles (3.2 km.) north of the city of Lancaster, Pennsylvania, near Fruitville, and westward at various localities to the Susquehanna River, notably 1 mile (1.6 km.) north of Rohrsertown on the farm of Noah L. Getz.

(46) upper part of Rome sandstone, 5.5 miles (8.8 km.) west of Cleveland, Tennessee.

In central Alabama numerous specimens of the cephalon have been found in the argillaceous-arenaceous Montevallo shales at the following localities: (17a) 1.5 miles (2.4 km.) west of Helena on the Elyton road; (141d) ½ mile (.8 km.) north of Helena; (164a) 2 miles (3.2 km.) north of Helena; (56c) about 1,000 feet (305 m.) north-east of Helena on roadside just north of Buck Creek; and (164c) 4 miles (6.4 km.) south of Helena; all in Shelby County, Alabama.

Genus OLENELLUS Hall

- Olenus* HALL, 1859, Twelfth Ann. Rept. New York State Cab. Nat. Hist., p. 59. (Merely places the genotype of *Olenellus* under *Olenus*.)
- Olenus* HALL, 1859, Nat. Hist. New York, Paleontology, Vol. 3, pt. 1, p. 525. (Copy of preceding reference.)
- Barrandia* HALL (in part), 1860, Thirteenth Ann. Rept. New York State Cab. Nat. Hist., p. 115. (Described and discussed as a new genus; beginning with the 5th paragraph the text is a description of "*Barrandia thompsoni*." As described the genus includes forms now referred to both *Olenellus* and *Mesonacis*. The generic name *Barrandia* was preoccupied and Hall later [1862, p. 114] proposed *Olenellus*.)
- Paradoxides* EMMONS, 1860, Manual of Geology, 2d ed., p. 88, fig. 70. (Illustrates a specimen of *Olenellus thompsoni* Hall as *Paradoxides macrocephalus*. In the first edition this figure was labeled *Paradoxides brachycephalus*.)
- Not *Barrandia* McCoy, proposed for a genus of trilobites.
- Barrandia* HALL (in part), 1861, Report on the Geology of Vermont, Vol. 1, p. 369. (Copy of Hall, 1860, p. 115; the reference including species now referred to both *Mesonacis* and *Olenellus*. Beginning with the 5th paragraph the text is a description of the species "*Barrandia thompsoni*"; this is also copied from Hall [1860].)
- Olenellus* HALL, 1862, Fifteenth Rept. New York State Cab. Nat. Hist., p. 114. (Proposed as a new genus to replace *Barrandia* which was preoccupied by McCoy. The name had been used in Manuscript as early as 1860.)
- Olenellus* (Hall), FORD (in part), 1881, American Journ. Sci., 3d ser., Vol. 22, p. 251. (As discussed throughout this paper the genus *Olenellus* includes forms now referred to *Elliptocephala*, *Mesonacis*, and *Olenellus*.)
- Olenellus* (Hall), WALCOTT (in part), 1886, Bull. U. S. Geol. Survey, 30, pp. 162-166. (Described and discussed in its relations to other genera. As discussed the genus includes forms now referred to *Callavia*, *Elliptocephala*, and *Peachella*.)
- Olenellus* (Hall), HOLM (in part), 1887, Geol. Fören. i Stockholm Förhandl., Bd. 9, Häfte 7, pp. 498-499. (Described in Swedish. As described and discussed throughout the paper the genus includes many of the forms now placed in the family Mesonacidæ.)
- Olenellus* MARCOU, 1889, Proc. Boston Soc. Nat. Hist., Vol. 24, p. 74. (Considers *Olenellus* a synonym of "*Elliptocephalus*.")
- Olenellus* (Hall), WALCOTT, 1890, Proc. U. S. National Museum, Vol. 12, pp. 40-41. (States that *Olenellus* is stratigraphically older than *Paradoxides*.)
- Olenellus* MARCOU, 1890, American Geologist, Vol. 5, p. 362. (Considers *Olenellus* a synonym of "*Elliptocephalus*.")
- Olenellus* Hall, WALCOTT (in part), 1891, Tenth Ann. Rept. U. S. Geol. Survey, pp. 633-635. (Discussed in its relations to other genera. As discussed the genus includes forms now referred to *Callavia*.)

- Olenellus* COLE (in part), 1892, Natural Science, Vol. 1, pp. 340-346. (A historical discussion of *Olenellus* and many of the other forms now placed in the family Mesonacidæ.)
- Olenellus* (Hall), PEACH and HORNE, 1892, Quart. Journ. Geol. Soc. London, Vol. 48, p. 236. (Defines restricted use of *Olenellus*.)
- Olenellus* (Hall), BERNARD (in part), 1894, Quart. Journ. Geol. Soc. London, Vol. 50, pp. 412, 419, 430. (Refers to *Olenellus* in discussing the systematic position of the trilobites, but most of the references are based on the study of forms now referred to *Elliptocephala asaphoides*.)
- Olenellus* (Hall), PEACH, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, pp. 671-673. (Refers to certain characters in connection with a discussion of the Scottish species of the genus.)
- Olenellus* (Hall), BEECHER, 1897, American Journ. Sci., 4th ser., Vol. 3, p. 191. (Refers to genus in discussing classification and includes it under family *Paradoxina*.)
- Olenellus* MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, p. 317. (Characterized. The genus is discussed frequently on pages 309-320 of the paper.)
- Olenellus* WELLER (in part), 1900, Ann. Rept. Geol. Survey New Jersey for 1899, pp. 50-51. (A discussion of the genus in its broader sense.)
- Olenellus* (Hall), POMPECKJ, 1901, Zeitschr. Deutschen geol. Gesellsch., Vol. 53, Heft 2, pp. 14-17. (*Olcnoopsis* is compared with *Olenellus* and other genera of the Mesonacidæ.)
- Olenellus* (Hall), LINDSTRÖM, 1901, Kongl. Svenska Vet.-Akad. Handlingar, Vol. 34, No. 8, p. 24. (Considers *Olcnellus* an eyeless, sutureless trilobite. The discussion of the Olenellidæ on pages 12-18 is almost entirely based on features exhibited by the type species of the genus *Elliptocephala*, and a reference to those pages is therefore placed under the latter genus.)

Genotype.—*Olenus thompsoni* Hall, 1859.

The adult form of *Olenellus thompsoni* Hall has been described and illustrated [see Walcott, 1886, p. 167, and 1891, p. 635], but discoveries made since 1891 have added so much to our knowledge of the younger stages of growth of some species of the genus as restricted in this paper [p. 328] that a brief description of them will be given.

For convenience of reference dorsal shields from the type locality at Parkers quarry, Georgia Township, Vermont, are illustrated [pl. 34, fig. 9; pl. 35, fig. 1].

Olenellus has a large semicircular cephalon, elongate eyes, and the anterior expanded lobe of the glabella is more or less clearly united to the eye lobes by connecting ridges. The thorax has fourteen segments and an elongate terminal telson that is quite unlike the pygidium of any other genus of trilobites, but that is similar in appearance to the telson of *Limulus*. The third segment of the thorax is enlarged and extended in a strong and long pleura on each side.

The hypostoma may be almost globose and oval in outline, with smooth posterior and postero-lateral margins [pl. 38, figs. 2 and 3], or elongate oval with the margins more or less denticulated.

Development of the dorsal shield.—From the observations made in the description of *Pædumias transitans* [p. 307] it is concluded that *Olenellus*, as now restricted is:

First.—A *Holmia* without large third segment or telson [pl. 32, figs. 1-3]. *Holmia* stage.

Second.—A form with large third segment but without a dorsal spine on the fifteenth segment [pl. 32, figs. 4-7]. *Intermediate* stage.

Third.—A *Pædumias* with large third segment, large spine on fifteenth segment, and with rudimentary segments and plate-like pygidium posterior to the fifteenth segment [pl. 33].

Fourth.—A true *Olenellus* with large third segment, fifteenth segment a long telson, and without observable segments or plate-like pygidium posterior to the fifteenth segment [pl. 34, fig. 9; pl. 35, fig. 1]. *Olenellus* stage.

The *Nevadia* stage of *Olenellus* is unknown, unless it is represented by figs. 2 and 3, pl. 32, where the pleuræ of the thoracic segments are apparently simple and unfurrowed. It is quite probable, however, that the *Nevadia* stage has, by acceleration, been passed and lost in the development of *Olenellus*.

The telson of *Olenellus* has long attracted the attention of paleontologists. Prof. R. P. Whitfield said of it in 1884 [p. 152]:

“This feature of the pygidium is so distinctive among all other trilobites that it alone would serve as a generic distinction, and if the condensation of parts indicates development of organization this form would appear to be below even *Paradoxides* and should precede it in age.”

In commenting on Whitfield's observations in 1886 I said [Walcott, 1886, p. 166]:

“From our present knowledge of these forms we reverse the application made above and regard the telson as representing the condensed parts, and the form as higher in organization and succeeding *Paradoxides* in time.”

Dr. B. N. Peach [1894, p. 672] considered the telson of *Olenellus* as the homologue of the small pygidium of *Holmia* and *Mesonacis*.

Dr. John E. Marr [1896, p. 764] wrote: “The posterior segments of the remarkable trilobite *Mesonacis vermontana* are of a much more delicate character than the anterior ones, and the resemblance of the spine on the fifteenth ‘body-segment’ of this species to the

terminal spine of *Olenellus* proper, suggests that in the latter subgenus posterior segments of a purely membranous character may have existed, devoid of hard parts."

Dr. Charles E. Beecher [1897, p. 191], in his memoir on "Outline of the Natural Classification of the Trilobites," says of the family *Paradoxinae*, "Most of the genera are distinguished by their long, narrow eyes . . . but more especially by the rudimentary character of the pygidium. In *Olenellus* the pygidium is a long telson-like spine."

Geographic distribution.—*Olenellus*, as restricted, is found in the sediments of the Appalachian sea as *O. thompsoni* (Hall) on the eastern side of the great pre-Cambrian Algonkian North American continental area from the Straits of Belle Isle to central Alabama. On the western side it occurs as *O. canadensis* Walcott and *O. gilberti* Meek as far north in British Columbia as Kicking Horse Pass in the Rocky Mountains; in Utah as *O. gilberti* Meek in the Wasatch Mountains; in the Eureka mining district of Nevada as *O. fremonti* Walcott; in the Pioche mining district and vicinity as *O. fremonti* Walcott; and in southwestern Nevada and southeastern California as *O. fremonti*, *O. argentus*, and *O. ? claytoni*.

At all the American localities *Olenellus* (restricted) occurs in the upper parts of the Lower Cambrian terrane.

On the eastern side of the Atlantic Basin *O. thompsoni* is represented by the closely allied *O. lapworthi* Peach and Horn [1892, p. 236] of northwest Scotland. This locality has also given *O. reticulatus* Peach [1894, p. 665], and *O. gigas* Peach [1894, p. 666].

As far as known, *Olenellus* does not occur on the Asiatic continent. If found at all, it will probably be in sediments deposited on the outer margins of that continental area in early Cambrian time prior to the transgression of the Middle Cambrian sea over large areas of what is now Siberia, Manchuria, central and eastern China, and northern India.

OLENELLUS ? ARGENTUS, new species

PLATE 40, FIGS. 12-16

Holmia rozeci WALCOTT (in part), 1908, Smithsonian Misc. Coll., Vol. 53, No. 5, p. 189 (3 of section only). (The specimens listed under this name from 3 of the Barrel Spring section are referred in this paper to *Olenellus argentus* and *Olenellus gilberti*.)

Of this species only the cephalon is known. The globose anterior lobe of the glabella, very strong marginal border, small palpebral

lobe, strongly granular surface, and strong intergenal and genal spines distinguish it from all known species. In its small palpebral lobes and tendency to develop abnormal forms [pl. 40, fig. 14] *O. argentus* resembles *O. fremonti* [pl. 37, figs. 9-11]. The shagreen granulated surface is shown by fig. 16, and the occipital ring with its short, sharp, median spine by fig. 15. The pointed surface granulations have a tendency to group in lines on the genal spines, but on the cheeks and glabella there is little trace of systematic arrangement. My impression of this surface is that it was formed by the cutting into sections, by transverse furrows, of the irregular network of ridges so characteristic of the surface of most species of the Mesonacidae, this process finally forming a large number of sharp isolated granules.

The strong genal spines and thick outer border of the cephalon are more nearly similar to those of *Peachella iddingsi* [pl. 40, figs. 17] than any other species. The generic reference is doubtful, and will remain so until more is known of the elements of the thorax and pygidium.

The stratigraphic horizon of this species is over 1,000 feet higher in the Barrel Spring section of Nevada than the horizon of *Olenellus fremonti* and *O. ? claytoni*. The associated fossils are:

- Archæochyathus* ?.
- Kutorgina cingulata* (Billings).
- Kutorgina perugata* Walcott.
- Siphonotreta ? dubia*, n. sp.
- Swantonina weeksi* Walcott.
- Swantonina* ? sp.
- Stenotheca* cf. *elongata* Walcott.
- Stenotheca* cf. *rugosa* Walcott.
- Ptychoparia* sp.
- Wanneria ? gracile* new species.

FORMATION AND LOCALITY.—Lower Cambrian: (iv) shales of No. 3 of the Silver Peak Group, Barrel Spring section [Walcott, 1908c, p. 189], 3 miles (4.8 km.) north of Valcalda Spring, and 4 miles (6.4 km.) west-northwest of the Drinkwater Mine, Silver Peak Quadrangle, Esmeralda County, Nevada.

OLENELLUS CANADENSIS, new species

PLATE 38, FIGS. 1-10

Olenellus canadensis WALCOTT (in part), 1908, Canadian Alpine Journal, Vol. 1, No. 2, p. 242. (Name used in list of fossils occurring in geologic section. The specimens listed include forms now referred to *Olenellus gilberti*.)

Olenellus canadensis WALCOTT (in part), 1908, Smithsonian Misc. Coll., Vol. 53, No. 5, p. 215. (Name used in section. In both cases, however, the specimens listed include forms now referred to *Olenellus gilberti*.)

Cephalon semicircular in outline, convex; bordered in large specimens by a strong, moderately convex outer marginal rim that is narrow in front of the glabella, and that gradually broadens out on each side toward the genal angle, where it is continued as a long, strong, rounded spine. The posterior marginal border is narrow, slightly rounded, and merged at the genal angle into the outer border; in some large specimens the genal angle is carried forward and an intergenal angle [fig. 1] occurs about three-fifths of the distance out from the glabella to the outer margin of the cephalon; in other specimens the posterior border extends without interruption from the glabella out to the genal spine, as shown by fig. 4. Glabella elongate, occupying the entire length of the cephalon between the anterior, rounded border and the occipital ring; the anterior lobe is nearly as long as the three posterior lobes, transversely elliptical in outline, somewhat tumid, and nearly one-third broader than the posterior lobe: the two lobes next back of the anterior lobe are united at their outer ends, the furrow between them not extending to the dorsal furrow; the posterior lobe is transverse, arching slightly forward at the ends, and about the same width as the occipital ring and the two lobes in front of it; on some of the more perfectly preserved cephalons there is a slight median node at the posterior margin of the two posterior glabellar lobes and the occipital ring [see fig. 6]. Occipital segment broad, slightly convex, and in appearance similar to the posterior lobe of the glabella.

Eye lobe short, crescentiform, narrow, extending from the base of the expanded anterior lobe of the glabella backward and opposite the two anterior, narrow lobes; the posterior end of the eye lobe is separated from the dorsal furrow beside the glabella by a narrow, elongate subtriangular tubercle that extends from opposite the second narrow glabellar lobe back nearly to the rounded posterior marginal rim of the head. Cheeks broad, moderately convex, and marked

back of the eye lobe by a raised line that extends from the base of the eye lobe backward and slightly outward to the posterior margin of the head at the intergenal angle when the latter is present: this corresponds in position to the facial suture in the genus *Paradoxides*.

Numerous fragments of the thoracic segments have been found in association with the cephalon, but nothing is known of the number of segments or the character of their axial lobe. Two fragments of the pleural portion of the segment are illustrated by figs. 9 and 10. These indicate similar characters to those of the segments of *Olenellus thompsoni* (Hall) [pls. 34 and 35].

The telson [fig. 8] is known only by fragments. It is an elongate, slender telson without segments or lateral lobes, in this respect resembling the telson of *Olenellus thompsoni* Hall [pl. 35, fig. 1] and *O. fremonti* Walcott [pl. 37, fig. 7].

Hypostoma moderately convex, broad in front and narrow toward the posterior margin. The anterior margin shows a rounded, smooth edge that fitted into a curved recess in the doublure of the head. The lateral margin forms an elevated rim for a short distance, and then curves downward to the more elevated posterior rim; the posterior marginal rim is separated from the body by a sulcus that disappears on each side; a second groove or sulcus arches across so as to represent a narrow lobe, as shown by fig. 3. A large number of more or less crushed specimens of the hypostoma were found associated with the fragments of the cephalon and thorax.

The surface of the head and the fragments of thoracic segments have the characteristic *Olenellus* marking. It forms an inosculating, fine, raised fretwork. This type of surface is beautifully shown by figs. 4 and 5, pl. 37, of this paper.

Dimensions.—The largest specimen of a cephalon has a length of 4.5 cm., and a width of 7 cm. A small head 4 mm. in length has a width of 7 cm.

Observations.—The presence of the genus *Olenellus* in the Rocky Mountain regions of British Columbia has long been known. In 1886 I identified for Dr. Geo. M. Dawson, of the Canadian Geological Survey, among the fragments of fossils found at Kicking Horse Pass, a species of *Olenellus* that appeared to be *Olenellus howelli* Meek.¹ During the summer of 1907 I visited the Kicking Horse Pass and made an examination of the strata in which *Olenellus* occurs. The preliminary study of the fragmentary material collected

¹ This is the species that I placed with *Olenellus gilberti* [Walcott, 1886, pp. 164 and 170].

indicated that it was a species distinct from *Olenellus howelli* [= *gilberti*], and in the geological section published in 1908 [Walcott, 1908c, p. 242] the name *Olenellus canadensis* was used for this species. The name was also used in a second publication [Walcott, 1908f, p. 215].

O. canadensis differs from *O. gilberti*, *O. thompsoni*, and *O. fremonti* in its very short eye lobe and the tubercles back of the eye extending to the posterior margin. The fragments of this species occur in immense numbers in several horizons of the Mount Whyte formation along a line of outcrop of some 30 miles in length.

The associated species in the Mount Bosworth section are:

- Nisusia festinata* (Billings).
- Scenella varians* Walcott.
- Hyolithellus*.
- Ptychoparia*.
- Agraulos*.
- Protypus fieldensis*, new species.

At this horizon on Mount Stephen were found:

- Micromitra (Iphidella) pannula* (White).
- Acrotreta sagittalis taconica* (Walcott).
- Kutorgina cingulata* (Billings).
- Kutorgina*, sp. undt.
- Nisusia festinata* (Billings).
- Hyolithes billingsi* Walcott.
- Scenella varians* Walcott.
- Protypus*, new species.
- Agraulos*, sp. undt.
- Ptychoparia*, 2 sp. undt.

FORMATION AND LOCALITY.—Lower Cambrian: (35f) bluish-black and gray limestone of the Mount Whyte formation, about 300 feet (91 m.) below the top of the Lower Cambrian in No. 6 of field section, just above the old railway tunnel on the north shoulder of Mt. Stephen, 3 miles east of Field, British Columbia. Fragments of *Olenellus*, probably of this species, occur at the same locality as No. 35f, but at horizons 50 feet (57m) and 115 feet (57e) below the top of the Lower Cambrian.

(35h) about 375 feet (114 m.) below the top of the Lower Cambrian in gray limestone forming No. 4 of the Mount Whyte formation [Walcott, 1908c, p. 214]; and (58y) sandstone about 200 feet (61 m.) below the top of the Lower Cambrian; both on the slopes

of Mount Bosworth, a little north of the Canadian Pacific Railway track between Stephen and Hector, British Columbia. Fragments of a large *Olenellus*, probably of this species, occur at the same locality as Nos. 35h and 58y, but at a horizon 400 to 600 feet below the top of the Lower Cambrian.

(35l) dark, bluish-gray limestone at the base of the Mount Whyte formation; and (60c) calcareous sandstones of the upper 20 feet of the St. Piran formation; both on the south slope of Ptarmigan Pass, at the head of the Corral Creek, 9 miles (14.4 km.) north-northeast of Laggan on the Canadian Pacific Railway, Alberta.

(58v) about 450 feet (137 m.) below the top of the Lower Cambrian in a brownish-gray sandstone forming No. 1 of the field section of the St. Piran formation, in the amphitheater between Popes Peak and Mount Whyte, 3 miles (4.8 km.) northwest of Lake Louise, southeast of Laggan, on the Canadian Pacific Railway, Alberta.

(58x) about 300 feet (91 m.) below the top of the Lower Cambrian in the sandstones of the St. Piran formation, just below the big cliff on the east shoulder of Castle Mountain, north of Castle, on the Canadian Pacific Railway, Alberta.

OLENELLUS ? CLAYTONI, new species

PLATE 40, FIGS. 9-11

Olenellus claytoni WALCOTT (in part), 1908, Smithsonian Misc. Coll., Vol. 53, No. 5, p. 189. (Name used in No. 6 of section. The specimens listed include forms now referred to *Olenellus gilberti*.)

Of this species forty-eight specimens of the cephalon and two of the hypostoma are in the collection. The cephalon is characterized by having a glabella constricted at the third pair of furrows, from whence it widens to the large, expanded anterior lobe. The palpebral lobes are large and long like those of *O. thompsoni* [pl. 34]. I was at first inclined to place *O. claytoni* with *O. fremonti* [pl. 37], but the shorter palpebral lobes and different outline of the glabella of the latter led me to separate the two forms. The outline of the glabella is more like that of *Wanneria walcottanus* [pl. 30, fig. 2] and small cephalon of *Elliptocephala asaphoides* [pl. 24, fig. 6], but in specimens of the *O. ? claytoni* of the same size this similarity is not present.

A small cephalon 2 mm. in length has very strong connecting ridges that merge into the expanded anterior lobe of the glabella so that it appears much like the young cephalon of *Olenellus lap-*

worthi [pl. 39, fig. 4] and *Pædeumias transitans* [pl. 32, fig. 8], except that the glabella is more expanded at the first lobe in *O. claytoni*.

Dimensions.—The largest cephalon in the collection has a length of 13 mm., width 28 mm. The relative proportions of the different parts are shown by figs. 9 and 10, pl. 40. Fig. 10 is compressed laterally with the result that the glabella is narrowed and ridged at the center.

The specimens of the hypostoma show that it had a large, oval body connected with a narrow neck to a strong, rounded posterior border; the sulcus within the border on each side is sufficiently strong to clearly define the neck connecting the body and posterior border [fig. 9].

A few fragments of thoracic segments occur in association with the cephalons, but nothing to prove more than that the pleuræ had a wide furrow. The test of all the specimens has been destroyed, but the surface of the cephalon, as shown in the fine sandstone matrix, is known to have been marked by a fine, irregular network of very fine, irregular ridges.

Olenellus? claytoni occurs in an arenaceous shale just above a mass of andesite in the Barrel Spring section [Walcott, 1908c, p. 189, 6 of section]. *Olenellus fremonti* and *Salterella* sp. occur in an argillaceous shale at nearly the same horizon, but are not associated with *O.? claytoni*.

FORMATION AND LOCALITY.—Lower Cambrian: (1k and 1i) "Silver Peak Group," in arenaceous shales interbedded in the lower part of No. 6 of the Barrel Spring section [Walcott, 1908c, p. 189], 1.5 and 1.75 miles (2.4 and 2.8 km.) south of Barrel Spring, Silver Peak Quadrangle, Esmeralda County, Nevada.

OLENELLUS FREMONTI, new species

PLATE 37, FIGS. 1-22; PLATE 41, FIG. 8

Olenellus gilberti WALCOTT (in part) [not MEEK], 1884, Monogr. U. S. Geol. Survey, Vol. 8, p. 29, pl. 9, fig. 16a (not fig. 16 and pl. 21, fig. 13, referred in this paper to *Callavia nevadensis*; nor pl. 21, fig. 14, referred in this paper to *Olenellus gilberti*). (Described.)

Olenellus howelli WALCOTT [not MEEK], 1884, Monogr. U. S. Geol. Survey, Vol. 8, pp. 30-31, pl. 9, figs. 15, 15a-c; pl. 21, figs. 1-9, and 16-17. (Described and discussed. Figures 15, 15a, 15b, and 15c of plate 9 are copied in this paper, pl. 37, figs. 14, 16, 8, and 6a respectively. Figures 2-9 of pl. 21 are copied in this paper, pl. 37, figs. 10, 12, 11, 15, 13, 17, 19, and 18 respectively.)

- Olenellus gilberti* WALCOTT (in part) [not MEEK], 1886, Bull. U. S. Geol. Survey, No. 30, pp. 170-180, pl. 18, fig. 1c; pl. 19, figs. 2e, 2h, and 2i; pl. 20 figs. 1, 1a-i, 1k-m; and pl. 21, figs. 2 and 2a (not pl. 18, figs. 1, 1a-b; pl. 19, figs. 2, 2a, 2b, 2k; pl. 20, fig. 4; and pl. 21, figs. 1 and 1a = *Olenellus gilberti*; and not pl. 19, figs. 2c, 2d, 2f, 2g = *Callavia nevadensis*). (Described and discussed. Figures 2e and 2i, pl. 19, are copied in this paper pl. 37, figs. 20 and 6 respectively; fig. 2h, p. 19, is copied from Walcott, 1884, pl. 9, fig. 15c; figs. 1, 1a, and 1b, pl. 20, are copied from Walcott, 1884, pl. 9, figs. 15b, 15a, and 15 respectively; figs. 1c, 1d, 1e, 1g, 1h, 1i, 1k, 1l, and 1m, pl. 20, are copied from Walcott, 1884, pl. 21, figs. 1, 2, 3, 4, 5, 6, 8, 9, and 7 respectively; fig. 1f, pl. 20, is copied in this paper, pl. 37, fig. 9; and the specimen represented by figures 2 and 2a, pl. 21, is copied with slight changes in this paper, pl. 37, fig. 7.)
- Olenellus gilberti* LESLEY (in part), 1889, Geol. Survey Pennsylvania, Report P4, Vol. 2, p. 490, figs. 2a, and cephalons represented by figs. 1, 1a, 1b, and 1f (not the whole specimen represented by figs. 1 and 1a which is a true *Olenellus gilberti*). (Figure 2a is copied from Walcott, 1886, pl. 21, fig. 2a; figs. 1, 1a, 1b, and 1f are copied from figures of the same number on plate 20 of Walcott's paper [1886].)
- Olenellus gilberti* WALCOTT (in part) [not MEEK], 1891, Tenth Ann. Rept. U. S. Geol. Survey, pl. 84, figs. 1d and 1f; pl. 85, figs. 1, 1a, and 1f; and pl. 86, figs. 1, 1a-i, 1k-m (not pl. 84, figs. 1, 1a-c; pl. 85, figs. 1b-d; and pl. 86, fig. 4 = *Olenellus gilberti*; and not pl. 84, figs. 1e and 1g; and pl. 85, figs. 1e and 1g = *Callavia nevadensis*). (No text reference. Fig. 1d, pl. 84, is copied from Walcott, 1886, pl. 18, fig. 1c; figs. 1f, pl. 84, and 1f, pl. 85, are copied from Walcott 1886, pl. 19, figs. 2i and 2e respectively; pl. 86 is a copy of pl. 20 of Walcott's paper [1886]; and figs. 1 and 1a, pl. 85, are copied from Walcott, 1886, pl. 21, figs. 2 and 2a.)
- Olenellus gilberti* PEACH, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, p. 671, pl. 32, figs. 9 and 10. (Mentioned. Figures 9 and 10 are copied from Walcott, 1886, pl. 20, figs. 1f and 1a.)
- Holmia weeksi* WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, No. 5, p. 187, and p. 189 (6 of section only). (The specimens listed under this name on the pages mentioned are referred in this paper to *Olenellus fremonti*.)
- Olenellus fremonti* WALCOTT, 1908, Idem, p. 187. (Name given in a list of the species occurring near Resting Springs.)

I formerly referred specimens now included in this species to *Olenellus gilberti* [Walcott, 1884, 1886, and 1891], but with the discovery of additional material, specimens showing variations of such constant character were found that it became necessary to propose a new species to include them.

The cephalon of *O. fremonti* differs from that of *O. gilberti* [pl. 36]: (a) in having a more expanded anterior glabella close to the rounded frontal border; (b) in having a shorter palpebral lobe, both

in the young and the adult; and (c) in having an unusually expanded pleural lobe to the third thoracic segment. A comparison of the young cephalons, as outlined on pl. 37, with those of *O. gilberti*, illustrated on pl. 36, shows some of the differences between the two species.

The variations in the cephalon of *O. fremonti* have been described [Walcott, 1886, pp. 173-178], and reference is also made to them in the introduction to this paper [p. 237].

The species that is most nearly related appears to be *O. thompsoni* [pl. 34], but we find that the latter differs from *O. fremonti* [pl. 37] in having: (a) a space between the glabella and the marginal rim; (b) a less expanded frontal glabellar lobe and longer palpebral lobes; (c) *O. fremonti* also has a peculiarly expanded pleural lobe of the third segment of the thorax [pl. 37, figs. 6, 6a].

The same differences exist in relation to *O. lapworthi* [pl. 39]. It differs from *O. logani* [pl. 41] in details mentioned under that species.

Olenellus fremonti is found associated with *O. gilberti* in Nevada at locality No. 30; the two species also occur at locality 1 β , but not in same layer of rock. Comparisons have been made above with *O. gilberti*.

The hypostoma is very rarely preserved. It is much like that of *O. gilberti* [pl. 36, fig. 5] in having a denticulated posterior margin [pl. 37, figs. 21, 22], and both are much like the hypostoma of *Pacdeumias transitans* [pl. 34, figs. 6 and 7].

The outer surface is similar to that of *O. gilberti* and other species of the genus. It is beautifully shown by figs. 4 and 5, pl. 37.

Dimensions.—The largest specimen of the cephalon in the collection has a length of 50 mm., width about 80 mm. This would give an entire dorsal shield, exclusive of the long telson, a length of about 115 mm., which indicates that *O. fremonti* was one of the largest of the Mesonacidae.

FORMATION AND LOCALITY.—Lower Cambrian: (30) arenaceous shales of the Pioche formation, west slope of Highland Range at edge of desert, 8 miles (12.8 km.) north of Bennetts Spring, and about 8 miles (12.8 km.) west of Pioche, Lincoln County; (313g) thin-bedded limestones interbedded in shales above a massive series of sandstones, in the Groom Mining District, at the south end of the Timpahute Range, near the line between Nye and Lincoln counties; (52) arenaceous shales above the Prospect Mountain sandstones, summit of Prospect Mountain, Eureka District, Eureka

County; (51) in thin layers of limestone interbedded between shales and layers of sandstone of the Prospect Mountain formation, west side of summit of Prospect Mountain, Eureka District, Eureka County; and (1p) limestones of No. 2 of the Silver Peak Group, Barrel Spring section [Walcott, 1908c, p. 189], about 2.5 miles (4 km.) south of Barrel Spring and .5 mile (.8 km.) east of road, Silver Peak Quadrangle, Esmeralda County; all in Nevada.

(176 and 178a) in arenaceous shales apparently lying between massive limestones carrying *Archæocyathus*, south end of Deep Spring Valley, about 20 miles (32 km.) east-southeast of Big Pine in Owens Valley; (14p) quartzitic sandstones near Resting (Fresh Water) Springs, which is in the southwest corner of T. 21 N., R. 8 E., on the Armagosa River, Inyo County; and (141) sandstones about 800 feet (244m.) below massive blue limestones [see Walcott, 1908c, p. 187] in pass through Kingston Range, 15 miles (24 km.) east of Resting Springs; all in California.

Fragments of an *Olenellus* with a strong marginal border about the cephalon similar to that of *Olenellus fremonti* occur in (593) a compact sandstone 2.5 miles (4 km.) west of Siam and 7 miles (11 km.) northeast of Cadiz, on the Atlantic and Pacific Railway, San Bernardino County, California.

OLENELLUS ? GIGAS Peach

PLATE 40, FIG. 1

Olenellus gigas PEACH, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, p. 666, text fig. 1, p. 667. (Described essentially as below. The specimen from which text figure 1 was drawn is reproduced in this paper, pl. 40, fig. 1.)

Of this species only fragments of a large cephalon are known. One of these is illustrated by fig. 1. Of this and several other fragments Dr. Peach tells us that the cephalon is

Much wider compared with its depth than in *O. lapworthi* and *O. reticulatus*. It is further distinguished from the latter by its broad margin and strong genal spine. The ornamentation is readily seen, even with the unaided eye. As stated in the former paper, the pattern of the reticulation is more elongated on the margins and spines than on the general surface, but this applies equally to all the species of *Olenellus*.

Portions of cheeks and genal spines of individuals nearly as large as the above, on which the pattern of the ornamentation is much smaller proportionally to their size, occur in the collection.

Measurements.—Length of head-shield, 52 mm.; breadth of head-shield, 106 mm. = 4½ inches.

A comparison with American specimens of the Mesonacidae leads me to think that this form may be most nearly related to *Mesonacis vermontana*. With the limited material now available for comparison I will leave it, doubtfully, under *Olenellus*.

FORMATION AND LOCALITY.—Lower Cambrian: argillaceous shale interbedded in "Serpulite grit," a coarse quartzitic sandstone, northern slope of Meal a' Ghubbais 1,200-1,300 feet (366-396 m.) above Loch Maree, 4 miles (6.4 km.) northwest of Kenlochewe in the west of Ross-shire, Scotland.

OLENELLUS GILBERTI Meek

PLATE 36, FIGS. 1-17; PLATE 43, FIGS. 5 AND 6

- Olenellus gilberti* MEEK, 1874. (Manuscript.)
Olenellus howelli MEEK, 1874. (Manuscript.)
Olenellus gilberti (Meek), WHITE, 1874, Geogr. and Geol. Expl. and Surv. West 100th Meridian, Prelim. Rept., p. 7. (Copies Meek's manuscript description.)
Olenellus howelli (MEEK), WHITE, 1874, Idem, Prelim. Rept., p. 8. (Copies Meek's manuscript description.)
Olenus (*Olenellus*) *gilberti* (Meek), GILBERT, 1875, Idem, Vol. 3, pp. 182-183. (Copied from White, 1874, p. 7.)
Olenus (*Olenellus*) *howelli* (Meek), GILBERT, 1875, Idem, Vol. 3, p. 183. (Copied from White, 1874, p. 8.)
Olenellus gilberti (Meek), WHITE, 1877, Idem, Vol. 4, pt. 1, pp. 44-46, pl. 2, figs. 3a-c. (Described and discussed. The specimens represented by figures 3a, 3b, and 3c are redrawn in this paper, pl. 36, figs. 3, 1, and 2 respectively.)
Olenellus howelli (Meek), WHITE, 1877, Idem, Vol. 4, pt. 1, pp. 47-48, pl. 2, figs. 4a-b. (Described and discussed. The specimen represented by figures 4a-b is redrawn in this paper, pl. 36, figs. 4 and 4a.)
Olenellus gilberti WALCOTT (in part) [not MEEK], 1884, Monogr. U. S. Geol. Survey, Vol. 8, p. 29, pl. 21, fig. 14 (not pl. 9, fig. 16 and pl. 21, fig. 13 referred in this paper to *Callavia nevadensis*; and not pl. 9, fig. 16a, referred in this paper to *Olenellus fremonti*). (Described. Figure 14 is an outline drawing of the specimen figured by White, 1877, pl. 2, fig. 3c, a specimen which is redrawn in this paper, pl. 36, fig. 2.)
Not *Olenellus howelli* WALCOTT, 1884, Idem, pp. 30-31, pl. 9, figs. 15, 15a-c, and pl. 21, figs. 1-9, 16-17. (Referred in this paper to *Olenellus fremonti*.)
Olenellus gilberti (Meek), WALCOTT (in part), 1886, Bull. U. S. Geol. Survey, No. 30, pp. 170-180, pl. 18, figs. 1, 1a-b; pl. 19, figs. 2, 2a, 2b, 2k; pl. 20, fig. 4; and pl. 21, figs. 1 and 1a (not pl. 18, fig. 1c; pl. 19, figs. 2e, 2h, 2i; pl. 20, figs. 1, 1a-i, 1k-m; and pl. 21, figs. 2 and 2a = *Olenellus fremonti*; and not pl. 19, figs. 2c, 2d, 2f, and 2g = *Callavia nevadensis*). (Described and discussed. Figs. 1 and 1a, pl. 18, are copied from White, 1877, pl. 2, figs. 4a and 4b; figs. 2, 2a, 2b, and 2k, pl. 19, are copied

from White, 1877, pl. 2, figs. 3b, 3a, 3c, and 3d respectively; fig. 4, pl. 20, is copied from Walcott, 1884, pl. 21, fig. 14; and pl. 21 is copied in this paper, pl. 36, fig. 9.)

Olenellus gilberti (Meek), HOLM, 1887, Geol. Fören. i Stockholm Förhandl., Bd. 9, Häfte 7, pp. 514-515. (Described in Swedish. The species is frequently mentioned also in the discussion of "*Olenellus kjerulfi*.")

Olenellus gilberti LESLEY (in part), 1889, Geol. Survey Pennsylvania, Report P4, Vol. 2, p. 490, figs. 1 and 1a (not fig. 2a nor the cephalons represented by figs. 1, 1a, 1b, and 1f, these are all referred in this paper to *Olenellus fremonti*). (Figures 1 and 1a are copied from Walcott, 1886, pl. 21, figs. 1 and 1a.)

Olenellus gilberti (Meek), WALCOTT (in part), 1891, Tenth Ann. Rept. U. S. Geol. Survey, pl. 84, figs. 1, 1a-c; pl. 85, figs. 1b-d; and pl. 86, fig. 4 (not pl. 84, figs. 1d and 1f; pl. 85, figs. 1, 1a, and 1f; and pl. 86, figs. 1, 1a-i; 1k-m = *Olenellus fremonti*; and not pl. 84, figs. 1e and 1g; and pl. 85, figs. 1e and 1g = *Callavia nevadensis*). (No text reference. Figs. 1 and 1a, pl. 84, are copied from Walcott, 1886, pl. 21, figs. 1 and 1a; figs. 1b and 1c, pl. 84, are copied from Walcott, 1886, pl. 18, figs. 1 and 1a; figs. 1b-d, pl. 85, are copied from Walcott, 1886, pl. 19, figs. 2, 2a-b, respectively; and fig. 4, pl. 86, is copied from Walcott, 1884, pl. 21, fig. 14.)

Olenellus canadensis WALCOTT (in part), 1908, Canadian Alpine Journal, Vol. 1, No. 2, p. 242. (Name used in list of fossils occurring in a geologic section. The specimens listed include forms now referred to *Olenellus gilberti*.)

Olenellus gilberti Meek, WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, No. 5, p. 189. (Species listed in No. 2 of the Barrel Spring section.)

Holmia rowei WALCOTT (in part), 1908, Idem, p. 189 (3 of section only). (The specimens listed under this name from 3 of the Barrel Spring section are referred in this paper to *Olenellus argentus* and *Olenellus gilberti*.)

Olenellus claytoni WALCOTT (in part), 1908, Idem, p. 189. (The specimens listed under this name from 6 of the Barrel Spring section are referred in this paper to *Olenellus claytoni* and *Olenellus gilberti*.)

Olenellus canadensis WALCOTT (in part), 1908, Idem, p. 215. (Name used in section. In both cases, however, the specimens listed include forms now referred to *Olenellus gilberti*.)

Dorsal shield elongate ovate in outline; strongly convex anteriorly when not compressed in the rock. Cephalon of adult semicircular in outline, strongly convex in a granular limestone matrix [figs. 4 and 4a], moderately convex in shaly limestone [figs. 16 and 17], nearly flattened and with little convexity in siliceous shales [figs. 1, 2, and 3]; bordered by a rounded marginal rim that is extended into somewhat slender genal spines; the posterior marginal border is rounded and narrow, and, in most specimens, it has a thickened

intergenal angle beyond which it becomes more narrow and extends more or less obliquely forward to join the outer border [figs. 1, 2, 3, and 4]; in one example a short intergenal spine occurs [fig. 8]; a rounded, well-defined, shallow furrow separates the marginal border from the cheeks. The plane of the marginal border is slightly and broadly arched across the front, the arching or rising of the border beginning opposite the longitudinal center of the eye lobe.

Glabella elongate with sides nearly parallel to the point of attachment of the palpebral ridge to the slightly expanded anterior glabellar lobe; the glabella is convex and elevated above the level of the palpebral lobes; the anterior lobe arches down to the level of the frontal marginal rim and terminates at about the width of the marginal border from the inner edge of the border; the second and third lobes of the glabella are narrow and united across their ends as the furrow separating them does not extend to the dorsal furrow alongside the glabella; the fourth lobe is wider than the second and third, and of about the same width as the occipital furrow; the slightly oblique transverse furrows are united across the center by a very shallow transverse furrow; they terminate laterally at the dorsal furrow with the exception of the second pair, which in large specimens of the cephalon may be little more than transversely elongated pits [fig. 16]. Occipital ring strong and clearly defined; it is convex, with the exception of a depressed area extending from the base of the median spine outward to the end of the ring; the effect of this in flattened specimens is to give rise to what appears to be a division of the ring transversely into two parts; a small, elongate median node or short spine occurs near the posterior margin of the ring [fig. 3].

The anterior flattened rim of the palpebral lobe is joined to the postero-lateral base of the anterior lobe of the glabella, from which it arches back to opposite the center of the occipital ring, where it is about its own width from the dorsal furrow beside the glabella: its width is nearly that of the second and third transverse lobes of the glabella; the elongate central area of the palpebral lobe is slightly convex and depressed beneath the level of the outer rim; the visual surface of the eye is elongate and narrow, it rises abruptly from its base with a gentle outward curvature or bulging to the outer rim of the palpebral lobe. The openings of the corneal lenses of the eye appear to be circular when viewed with a half-inch Bausch and Lomb aplanatic triplet lens, but when photographed and enlarged to seventy-five diameters they have an hexagonal outline [pl. 43,

fig. 5], in this respect being similar to those of *Limulus* [pl. 43, figs. 1-4]. The lenses, as seen in one specimen, are arranged in quincunx order, the rows crossing the visual surface of the eye obliquely between the upper and lower margins. The narrow ridges between the lenses are rounded and have the same exterior appearance as the outer surface of the eye of *Limulus polyphemus*. The cheeks rise rather abruptly from the rounded intermarginal furrow and gently arch to the base of the eye and first glabellar lobe. A narrow, elevated line or ridge extends outward from the posterior base of the eye and crosses the posterior border obliquely so as to terminate at the intergenal angle or is continued into a short spine. This ridge follows the line of the facial suture which is probably in a condition of symphysis; no traces of the facial suture have been observed in front of the eye.

The only specimens preserving the thorax are flattened in shaly sandstone. The one illustrated has been compressed and distorted [fig. 9], but it shows the general form of the thorax and its segments. Fourteen segments and the base of the telson-like terminal spine can be determined. The axial lobe is convex and about one-half the width of the pleural lobes; a very short median spine, or sharp, elongate node, occurs at the posterior margin of each segment with its rather strong base reaching nearly half way across the segment; the pleural portions of each segment extend directly outward for a distance about one-half of their length and then curve gradually backward, passing into a slender, spine-like extension: the pleural furrow is broad and of nearly equal width from its inner end out to the geniculation of the pleura where it begins to narrow. The enlargement of the third segment is the same as in *Olenellus thompsoni* [pl. 35] and *Padcumias* [pl. 34]. The telson is long and slender, and much like that of *O. fremonti* [pl. 37, fig. 7] and *Olenellus thompsoni* [pl. 34, fig. 9].

Surface ornamented with irregular, fine, inosculating ridges that form a very fine network of varying pattern. On the border and cheeks the meshes are small, elongated, and subparallel to the margin: over the glabella the meshes are very fine and the same is true for the surface of the thorax: the interspaces between the ridges appear to be minutely granular. The inner surface of the cheeks is beautifully channelled by irregular canals that radiate from the base of the eye outward toward the intermarginal groove; the channels often run into each other, and they are frequently united by cross channels.

Dimensions.—The largest cephalon has a length of 41 mm., width 60 mm., convexity 13 mm. [figs. 4 and 5]. The only specimen of the thorax is too much distorted to base measurements upon it.

Young stages of growth.—Some of the younger stages of growth of the cephalon are beautifully preserved in a compact, dark limestone from Ptarmigan Pass (locality No. 351). A few are illustrated. These show that in the cephalons from 2 to 6 mm. in length there is considerable variation in outline. The smallest have a subquadrilateral outline with a distinct antero-lateral angle and short spine [figs. 11-13]. As the cephalon increases in size the angle and spine disappear, and the evenly rounded outline is unbroken from the genal angles to the broadly rounded front margin [figs. 15-17]. The palpebral lobes of the smallest cephalon, 1.75 mm. in length, terminate posteriorly opposite the third glabellar furrow [fig. 11], and this continues up to specimens 15 mm. in length [fig. 15], but in the large cephalons 20 to 40 mm. in length the palpebral lobe is proportionally larger and ends at the furrow within the posterior margin of the cephalon [figs. 1-4, 16 and 17]. The space between the frontal lobe of the glabella and the anterior wire-like border of the cephalon varies slightly, but it is rarely that it is narrower than the width of the frontal border. The intergenal spines [figs. 11-14] are the continuation of the ridge running from the base of the eye that appears to represent the line of the facial suture back of the eye; the antero-lateral spines are in the position where I should anticipate finding the termination of the facial suture, in front of the eye. The comparison of the young stages of growth of this species with similar known stages in other species is made in the introduction [pp. 236-243].

An hypostoma occurring (locality No. 1h) with specimens of the cephalon of this species has a denticulated posterior margin much like that of the hypostoma of *Wanneria halli* [pl. 31, fig. 9], and *Olenellus fremonti* [pl. 37, figs. 21, 22]. It is strange that there are almost no traces of the hypostoma in association with the large number of specimens of the cephalon that occur at many localities, both in Nevada and Alberta. The hypostoma of *O. canadensis* is unusually abundant in association with that species and *O. gilberti*.

Observations.—In my earlier work [Walcott, 1884, 1886, and 1891] I gave a large variation to this species, and included in it forms that are now grouped under *Callavia nevadensis* and *Olenellus fremonti*. As now restricted, *O. gilberti* includes forms that have

a wide geographic distribution in the Cordilleran area of the United States and Canada, and a possible stratigraphic range of several hundred feet in the upper portion of the Lower Cambrian (Georgian) formations. Its representative on the eastern side of the continent in the Appalachian area is *Olenellus thompsoni* [pl. 34], and in Scotland *O. lapworthi* [pl. 39]. In Canada a form that I have identified with this species occurs in the Mount Whyte formation at several localities, the most prolific of which is at Ptarmigan Pass, Alberta (locality No. 351), where a number of small and large cephalons were found in a thin layer of limestone at the base of an argillaceous shale. Fragments of *O. canadensis* are also abundant in this limestone and in the arenaceous beds beneath. Another notable locality is near the base of the Mount Stephen section (locality No. 35f), about 300 feet below the summit of the Lower Cambrian.

Comparison with other species of *Olenellus* shows that *O. gilberti* differs from *O. fremonti* [pl. 37]: (a) in having its glabella separated from the frontal border by a clear space; (b) in having a longer, larger palpebral lobe and eye; (c) in having the third thoracic segment very little, if any, larger than the fourth and fifth; (d) in having the pleural lobes proportionally wider. The two species are associated in eastern (locality no. 30) and western Nevada (locality no. 1p).

From *O. thompsoni* it differs in the less expanded anterior lobe of the glabella and the space in front of the lobe.

From *O. lapworthi* [pl. 39, figs. 1-8] it differs in many minor details and most notably in the form of the thorax and thoracic segments.

The most nearly related cephalon is that of *Pædeumias transitans* [pl. 34], and the thorax of the two species is very similar back to the large spine. If *O. gilberti* should be found to have rudimentary segments and pygidium posterior to its telson-like spine the two forms would probably be placed under the species *gilberti* of the genus *Pædeumias*.

FORMATION AND LOCALITY.—Lower Cambrian: (31a) in dark, fine, arenaceous shales and interbedded thin layers of limestone in the Pioche formation, on both the east and west slopes of the anticline of quartzitic sandstone at the mining camp of Pioche; and (30) west slope of Highland Range 8 miles (12.8 km.) north of Bennetts Spring and about 8 miles (12.8 km.) west of Pioche; both in Lincoln County, Nevada.

(**1m** and **1p**) limestones of No. 2 of the Silver Peak Group, Barrel Spring section [Walcott, 1908*c*, p. 189], about 2.5 miles (4 km.) south of Barrel Spring,¹ and .5 mile (.8 km.) east of the road; (**1l**) same locality as No. **1m**, in the shales of No. 3 of the Barrel Spring section [Walcott, 1908*c*, p. 189]; (**1i**) 1.5 miles (2.4 km.) south of Barrel Spring in No. 6 of the Barrel Spring section [Walcott, 1908*c*, p. 189]; (**1o**) same horizon as No. **1l**, 3 miles (4.8 km.) southeast of Barrel Spring; (**1y**) fine, arenaceous shales in small buttes in Clayton Valley, about 3 miles (4.8 km.) southeast of Silver Peak; and (**16g**) fine, arenaceous shale at the Paymaster Mining Camp, .25 mile (.4 km.) west of Esmeralda; all in Esmeralda County, Nevada.

(**30a'**) thin-bedded limestone on the north side of Big Cottonwood Canyon, 1 mile (1.6 km.) below Argenta, southeast of Salt Lake City, Utah.

(**60c**) calcareous sandstones of the upper 20 feet of the St. Piran formation; and (**35l**) limestone layer above the arenaceous beds of No. 60c, and below an argillaceous shale; both on the south slope of Ptarmigan Pass, near the head of Corral Creek, 9 miles (14.4 km.) northeast of Laggan, Alberta.

(**35e**) about 270 feet (83 m.) below the top of the Lower Cambrian in greenish, siliceous shales (64 feet) forming 2c of the field section in the amphitheater between Popes Peak and Mt. Whyte, 3 miles northwest of Lake Louise, which is southeast of Laggan, Alberta.

(**35h**) about 375 feet (114 m.) below the top of the Lower Cambrian in the shales of No. 4 of the Mount Whyte formation [Walcott, 1908*c*, pp. 214-215], on Mount Bosworth, north of the Canadian Pacific Railway between Hector and Stephen; (**35f**) about 300 feet (91 m.) below the top of the Lower Cambrian in the limestone forming 6 of the Mount Whyte formation [Walcott, 1908*b*, p. 242], just above the old tunnel on the north shoulder of Mt. Stephen, 3 miles (4.8 km.) east of Field; and (**57i**) about 175 feet (53 m.) below the top of the Lower Cambrian in the beds forming 4 of the Mount Whyte formation [Walcott, 1908*b*, p. 241] at the same locality as No. 35f; all in British Columbia.

¹ Barrel Spring is about 10 miles (16 km.) south of the town of Silver Peak in the Silver Peak Quadrangle.

OLENELLUS GILBERTI, var.

PLATE 40, FIG. 8

This small cephalon 3.5 mm. in length occurs in association with *Olenellus canadensis* [pl. 38] and *O. gilberti* [pl. 36]. Its large eye and broad space between the marginal rim and glabella distinguish it at once from *O. canadensis*, and its stronger marginal rim and very strong ridge connecting the anterior lobe of the glabella with the elevated eye lobe distinguish it from cephalons of the same size referred to *O. gilberti*. It is unlike the latter, but it has so many points in common with it that I will designate it as *O. gilberti* var.

FORMATION AND LOCALITY.—Lower Cambrian: Mount Whyte formation: (351) limestone layer above the arenaceous beds of the St. Piran formation and below an arenaceous shale, on the south slope of Ptarmigan Pass, near head of Corral Creek, 9 miles (14.4 km.) north-northeast of Laggan, Alberta, Canada.

OLENELLUS LAPWORTHII Peach

PLATE 39, FIGS. 1-7; AND PLATE 40, PART OF FIG. 3

Olenellus lapworthi PEACH and HORNE, 1892, Quart. Journ. Geol. Soc. London, Vol. 48, pp. 236-241, pl. 5, figs. 1-11. (Described and discussed.)

Olenellus lapworthi Peach and Horne, PEACH, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, pp. 662-664, pl. 29, figs. 1, 2, and 2a; pl. 30, fig. 7; pl. 32, fig. 8. (Described and discussed.)

Olenellus lapworthi elongatus PEACH, 1894, Idem, p. 664, pl. 29, figs. 3-6. (Characterized as a new variety. The specimen represented by figure 3, pl. 29, is redrawn in this paper, pl. 39, fig. 1.)

Olenellus intermedius PEACH, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, pp. 666-668, pl. 32, fig. 7. (Described and illustrated.)

Olenellus lapworthi belongs to that group of the Mesonacidæ represented by *O. thompsoni* [pl. 35], *O. gilberti* [pl. 36], and *O. fremonti* [pl. 37]. Its relation to the adult of *O. thompsoni* may be seen by comparing figs. 2-4, pl. 39, with fig. 9, pl. 34. A young stage of *O. lapworthi* [pl. 39, fig. 8] may be compared with a young specimen of *Pædeumias transitans* [pl. 32]. Also compare the hypostoma [fig. 7, pl. 39] with that represented by fig. 7, pl. 34.

Olenellus lapworthi differs from *O. thompsoni*: (a) in having a shorter eye lobe that extends more obliquely outward; and (b) in the geniculation of the pleuræ of the thoracic segments which is more abrupt [compare fig. 2, pl. 39, with fig. 1, pl. 35]. The eye

lobe of *O. lapworthi* is much like that of *O. fremonti* [pl. 37, fig. 2], but the relative position of the glabella and frontal border of the cephalon is different, as also the enlarged third segment. *O. gilberti* [pl. 36] has a larger eye lobe than *O. lapworthi*, but in other respects the two species are very closely related. It is also interesting to note that *O. intermedius* Peach [1894, pl. 32, fig. 7], a form that I think is the young of *O. lapworthi*, has antero-lateral angles on the cephalon not unlike similar angles on the young cephalons of *O. gilberti* [pl. 36, figs. 11-14].

In the synonymy of *O. lapworthi* I have included *O. intermedius* Peach and *O. lapworthi elongatus* Peach. The first I regard as a young cephalon preserving the antero-lateral angles that subsequently disappear, and the advanced genal angles and small eyes that are so well shown by the young of *O. fremonti* [pl. 37, figs. 11-12]. The variety *elongatus* appears from the specimens to be the result of elongation by slight distortion in the shales.

A cephalon 26 mm. in length has a width of 44 mm. All of the illustrations on pl. 39 are from photographs of compressed specimens in a fine argillaceous shale.

The hypostoma [pl. 39, fig. 7] is much like that of *Pædeumias transitans* [pl. 34, figs. 5-7] in having an ovate body and denticulated posterior and postero-lateral margins. I found one quite young cephalon in the material of the Geological Survey of Scotland [fig. 6] 1.5 mm. in length that shows prolonged intergenal spines, elongated eye lobes, and segmented palpebral lobes, not unlike those of *Elliptocephala asaphoides* [pl. 25, figs. 9-10].

The surface of the cephalon and thorax is marked by a rather strong network of fine, slightly elevated ridges of the same character as those on *O. reticulatus* [pl. 39, figs. 10, 11], except that the network and ridges are finer.

O. lapworthi differs from the associated *O. reticulatus* in its larger eye lobe, more finely reticulated surface and minor details mentioned under the latter species. It is the representative on the eastern side of the Atlantic basin of *O. thompsoni* of the St. Lawrence province of the western side of the Atlantic. The closely allied *O. gilberti* is from the Cordilleran trough of western America.

FORMATION AND LOCALITY.—Lower Cambrian: argillaceous shale interbedded in "Serpulite grit," a coarse, quartzitic sandstone, northern slope of Meal a' Ghubhais, 1,200-1,300 (366-396 m.) above Loch Maree, 4 miles (6.4 km.) northwest of Kenlochewe in the west of Ross-shire, Scotland.

OLENELLUS LOGANI, new species

PLATE 41, FIGS. 5, 6

Cephalon transversely semicircular in outline with the marginal border at the genal angles prolonged into slender spines; strongly convex with the eye lobes and front lobe of the glabella rising abruptly from the cheeks and frontal marginal border; marginal border very distinctly rounded, strong, and arching up slightly in front of the glabella from the plane of the lower edge of the cephalon; at the genal angles it merges into the genal spine and the narrow, rounded posterior marginal border of the cephalon: the latter border is crossed obliquely by a low, slender ridge that is extended beyond the border as a short intergenal spine.

Glabella with a convex, expanded anterior lobe that rises abruptly from just within the front marginal border; in a small specimen 4.5 mm. in length there is a narrow space between the border and the glabella; the glabella is divided into four lobes and the occipital ring by four pairs of furrows that extend obliquely inward and backward from the dorsal furrow on each side to the median line, where they unite, except in the case of the anterior pair which fade out just before reaching the median line; the second pair of furrows curve backward at their outer end so as to arch nearly around the ends of the third glabellar lobe; the anterior lobe is as long as the three narrow lobes combined and a little wider than long; it is connected at its postero-lateral margin, on each side, with the palpebral lobes by strong, rounded ridges that are a little depressed at the dorsal furrow; a faint furrow extends inward on each side a short distance from the point where the anterior margin of the palpebral ridges joins the anterior glabellar lobe; this pair of furrows indicates that the lobe is formed of two segments of the original primitive cephalon.¹ The palpebral segment is beautifully shown by the young of *Elliptocephala asaphoides* [pl. 25, figs. 9 and 10]. The second glabellar lobe is narrow and arched slightly backward at each end so as to nearly enclose the ends of the third lobe, which is thus shortened as compared with the second and fourth lobes; the third lobe is cut off by the arching of the second, but the fourth lobe extends out to the dorsal furrow where, with a very slight interruption, it crosses the line of the dorsal furrow and merges into the space within the palpebral lobe; the third and fourth lobes are

¹ This anterior pair of furrows is shown for *Paradoxides* by Barrande's illustrations of *P. spinosus* [Barrande, 1852, pl. 12, figs. 2, 3, and 6; pl. 13, fig. 1] and *P. pusillus* [Barrande, 1872, pl. 9, fig. 23].

a little larger longitudinally than the second lobe; the second, third, and fourth lobes all arch backward at the center where they are most convex and rounded so as to give the impression of a longitudinal ridge extending from the base of the first lobe backward and across the occipital ring, where it terminates in a minute node; the extensions of the second and fourth lobes into the interpalpebral lobe space suggest the primitive segmentation of the cephalon, as shown in the young of *Elliptocephala asaphoides* [pl. 25, figs. 9 and 10], and *Padeumias transitans* [pl. 25, fig. 22]. On the largest cephalon, 11 mm. in length, there is a faint, shallow, narrow groove on each side in advance of the palpebral ridge just within the base of the anterior glabellar lobe that outlines a very narrow ridge somewhat similar to that of *Callavia crosbyi* [pl. 28, fig. 1], except that it is not as clearly defined. Occipital ring rounded, prominent, arched a little backward, and with a minute, median, sharp node on a longitudinally elongated base.

Palpebral lobes narrow, slightly rounded, gently curved, connected to the first glabellar lobe by a rounded ridge and terminating posteriorly opposite the ends of the fourth pair of glabellar furrows at about the width of the palpebral lobe from the dorsal furrows beside the glabella; the lobes rise to nearly the level of the median line of the glabella and cap the visual surface of the eye, which rises abruptly from the cheeks; interpalpebral space depressed and separated from the third and fourth lobes of the glabella by a very faint dorsal furrow; visual surface of eye narrow and arching beneath the outer edges of the palpebral lobe. Cheeks of medium width and rising rather abruptly from the intermarginal furrow to the base of the eye; nothing can be seen on the outer surface indicating a facial suture, but the cast of the inner surface shows a narrow ridge extending from the posterior end of the eye outward and backward so as to cross the marginal border at about two-thirds of the distance from the occipital ring to the genal angle.

Surface beautifully ornamented by a fine network of very narrow, slightly elevated ridges; on the marginal border the meshes of the network are elongated subparallel to the border; on the large first lobe of the glabella the long axes of the meshes curve around subparallel to the anterior margin of the lobe; over the remaining portions of the surface no marked direction is noted as the meshes are irregular in form and arrangement; the inner surface of the cheeks shows the cast of a system of irregular channels extending outward from the base of the eye toward the intermarginal groove.

Dimensions.—The largest cephalon has a length of 11 mm., width 20 mm. The proportions of the various parts are shown in the photograph of an entire cephalon illustrated by fig. 5, pl. 41.

Observations.—*O. logani* is the Atlantic Province representative of *O. fremonti* [pl. 37] of the southern Pacific Province area. It differs from *O. fremonti* in minor details of the glabella, especially the furrow and smaller lobes, in its proportionally larger eyes, and in the regular form of its genal angles. It has larger eyes than *O. canadensis* [pl. 38].

FORMATION AND LOCALITY.—Lower Cambrian: L'Anse au Loup limestone at L'Anse au Loup, Labrador, on the Straits of Belle Isle, Canada.

Type specimens in the Museum of the Geological Survey of Canada.

OLENELLUS RETICULATUS Peach

PLATE 39, FIGS. 9-13

Olenellus reticulatus PEACH, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, pp. 665-666, text fig. A, p. 673, pl. 30, figs. 1-6, 8-14; pl. 31, figs. 1-7. (Described and illustrated, most of the description being copied below. The specimens represented by figures 1 and 2 of plate 30 are redrawn in this paper, pl. 39, figs. 9 and 10.)

Dr. Peach, in comparing this species with its most nearly related form, *O. lapworthi*, says, after stating that it is of larger size:

The reticulated ornament on its test appears to be much larger in pattern (compared with its size) than in that species, and this difference, which makes it conspicuously visible to the naked eye, has suggested the specific name which I propose for the new form. In general aspect it much resembles the elongated variety of *O. lapworthi*. It differs from that chiefly in the head-shield, which is deeper in comparison with its breadth. The glabella is longer in proportion to the size of the head-shield, and the individual lobes are each more elongated, while the angles made by the furrows with the general axis of the body are more acute. The distal ends of the eye lobes are not so far removed from the edge of the glabella, nor do they extend so far backwards, but end well in front of the fourth furrow, while those of *O. lapworthi* extend beyond it. The raised margin that bounds the cheeks is not so wide in proportion; the genal spine is more slender, and is placed a little more anteriorly, and the notch between it and the pleural angle is deeper than in *O. lapworthi*.

The arrangement of the details of its body-segments is similar to that of *O. lapworthi*, but the peculiarities of the pleura of the third segment are even more pronounced, the spines being longer relatively, and sometimes more incurved. The spines on the pleura of the sixth and three succeeding segments are longer and more slender. Tubercles have been observed in the mid-line on the occipital ring, on the axes of the first three free segments, and on several of the posterior

ones. They have not been observed on all the intermediate segments, but this may be owing to bad preservation or faulty observation, as it is probable that they once existed.

The telson is long and styloform, and tapers rapidly at first and then decreasingly. Its articulation with the last free segment is well shown in the specimen from which pl. 30, fig. 12, was taken. Projecting from the posterior margin of the axis of the fourteenth free segment, at about 1.5 of its width from each side, are two small protuberances. Corresponding projections proceed forwards from the hinge-line of the telson, and interlock with them on their outside. Beyond them the anterior edge of the telson is continued in nearly the same line with the hinge, so that the anterior angles of the telson appear to be overlapped by the pleura of the last free segment. A "lock joint" is thus formed which does not allow of the telson folding downward beyond a certain angle with the plane of the last segment.

The most marked and to me important point of difference with *O. lapworthi* is the much smaller eye. This is best seen by comparing fig. 12 with fig. 1 on pl. 39. The eye of *O. reticulatus* is like that of *O. canadensis* [pl. 38, figs. 4, 5, 6], and in both species we find a tubercle between the posterior end of the eye lobe and the glabella.

FORMATION AND LOCALITY.—Lower Cambrian: argillaceous shale interbedded in "Serpulite grit," a coarse quartzitic sandstone, northern slope of Meal a' Ghubhais, 1,200-1,300 feet (366-396 m.) above Loch Maree, 4 miles (6.4 km.) northwest of Kenlochewe in the west of Ross-shire, Scotland.

OLENELLUS THOMPSONI (Hall)

PLATE 34, FIG. 9; PLATE 35, FIGS. 1-7

Olenus thompsoni HALL, 1859, Twelfth Ann. Rept. New York State Cab. Nat. Hist., p. 59, fig. 1, p. 60. (Described as a new species.)

Olenus thompsoni HALL, 1859, Nat. Hist. New York, Paleontology, Vol. 3, pt. 1, pp. 525-526, text figure, p. 526. (Copy of the preceding reference.)

Barrandia thompsoni HALL, 1860, Thirteenth Ann. Rept. New York State Cab. Nat. Hist., pp. 115-116, text figure, p. 116. (Described, beginning with the 5th paragraph under "Genus Barrandia.")

Paradoxides asaphoides EMMONS, 1860, Manual of Geology, 2d ed., p. 87. (Name used in legend of fig. 70, p. 87, see following reference.)

Paradoxides macrocephalus EMMONS, 1860, Iden, p. 88, fig. 70. (In the text reference on page 87 this figure is referred to as *Paradoxides asaphoides*; but from the figure there is little doubt that it was taken from a specimen of *O. thompsoni*. In the first edition of the Manual of Geology the figure is labeled *Paradoxides brachycephalus*. On page 280 there is a note on the stratigraphic position of the species.)

- Eliptocephalus (Paradoxides) asaphoides* EMMONS, 1860, Idem, p. 280.
(Note on the stratigraphic position of the species.)
- Paradoxides thompsoni* (Hall), EMMONS, 1860, Idem, p. 280, note A.
(Note on the stratigraphic position of the species.)
- Paradoxides thompsoni* (Hall), BARRANDE, 1861, Bull. Soc. Géol. de France, 2d ser., Vol. 18, p. 276, pl. 5, fig. 6. (Translates into French the description given by Hall, 1859, p. 59. Figure 6 is copied from Hall's figure [1859, fig. 1, p. 60].)
- Paradoxides macrocephalus* Emmons, BARRANDE, 1861, Idem, pp. 276-277, pl. 5, fig. 7. (Discussed in French. Figure 7 is copied from Emmons, 1860, fig. 70, p. 88.)
- Not *Paradoxides thompsoni* BILLINGS, 1861, Geol. Survey Canada, Paleozoic Fossils, p. 11. (Referred in this paper to *Pædeumias transitans*, see page 305.)
- Barrandia thompsoni* HALL, 1861, Report on the Geology of Vermont, Vol. 1, pp. 369-370. (Copy of Hall, 1860, pp. 115-116.)
- Barrandia thompsoni* HALL, 1862, Report on the Geology of Vermont, Vol. 2, pl. 13, fig. 1. (Copied from Hall, 1860, text figure, p. 116.)
- Olenellus thompsoni* HALL, 1862, Fifteenth Ann. Rept. New York State Cab. Nat. Hist., p. 114. (Generic name *Olenellus* proposed for this species, *Barrandia* being preoccupied.)
- Not *Olenellus thompsoni* BILLINGS, 1865, Geol. Survey Canada, Paleozoic Fossils, Vol. 1, p. 11. (Reprinted from Billings, 1861a, p. 11, substituting *Olenellus* for *Paradoxides*, but the species is referred in this paper to *Pædeumias transitans*.)
- Olenellus thompsoni* (Hall), FORD, 1881, American Journ. Sci., 3d ser., Vol. 22, fig. 12, p. 258. (Figure 12 is copied from Hall, 1860, text figure on page 116.)
- Not *Olenellus thompsoni* WHITFIELD, 1884, Bull. American Mus. Nat. Hist., Vol. 1, No. 5, pp. 151-153, pl. 15, fig. 1. (Referred in this paper to *Pædeumias transitans*.)
- Olenellus thompsoni* (Hall), WALCOTT (in part), 1886, Bull. U. S. Geol. Survey No. 30, pp. 167-168, pl. 17, figs. 2, 4 and 9; pl. 22, fig. 1, and pl. 23, fig. 1. (not fig. 1, pl. 17 referred in this paper to *Olenellus thompsoni crassimarginatus*). (Copies the original description given by Hall [1859, p. 59] and discusses species. Figure 2, pl. 17, is redrawn in this paper, pl. 34, fig. 9; fig. 9, pl. 17, is a restored drawing of the specimen which is figured in this paper, pl. 35, fig. 4; and fig. 1, pl. 23, is copied with slight alterations in figure 1 of plate 35 of this paper.)
- Olenellus thompsoni* (Hall), HOLM, 1887, Geol. Fören. i Stockholm Förhandl., Bd. 9, Häfte 7, p. 514. (Described in Swedish. The species is frequently mentioned also in the discussion of "*Olenellus kjerulfi*.")
- Elliptocephala thompsoni* (Hall), MILLER, 1889, North American Geology and Paleontology, p. 546, text fig. 1003. (Figure 1003 is copied from Walcott, 1886, pl. 17, fig. 2.)
- Olenellus thompsoni*, LESLEY, 1889, Geol. Survey Pennsylvania, Rept. P4, Vol. 2, p. 491, 3 text figures. (The large figure is copied from Walcott, 1886, pl. 22, fig. 1; figures 2 and 9 are copied from Walcott, 1886, pl. 17, figs. 2 and 9.)

- Olenellus thompsoni* (Hall), WALCOTT (in part), 1891, Tenth Ann. Rept. U. S. Geol. Survey, pl. 82, figs. 1 and 1a; pl. 83, figs. 1 and 1a (not fig. 1b, pl. 83, which is referred in this paper to *Olenellus thompsoni crassimarginatus*). (No text reference. Figures 1 and 1a, pl. 82, and 1 and 1a, pl. 83, are copied from Walcott, 1886, pl. 23, fig. 1; pl. 17, fig. 9; pl. 22, fig. 1; and pl. 17, fig. 2, respectively.)
- Olenellus thompsoni* (Hall), COLE, 1892, Natural Science, Vol. 1, fig. 1, p. 343. (Gives diagrammatic outline of Walcott's figure, 1886, pl. 17, fig. 2.)
- Olenellus thompsoni* (Hall), FRECH, 1897, additional plates inserted in 1897 in *Lethæa geognostica*, pt. 1, *Lethæa Paleozoica*, Atlas, pl. 1a, fig. 7. (Figure 7 is copied from Walcott, 1886, pl. 23, fig. 1.)
- Olenellus thompsoni* (Hall), MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, pp. 314 and 317, pl. 13, fig. 2. (Mentioned at several places in the text. The figure is copied from Walcott, 1886, pl. 17, fig. 2.)
- Olenellus thompsoni* (Hall), LINDSTRÖM, 1901, Kongl. Svenska Vet.-Akad. Handlingar, Vol. 34, No. 8, p. 12. (Merely refers to species in discussion of "facial ridge.")

The adult form of *Olenellus thompsoni* Hall has been described and illustrated [see Walcott, 1886, p. 167; also 1891, p. 635], but with the discovery of *Pædeumias transitans* [pls. 32, 33, and 34] a limitation of the variation in the cephalon has been found that may be of service in identifying the species in the future. The illustration accompanying the original descriptions of *Olenus thompsoni* [Hall, 1859, p. 60, fig. 1] shows a cephalon with strong marginal rim, elongate eyes, and with anterior lobe of the glabella terminating in front at the marginal border, as in our fig. 9, pl. 34. I find in the collections from the locality at Parkers quarry, where the specimen described and illustrated by Hall came from, a number of finely preserved specimens in which the anterior lobe touches the anterior border, as in fig. 9, pl. 34, and in the illustration by Hall. On the cephalon of *Pædeumias transitans* the glabella is separated from the marginal border by a distinct space [pls. 32, 33, and 34], except in fig. 1, pl. 33, where the glabella is crushed down nearly to the border. This distinction between the cephalon of *O. thompsoni* and *Pædeumias transitans* is found in specimens from Vermont, Pennsylvania, Tennessee, and Alabama. It is quite probable that the separated cephalons of *Mesonacis vermontana* [pl. 26, fig. 1] may be taken for those of *O. thompsoni* when the thorax is broken away, but this is not of serious importance as the two species are associated both in Vermont and Pennsylvania.

The hypostoma of the adult is very rarely preserved at the Georgia, Vermont, localities. In one example [pl. 35, fig. 3] the bases of

three spines are indicated along the postero-lateral margin. It is quite probable that the hypostoma was similar to that represented by fig. 7, pl. 34.

Comparison with other species.—The most nearly related species to *O. thompsoni* [pl. 34, fig. 9] is *O. fremonti* [pl. 37, figs. 1 to 7]. The most marked difference between them is in the larger frontal lobe of the glabella and smaller eye lobe of *O. fremonti*. The cephalon of the latter also has a much greater variation in outline resulting from the position of the genal angles. From *Pædecumias transitans* [pls. 32 and 34] it differs in having the glabella close to the front marginal border, and in the absence of the rudimentary segments and pygidium posterior to the fifteenth segment, parts which are represented in *O. thompsoni* by a strong, long telson. From *O. gilberti* [pl. 36] it differs in the cephalon in the same manner as from *P. transitans*.

Distribution.—Numerous specimens of the cephalon have been collected from the limestone on the north shore of the Straits of Belle Isle, Labrador; on the west coast of Newfoundland at Bonne Bay; along the St. Lawrence Valley from Bic to the Island of Orleans, near Quebec; on the east side of the Champlain Valley, Franklin County, Vermont; in central Pennsylvania; and from thence to central Alabama.

Dimensions.—The proportions of the various parts of the dorsal shield are clearly shown by the figures on pls. 34 and 35. The larger fragments found indicate a dorsal shield 150 to 160 mm. in length. The average size of adults is from 60 to 100 mm. in length, including terminal telson.

FORMATION AND LOCALITY.—Upper part of Lower Cambrian: (25) in the argillaceous shales of Parkers quarry, near Georgia; (25a) 2 miles east of Swanton, on the Donaldson farm; and I noted its presence west of St. Albans, in the outskirts of the city; in the massive magnesian limestones, west of Parkers quarry, and also about 1.5 miles (2.4 km.) east of the hotel at Highgate Springs; all in Franklin County, Vermont.

This species occurs in the conglomerate limestones of Bic Harbor, Trois Pistoles, St. Simon, and on the Island of Orleans, in the St. Lawrence River, below Quebec, Canada [Walcott, 1886, p. 26].

(49d) 3 miles (4.8 km.) east of Waynesboro, Franklin County; (49f) Mt. Holly quartzite at Mt. Holly Gap, South Mountain¹; (8q) argillaceous shales and limestone, 3 miles (4.8 km.) northwest

¹ See also Walcott, 1896, pp. 24-26.

of the city of York; (49c) just north of the railway station at Emigsville, York County; (49b) 2 miles (3.2 km.) northwest of Emigsville in continuation of the ridge from which No. 49c was collected; (49e) 1 mile (1.6 km.) south of Mt. Zion Church and 4 miles (6.4 km.) northeast of York; and (12w) just west of Fruitville, about 2 miles (3.2 km.) north of the city of Lancaster and westward at various localities to the Susquehanna River, notably 1 mile (1.6 km.) north of Rohrerstown on farm of Noah L. Getz, Lancaster County; all in Pennsylvania.

(47d) 1 mile (1.6 km.) east-southeast of Smithsburgh; (47e) 2 miles (3.2 km.) south of Keedysville, on Observatory Hill; and (47f) at Eakles Mill, 2 miles (3.2 km.) south of Keedysville; all in Washington County, Maryland.

(47) in a hard sandstone .75 mile (1.2 km.) up a little brook opposite Gilmore on the south side of the Shenandoah River; (47g) shaly sandstone on Mason Creek 1 mile (1.6 km.) east of Salem; and (47c) on the south side of the Potomac River, 2 miles (3.2 km.) west of Harpers Ferry bridge; all in Virginia.

(46) at the western base of the ridge of Knox sandstone [Safford] 5.5 miles (8.8 km.) west of Cleveland; and (46a) upper portion of Knox sandstone in the village of Rhea Springs, Roane County; both in Tennessee.

(164a) argillaceo-arenaceous Montevallo shale 2 miles (3.2 km.) north of Montevallo, Shelby County, Alabama.

Fragments of a large *Olenellus* that may belong to this species occur in (59m) Weisner quartzite in the Roan Iron Mine, Bartow County, Georgia.

OLENELLUS THOMPSONI CRASSIMARGINATUS, new variety

PLATE 35, FIGS. 8-10

Olenellus thompsoni WALCOTT (in part) [not (Hall)], 1886, Bull. U. S. Geol. Survey, No. 30, pp. 167-168, pl. 17, fig. 1 (not pl. 17, figs. 2, 4, and 9; pl. 22, fig. 1; nor pl. 23, fig. 1 = *Olenellus thompsoni*). (Copies the original description given by Hall [1859, p. 59] and discusses species. Figure 1 is copied in this paper, pl. 35, fig. 8.)

Olenellus thompsoni WALCOTT (in part) [not (Hall)], 1891, Tenth Ann. Rept. U. S. Geol. Survey, pl. 83, fig. 1b (not pl. 82, figs. 1 and 1a; not pl. 83, figs. 1 and 1a = *Olenellus thompsoni*). (No text reference. Figure 1b is copied from Walcott, 1886, pl. 17, fig. 1.)

This variety is founded on a number of specimens of the cephalon with a broad, somewhat flattened marginal rim that in specimens of the same size is proportionally broader than in *Olenellus thompsoni*. The palpebral lobe is also broad.

FORMATION AND LOCALITY.—Lower Cambrian: (25) *dark, siliceous shales at Parkers quarry near Georgia, Franklin County, Vermont.*

(8q) drab and gray calcareo-argillaceous and arenaceous shales 2 miles (3.2 km.) northwest of the city of York; (49) sandstone on Codorus Creek, $\frac{1}{8}$ mile (.2 km.) below Meyers Mill, near Emigs-ville; and (49a) sandstone on the Liverpool Road, south of the Schoolhouse 3 miles (4.8 km.) northwest of York; all in York County, Pennsylvania.

OLENELLUS ?? WALCOTTI (Shaler and Foerste)

PLATE 24, FIG. 11

Paradoxides walcotti SHALER and FOERSTE, 1888, Bull. Museum Comp. Zool., Whole Series, Vol. 16, No. 2 (Geol. Series, Vol. 2), pp. 36-37, pl. 2, fig. 12. (Described and discussed. The specimen represented by figure 12 is redrawn in this paper, pl. 24, fig. 11.)

Olenellus walcotti (Shaler and Foerste), WALCOTT, 1891, Tenth Ann. Rept. U. S. Geol. Survey, pp. 636-637, pl. 88, fig. 2. (Reproduces figure and description of Shaler and Foerste [1888, pp. 36-37, pl. 2, fig. 12], and refers species to *Olenellus*.)

Olenellus walcotti (Shaler and Foerste), GRABAU, 1900, Occasional Papers, Boston Soc. Nat. Hist., No. 4, Vol. 1, pt. 3, p. 669. (Mentioned.)

Nothing has been added to our knowledge of this species since my paper of 1891. There is not sufficient material to identify it with *Elliptocphala asaphoides* Emmons, nor to positively decide that it is not identical. The cephalon on which the species is founded was found in a stratum of rock carrying six species that are associated with *E. asaphoides* in Rensselaer and Washington counties, New York, namely: *Fordilla troyensis*, *Stenotheca rugosa*, *Platyceras primævum*, *Hyolithes communis emmonsi*, *H. americanus*, and *Hyolithellus micans*.

FORMATION AND LOCALITY.—Lower Cambrian: (326d) reddish-brown arenaceous shale near North Attleboro, Bristol County, Massachusetts.

OLENELLUS ?, sp. undt.

Olenellus sp., MOBERG, 1892, Om Olenellusledet i sydliga Skandinavien, p. 4. (Occurrence mentioned.)

Olenellus ? sp. n., MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, pp. 338-339, pl. 15, figs. 18-19. (Preceding reference copied and species discussed.)

Fragments of a species of trilobite that in some respects resembles *Mesonacis torelli* [pl. 26, figs. 5-18] are mentioned by Dr. Moberg

and doubtfully placed under *Olenellus*. His illustrations indicate a large trilobite that, when better specimens are found, may be a species related to, but distinct from, *M. torelli*, or it may be identical with that species.

FORMATION AND LOCALITY.—Phosphatic nodules in green sandstone on the shore, half way between Brantevik and Gislöfshammer, Sweden [Moberg, 1899, p. 338].

OLENELLUS ?, sp. undt.

PLATE 39, FIG. 14

Of this form only one small cephalon, 1.25 mm. in length, has been found in the collections from the *Olenellus lapworthi* zone of north-west Scotland. The elongate slightly tapering glabella and long eye lobes are like those of the young and small cephalons of *Olenellus*, so that for the present the reference is made to that genus. The cephalon is associated with *Olenellus lapworthi*, *O. reticulatus*, *O. gigas*, and *Olenelloides armatus*.

FORMATION AND LOCALITY.—Lower Cambrian: argillaceous shale interbedded in "Serpulite grit," a coarse quartzitic sandstone, northern slope of Meal a' Ghubhais, 1,200-1,300 feet (366-396 m.) above Loch Marce, 4 miles (6.4 km.) northwest of Kenlochewe, in the west of Ross-shire, Scotland.

PEACHELLA, new genus¹

Of this genus only the cephalon of one species is known. This is described under the species *P. iddingsi*.

Genotype.—*Olenellus iddingsi* Walcott [1884, p. 28].

The generic name is given in honor of Dr. B. N. Peach, of the Geological Survey of Scotland.

Stratigraphic range.—In arenaceous shales and thin, interbedded layers of limestone of the Pioche formation, upper part of the Lower Cambrian (Georgian).

Geographic distribution.—Eastern third of Nevada for about 150 miles between the most northern and southern localities.

Observations.—The cephalon of *Peachella* [pl. 40, figs. 17, 18] is distinguished by its blunt, tumid genal spines; elongate, narrow glabella; small eyes and marked convexity. The small eye is not

¹ The type and only species of this genus has been placed under *Olenellus* in the following references: Walcott [1884, p. 28; 1886, p. 170; and 1891, p. 636] and Holm [1887, p. 515].

unlike that of *Olenellus canadensis* [pl. 38, fig. 6], except that it is close to the glabella at its posterior end. The glabella is comparable with that of the very young specimens of *Wanneria gracile* [pl. 38, fig. 22], but in the adult forms of the latter the glabella is broader at the occipital ring. The most nearly related cephalon is that of *O. fremonti*, as expressed in some of its phases of growth [pl. 37, figs. 14-16]. In these specimens the glabella is unusually narrow and the eyes small and near the glabella, and the genal spine is thickened more than usual, but, with the more expanded anterior lobe of the glabella, outward inclination of the eyes, and the impression obtained of the general assemblage of all the characters of the cephalon as seen at one view, there is no danger of confusing the two species. If we consider all the phases of the cephalon of *O. fremonti* as shown on pl. 37 the two forms are at once seen to be widely separated.

We know nothing of the thorax and pygidium, but with such a cephalon it is highly probable that strongly marked characters exist.

PEACHELLA IDDINGSI (Walcott)

PLATE 40, FIGS. 17-19

Olenellus iddingsi WALCOTT, 1884, Monogr. U. S. Geol. Survey, Vol. 8, p. 28, pl. 9, fig. 12. (Described as a new species. The specimen represented by figure 12 is redrawn in this paper, pl. 40, fig. 17, other specimens being used to restore broken portions.)

Olenellus iddingsi WALCOTT, 1886, Bull. U. S. Geol. Survey, No. 30, p. 170, pl. 19, fig. 1. (Reproduces the description and figure given by Walcott in 1884, and adds a paragraph on some specimens from a new locality.)

Olenellus iddingsi Walcott, HOLM, 1887, Geol. Fören. i Stockholm Förhandl., Bd. 9, Häfte 7, p. 515. (Described in Swedish.)

Olenellus iddingsi WALCOTT, 1891, Tenth Ann. Rept. U. S. Geol. Survey, p. 636, pl. 84, fig. 2. (No text reference. Figure 2 is copied from Walcott, 1884, pl. 9, fig. 12.)

Outline of cephalon roughly subtriangular with the length one-half the breadth at the genal angles; strongly convex in front and sloping to the posterior margin, or the outer margin slopes up toward the genal angles; marginal border narrow and wire-like in front and along the antero-lateral curvature of the border; when opposite the eyes the rounded border thickens and broadens so that it passes into the genal spine with a size and convexity that gives it the appearance of a distinctly elongated lobe; the genal spine is short, and in the larger specimens almost blunt in its outline; the posterior border is faintly defined between the glabella and genal

spine as a nearly flat border that in a small cephalon, 3.5 mm. in length, has a short, blunt intergenal spine close to the genal spine, very much as in *Callavia bröggeri* [pl. 27, fig. 1]. Glabella narrow, convex and contracting slightly at the sides from the occipital ring to the anterior lobe which widens and curves abruptly downward nearly to the front marginal rim of the cephalon; it is divided by four nearly transverse furrows into three narrow transverse lobes and a large anterior lobe; the anterior lobe expands in front of the eyes and curves over and down to just within the front marginal border which is broadly and slightly arched upward at its lower margin in front of the glabella: the two posterior transverse lobes of the glabella are longitudinally subequal in width and wider than the second lobe; occipital ring widening from the sides toward the posterior center where a small node occurs. Eyes small, about one-third the length of the cephalon: they rise abruptly from the cheeks and are very prominent when viewed from the side, although not raised above the level of the glabella; palpebral lobe defined from the anterior lobe of the glabella by a shallow furrow; it arches backward close to the glabella to a point opposite the center of the posterior transverse glabellar lobe; the cheeks slope rather abruptly up from the marginal border to the base of the eye; the interior of each cheek is marked by a narrow depressed line or furrow that extends with a gentle sigmoid curvature backward and outward to where it crosses the marginal border a short distance from the genal spine; in one specimen it crosses the border obliquely and disappears at the intergenal spine; this furrow appears to indicate the course of a facial suture back of the eye that is in a state of symphysis. In my original description [Walcott, 1884, p. 28] I called this line the facial suture. No trace of anything indicating a facial suture has been seen in front of the eye.

Surface minutely punctate with faint, irregular, very slightly elevated, narrow ridges that form an irregular network of elongated meshes. The outer surface usually adheres to the matrix to such an extent that only a few fragments show it at all.

Dimensions.—The largest cephalon in the collection has a length of 13 mm., width 26 mm.; convexity at anterior lobe of glabella 4 mm. Width of glabella at occipital ring 5 mm., at widest part of anterior lobe 5.5 mm.; length of eye 3.5 mm.

Thorax and pygidium unknown.

Observations.—This very unusual form is abundantly represented in the Nevada and Utah area of the Cordilleran Cambrian by many

fragments of the cephalon in association with *Olenellus fremonti*. It is readily recognized by the thick, obtuse genal spines of the adult, slender glabella, and small eyes.

The known stratigraphic range of *Peachella iddingsi* is in the arenaceous shales and interbedded siliceous limestone of the Pioche formation near the top of the Lower Cambrian. At the south end of the Timpahute range the following species are associated with it:

Nisusia (Jamesella) erecta Walcott.

Billingsella highlandensis Walcott.

Callavia nevadensis Walcott.

Olenellus fremonti Walcott.

On Prospect Peak, in the Eureka District, 145 miles north, *Olenellus fremonti* and *Protypus* sp. occur with it, and in the Highland Range 60 miles northeast of the Timpahute Range locality *O. fremonti* and *Callavia nevadensis* are found in the same hand specimens.

FORMATION AND LOCALITY.—Lower Cambrian Pioche formation: (52) arenaceous shales above the massive-bedded sandstones of the Prospect Mountain formation on the summit of Prospect Mountain, Eureka District, Eureka County; (30) arenaceous shales on west slope of the Highland Range at the edge of the desert, 8 miles (12.8 km.) north of Bennetts Spring and about 8 miles (12.8 km.) west of Pioche, Lincoln County; (60h and 313g) arenaceous shales and thin, interbedded limestone in the Groom Mining District at the south end of the Timpahute Range, near the line between Nye and Lincoln counties; all in Nevada.

Genus OLENELLOIDES Peach

Olenellus (Olenelloides) PEACH, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, pp. 668-669, and 671-674. (Described and discussed as a new subgenus.)

Olenelloides (Peach), BEECHER, 1897, American Journ. Sci., 4th ser., Vol. 3, p. 191. (Suggests that the genus represents the young of *Olenellus* or a related form.)

Olenelloides (Peach), MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, p. 320. (Brief description of genus.)

Dorsal shield small, elongate, narrowing from the broad, large cephalon to the small, narrow pygidium.

Cephalon large and provided with strong intergenal, genal, and antero-lateral spines; the intergenal spines appear to represent the postero-lateral termination of the facial sutures, and the antero-

lateral their anterior terminations at the margin, although the sutures are in a condition of symphysis and do not show on the specimens. Glabella subconical and divided by four transverse furrows into a globose anterior lobe and three, narrow, transverse lobes; occipital ring strong and with a minute median node; palpebral lobes small and united to the anterior lobe of the glabella by short ridges. No traces of facial sutures. Interpalpebral ridge crossed by faint furrows indicating the continuation of the glabellar lobes across the dorsal furrow out into the interpalpebral ridge.¹ The third glabellar lobe continues out into the intergenal spine.

Thorax with seven segments. Axial lobe large, convex; pleural lobes narrow and with the third, sixth, and seventh pair extended into long spines; pleural groove strong and obliquely transverse.

Pygidium a small plate with only one transverse furrow as far as known. It is almost enclosed by the spinous extension of the pleurae of the seventh segment.

Surface marked by a very fine network of slightly raised, very narrow, irregular ridges.

The largest dorsal shield has a length of about 11 mm., the greater number of specimens are smaller.

Genotype.—*Olenelloides armatus* Peach.

Stratigraphic range.—Upper beds of Lower Cambrian in association with *Olenellus lapworthi*.

Geographic distribution.—Northwest of Scotland, about upper portion of Loch Maree.

Observations.—This is essentially a larval form of *Olenellus*. The large cephalon and narrow thorax indicate this, and there are additional characters to be considered, such as the spinous extensions of the intergenal angles and antero-lateral angles similar to those in the young of *Olenellus gilberti* [pl. 36, figs. 11-14]. The glabella is conical and primitive as in *Nevadia* [pl. 23]. Eyes primitive and with an interpalpebral ridge as in the young of *Olenellus gilberti* [pl. 36, figs. 11, 12], *Elliptocephala* [pl. 25, figs. 9 and 10], and *Pedeumias transitans* [pl. 25, figs. 21 and 22]. The narrow pleural lobes suggest the pleural lobes of the young of *Pedeumias transitans* [pl. 32, figs. 4-6]. The spines of the third and sixth segments indicate a degenerate form.

¹The interpalpebral ridge is the ridge or elongated tubercle between the glabella and palpebral lobe that is formed by the extension of the three posterior glabellar lobes. These are well shown in the young cephalon of *Elliptocephala asaphoides* [pl. 25, figs. 9 and 10].

I regard *Olenelloides* as representing a degenerate form of the Mesonacidæ that came into existence shortly before the decadence and disappearance of the family.

Mr. B. N. Peach [1894, p. 668] stated when proposing the name *Olenelloides* that the name was "intended to show its strong likeness to some larval stages of other *Olenellids*."

Dr. Charles E. Beecher later [1897, p. 191] suggested that this genus might be the young of *Olenellus* or some related form. I think, now that we have so much additional information about the young stages of the Mesonacidæ, that it may be considered, as just stated, as representing a degenerate genus of the Mesonacidæ.

OLENELLOIDES ARMATUS Peach

PLATE 40, FIGS. 2 AND 3

Olenellus (Olenelloides) armatus PEACH, 1894, Quart. Journ. Geol. Soc. London, Vol. 50, pp. 669-670, pl. 32, figs. 1-6. (Described. None of the specimens figured are represented in this paper.)

Olenelloides armatus MOBERG, 1899, Geol. Fören. i Stockholm Förhandl., Bd. 21, Häfte 4, pp. 314 and 320, pl. 13, fig. 6. (Mentioned at several places in the text. The figure is copied from Peach, 1894, pl. 32, fig. 3.)

Dr. B. N. Peach has given a very full description of the material illustrating this species that was available when he made his study of it in 1894. Through the courtesy of the Director General of the Geological Survey the specimens studied by Dr. Peach and a number collected since were sent to me by Director Horne of the Scottish Survey. In the material I found one entire dorsal shield and its matrix. The matrix, being the clearer, is illustrated by fig. 3, pl. 40. The following description is drawn from it and the specimen it is the matrix of.

Dorsal shield small, elongate, converging in outline from the broad cephalon to the narrow pygidium; moderately convex.

Cephalon roughly hexagonal with the anterior and posterior sides each equal to the length of two of the shorter right and left sides. The outline is broken by three angles with long spines on each side; the postero-lateral angle corresponds to the intergenal angle of the young cephalon of *Olenellus gilberti* [pl. 36, figs. 11-14]; the median angles and spines correspond to the genal angles of the same, and the antero-lateral angles and spines to similar angles and spines of the young cephalon of *O. gilberti*; the antero-lateral spines are located at the points where the facial suture would apparently terminate on the outer margin. The round marginal rim

merges into the spines at the six angles, and extends inward at the posterior margin to the occipital ring.

Glabella elongate, subcylindrical, and divided by four pairs of transverse furrows into four lobes and an occipital ring; the anterior lobe is nearly circular in outline, globose, and sloping down from the anterior glabellar furrow at an angle of about 45° , to the intermarginal space just within the wire-like marginal rim; the second lobe is broadest at the ends and narrow at the center, owing to the anterior pair of furrows extending obliquely inward and backward while the second pair of furrows are almost at right angles to the sides of the glabella, and united without interruption at the median line so as to form a continuous furrow across the glabella; the third and fourth lobes and occipital ring have approximately the same width; they are separated by the third pair of glabellar furrows which extend inward and a little backward nearly to the median line, where they are united by a more shallow, transverse furrow; on both the third and fourth lobes there is a depressed space on the posterior half of the lobe that extends over about three-fifths of its length; this causes the lobe to have a raised front part connected with ends that appear on the third segment like flattened tubercles, and on the fourth segment, where the depressed space is less extended laterally, as low, elongate tubercles; when the glabella is compressed laterally the ends of the second, third, and fourth lobes have the tubercles or elevated ends of the lobes quite prominent, these resemble the lateral tubercles on the median lobe of the thoracic segments of some forms of *Agnostus* and *Microdiscus*. The ends of the fourth glabellar lobe appear to be united to a low ridge that extends obliquely outward and backward into the intergenal spine on each side; the first lobe is united to the palpebral lobe, while the second and third lobes are connected on each side with the long interpalpebral lobe or tubercle that extends parallel to the glabella from the second lobe to where it merges into the ridge connecting the fourth lobe and the intergenal spine on each side. Occipital ring marked by a shallow, narrow furrow that extends inward from each end at the posterior margin and crosses the ring obliquely nearly to the center just within the anterior margin of the ring. On the broad, transversely subtriangular space thus outlined a sharp, minute node occurs close to the posterior median margin of the ring. The glabella is separated from the other parts of the cephalon by a dorsal furrow that is of varying depth owing to the interruptions caused by the low ridges crossing it from the glabellar lobes; these ridges

are strongest at the first, second, and fourth lobes. Palpebral lobes prominent and extending obliquely outward and backward opposite the posterior half of the first glabellar lobe, and the entire second glabellar lobe; a strong ridge unites the palpebral lobe on each side with the side of the first glabellar lobe; the eye rises abruptly from the surface of the cheek opposite the genal spine and is so curved that the visual surface commands all parts of the dorsal shield except directly back of the glabella. I have not been able to find any trace of a furrow connecting the posterior end of the eye with the intergenal spine; if such existed it would extend along the outside of the longitudinal ridge next to the glabella. The inner slope from the palpebral lobe to the dorsal furrow beside the glabella is quite steep and gives great prominence to the eye. The elongate ridge on each side that rises between the eye and the glabella extends back to where it passes out into the intergenal spine; this interpalpebral ridge appears to be formed of the extensions of the glabellar lobes in the same manner as a somewhat similar ridge on the cephalon of the young of *Elliptocephala asaphoides* [pl. 25, figs. 9, 10]. In one specimen traces of segmentation are preserved on the ridges, and a connecting ridge crosses the dorsal furrow uniting the second and fourth glabellar lobes with the longitudinal ridge. The spaces between the front of the glabella, the eyes, and the longitudinal ridge back of the eyes and the marginal rim are very small and of little importance.

The thorax is largely formed of the axial lobe and spinose extensions of the seven thoracic segments (Dr. Peach mentions eight segments, but I can not make out more than seven). Axial lobe convex and separated from the pleural lobes by a clearly defined dorsal furrow; a minute median tubercle or spine occurs near the posterior margin of the segment and there are slight traces of furrows that begin near the anterior center of the segment and extend obliquely outward and backward to the postero-lateral edge, thus repeating the surface structure of the occipital ring. The first three segments are about as wide as the occipital ring, the others gradually narrow toward the pygidium; pleural lobes narrow; those of the first segment are shorter than their width, or longitudinally quadrilateral in outline; those of the second segment are a little longer than those of the first and those of the fourth and fifth are longer than wide; the pleuræ of the third segment are broader than those of the first and second, and are prolonged into a long spine that extends obliquely outward and backward at about the same angle as the inter-

genal spines of the cephalon; the pleuræ of the sixth segment are also extended in spines similar to those of the third segment, but the spines of the pleuræ of the seventh segment are bent abruptly backward so far that they converge slightly toward the median line; a small, short spine occurs at the postero-lateral angle of each of the pleuræ of the first, second, fourth, and fifth segments; the broad pleural furrow crosses the pleuræ obliquely from the antero-interior side to the postero-lateral side, and occupies the greater part of the surface of the pleuræ, except on the third and sixth segments, where the furrow extends out on the base of the large spinose extension of the pleura.

The pygidium is not shown on the specimens studied by Dr. Peach, but on two specimens collected since 1894 the outlines of a small pygidium can be seen between the incurved spines of the seventh segment; it is without spines or angles; about as long as wide at its point of junction with the seventh segment; roughly rounded, subtriangular in outline and marked by a transverse furrow about midway of its length. The pygidium resembles that of the young of *Pædeumias transitans*, as shown by fig. 4, pl. 32, of this paper.

Surface marked by a very minute network of very fine, irregular elevated lines or ridges.

Dimensions.—The largest specimen of the dorsal shield I have seen has a length of 9 mm., exclusive of the pygidium and spines (Dr. Peach mentions one 11 mm. in length). In an entire dorsal shield 4.5 mm. in length [pl. 40, fig. 3] the cephalon is one-half (2.25 mm.) of the total length; width at the intergenal spines 2.1 mm. The proportions of the various parts of the cephalon are fairly well shown by fig. 2, except that the specimen is a little shortened by distortion.

Observations.—The specimens illustrating this species are fairly well preserved in a very fine, hard argillaceous shale, but most of them have been more or less distorted by compression. A number of specimens of the cephalon have been found, but entire specimens are very rare. The relation of this species to the young of other species of the Mesonacidæ are discussed under remarks on the genus *Olenelloides*.

FORMATION AND LOCALITY.—Lower Cambrian: argillaceous shale interbedded in "Serpulite grit," a coarse quartzitic sandstone, northern slope of Meal a' Ghubhais, 1,200-1,300 feet (366-396 m.) above Loch Maree, 4 miles (6.4 km.) northwest of Kenlochewe in the west of Ross-shire, Scotland.

LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MESONACIDÆ, AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH

argentus [Olenellus] Walcott (new).....	= Olenellus argentus
armatus [Olenelloides] Moberg [1899, pp. 314 and 320, pl. 13, fig. 6].	= Olenelloides armatus
armatus [Olenellus (Olenelloides)] Peach [1894, pp. 669-670, pl. 32, figs. 1-6].	= Olenelloides armatus
asaphoides [Ebenezeria] Marcou [1888b, p. 123].	= Elliptocephala asaphoides
asaphoides [Elliptocephalus] Emmons [1849, p. 18].	= Elliptocephala asaphoides
asaphoides [Elliptocephalus] Emmons [1855, p. 114, figs. 1-3, pl. 1, fig. 18].	= Elliptocephala asaphoides
asaphoides [Elliptocephalus (Paradoxides)] Emmons [1860, p. 280].	= Olenellus thompsoni
asaphoides [Elliptocephala] Cole [1892, pp. 340-341].	= Elliptocephala asaphoides
asaphoides [Elliptocephala] Emmons [1844, p. 21, figs. 1-3].	= Elliptocephala asaphoides
asaphoides [Elliptocephala] Emmons [1846, p. 65, figs. 1-3].	= Elliptocephala asaphoides
asaphoides [Elliptocephalus] Marcou [1888a, p. 12].	= Elliptocephala asaphoides
asaphoides [Georgiellus] Moberg [1899, p. 316, pl. 13, figs. 1a-b].	= Elliptocephala asaphoides
asaphoides [Mesonacis (Olenellus)] Peach [1894, p. 671; text fig. C, p. 673; and pl. 32, fig. 11].	= Elliptocephala asaphoides
asaphoides [Olenellus] Bernard [1894, pp. 415-416 and 423-424; fig. 3, p. 415; figs. 4a-c and 5, p. 416; and fig. 9, p. 423].	= Elliptocephala asaphoides
asaphoides [Olenellus] Ford [1878, pp. 129-130].	= Elliptocephala asaphoides
asaphoides [Olenellus] Ford [1881, pp. 250-259, figs. 1-3, p. 251].	= Elliptocephala asaphoides
asaphoides [Olenellus] Holm [1887, p. 515].	= Elliptocephala asaphoides
asaphoides [Olenellus] Lesley [1889, p. 489, 10 text figs.].	= Elliptocephala asaphoides
asaphoides [Olenellus] Lindström [1901, pp. 12-18, text figs. 1-10, p. 13].	= Elliptocephala asaphoides
asaphoides [Olenellus] Matthew [1891, p. 289 and footnote].	= Elliptocephala asaphoides
asaphoides [Olenellus] Walcott [1884, pp. 36-37, pl. 21, figs. 10-12].	= Elliptocephala asaphoides
asaphoides [Olenellus] Walcott [1886, pp. 168-170, pl. 17, figs. 3-8 and 10; pl. 20, figs. 3, 3a-b; and pl. 25, fig. 8].	= Elliptocephala asaphoides
asaphoides [Olenellus (Elliptocephalus)] Ford [1877, pp. 265-272, pl. 4, figs. 1-10].	= Elliptocephala asaphoides
asaphoides [Olenellus (Georgiellus)] Pompeckj [1901, p. 161].	= Elliptocephala asaphoides
asaphoides [Olenellus (Mesonacis)] Beecher [1895, p. 176, figs. 6-8, p. 175].	= Elliptocephala asaphoides

LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MESONACIDÆ, AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH—Cont'd

asaphoides [Olenellus (Mesonacis)] Burr [1900, p. 45].	.....	= Callavia crosbyi
asaphoides [Olenellus (Mesonacis)] Clarke and Ruedemann [1903, pp. 730-732].	.....	= Elliotocephala asaphoides
asaphoides ? [Olenellus (Mesonacis)] Grabau [1900, pp. 667-669, pl. 34, figs. 2a-b].	.....	= Callavia crosbyi
asaphoides [Olenellus (Mesonacis)] Walcott [1890, p. 41].	.....	= Elliotocephala asaphoides
asaphoides [Olenellus (Mesonacis)] Walcott [1891, pp. 637-638, pl. 86, figs. 3, 3a-b; pl. 88, figs. 1, 1a-g; pl. 89, figs. 1 and 1a; and pl. 90, figs. 1 and 1a].	.....	= Elliotocephala asaphoides
asaphoides [Olenellus (Olenus)] Ford [1871a, p. 33].	.....	= Elliotocephala asaphoides
asaphoides [Olenellus (Olenus)] Ford [1871b, p. 210].	.....	= Elliotocephala asaphoides
asaphoides [Olenus] Fitch [1849, p. 865].	.....	= Elliotocephala asaphoides
asaphoides [Olenus] Hall [1847, pp. 256-257, pl. 67, figs. 2a-c].	.....	= Elliotocephala asaphoides
asaphoides [Paradoxides] Barrande [1801, pp. 273-276, pl. 5, figs. 4-5].	.....	= Olenellus thompsoni
asaphoides [Paradoxides] Emmons [1860, p. 87, legend of fig. 70].	.....	= Mesonacis (in part) and Olenellus
Barrandia Hall [1860, p. 115].	.....	(in part)
Barrandia Hall [1861, p. 369].	.....	= Mesonacis (in part) and Olenellus
Barrandia McCoy.	.....	(in part)
Barrandia thompsoni Hall [1860, pp. 115-116, fig., p. 116].	.....	does not = Olenellus
Barrandia thompsoni Hall [1861, pp. 369-370].	.....	= Olenellus thompsoni
Barrandia thompsoni Hall [1862a, pl. 13, fig. 1].	.....	= Olenellus thompsoni
Barrandia thompsoni Hall [1862a, pl. 13, fig. 1].	.....	= Olenellus thompsoni
Barrandia vermontana Hall [1860, p. 117, text fig.].	.....	= Mesonacis vermontana
Barrandia vermontana Hall [1861, p. 370].	.....	= Mesonacis vermontana (in part)
Barrandia vermontana Hall [1861, p. 370].	.....	and Pædeumias transitans (in part)
Barrandia vermontana Hall [1862a, pl. 13, fig. 2].	.....	= Mesonacis vermontana
Barrandia vermontana Hall [1862a, pl. 13, figs. 4 and 5].	.....	= Pædeumias transitans
bicensis [Callavia] Walcott (new).	.....	= Callavia bicensis

- LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MESONACIDÆ. AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH.—Cont'd
- canadensis [Olenellus] Walcott [1908c, p. 215]..... = Olenellus canadensis (in part) and Olenellus gilberti (in part)
- cartlandi [Olenellus (Holmia ?)] Raw [1909, MS.]..... = Callavia cartlandi
- Cephalacanthus Lacépède [1802, p. 323]..... = Fish
- Cephalacanthus Lapworth [1891a, p. 641]..... = Callavia (in part) and Holmia (in part)
- Cephalacanthus Lapworth [1891b, p. 531]..... = Callavia (in part) and Holmia (in part)
- Cephalacanthus bröggeri Lapworth [1891a, p. 641]..... = Callavia bröggeri
- Cephalacanthus callavei Lapworth [1891a, pp. 640-641]..... = Callavia callavei
- Cephalacanthus kjerulfi Lapworth [1891a, pp. 640-641]..... = Holmia kjerulfi
- claytoni [Olenellus] Walcott [1908c, p. 189, 6 of section]..... = Olenellus gilberti (in part) and Olenellus claytoni (in part)
- crassimarginatus [Olenellus thompsoni] Walcott (new)..... = Olenellus thompsoni crassimarginatus
- crosbyi [Callavia] Walcott (new)..... = Callavia crosbyi
- Ebenezeria Marcou [1888, p. 123]..... = Elliptocephala
- Ebenezeria asaphoides Marcou [1888b, p. 123]..... = Elliptocephala asaphoides
- Elliptocephalus Emmons [1849, p. 18]..... = Elliptocephala
- Elliptocephalus Emmons [1855, pp. 114-115]..... = Elliptocephala
- Elliptocephalus Marcou [1860, p. 371]..... = Elliptocephala
- Elliptocephalus asaphoides Emmons [1849, p. 18]..... = Elliptocephala asaphoides
- Elliptocephalus asaphoides Emmons [1855, p. 114, figs. 1-3, pl. 1, fig. 18]..... = Elliptocephala asaphoides
- Elliptocephalus (Paradoxides) asaphoides Emmons [1860, p. 280]..... = Olenellus thompsoni
- Elliptocephala Beecher [1897, pp. 191 and 192]..... = Elliptocephala
- Elliptocephala Cole [1892, p. 340]..... = Elliptocephala
- Elliptocephala Emmons [1844, p. 21]..... = Elliptocephala

- Elliptocephala Emmons [1846, p. 65]. = Elliptocephala
 Elliptocephala Matthew [1899, p. 59]. = Elliptocephala
 Elliptocephala asaphoides Cole [1892, pp. 340-341]. = Elliptocephala asaphoides
 Elliptocephala asaphoides Emmons [1844, p. 21, figs. 1-3]. = Elliptocephala asaphoides
 Elliptocephala asaphoides Emmons [1846, p. 65, figs. 1-3]. = Elliptocephala asaphoides
 Elliptocephala thompsoni Miller [1889, p. 546, fig. 1003]. = Olenellus thompsoni
 Elliptocephala (Mesonacis) Beecher [1897, p. 192]. = Mesonacis
 Elliptocephalus Marcou [1890, p. 362]. = Elliptocephala
 (Elliptocephalus) [Olenellus] Ford [1877, pp. 265-272]. = Elliptocephala
 Elliptocephalus asaphoides Marcou [1888a, p. 12]. = Elliptocephala asaphoides
 (Elliptocephalus) asaphoides [Olenellus] Ford [1877, pp. 265-272, pl. 4, figs. 1-10]. = Elliptocephala asaphoides
 Elliptocephalus (Schmidtia) Marcou [1890, p. 363]. = Mesonacis (in part) and Zaca-
 thoides (in part)
 Elliptocephalus (Schmidtia) mickwiti Marcou [1890, p. 363]. = Mesonacis mickwiti
 Elliptocephalus (Schmidtia) vermontana Marcou [1890, p. 363]. = Mesonacis vermontana
 elongatus [Olenellus lapworthi] Peach [1894, p. 664, pl. 29, figs. 3-6]. = Olenellus lapworthi
 fremonti [Olenellus] Walcott [1908c, p. 187]. = Olenellus fremonti
 Gen. ? Matthew [1888, pp. 75-76]. = Holmia
 (Gen. ?) kjerulfi [Paradoxides] Matthew [1888, pp. 75-76]. = Holmia kjerulfi
 Georgiellus Moberg [1899, p. 317]. = Elliptocephala
 (Georgiellus) [Olenellus] Pompeckj [1901, p. 16]. = Elliptocephala
 Georgiellus asaphoides Moberg [1899, p. 316, pl. 13, figs. 1a-b]. = Elliptocephala asaphoides
 (Georgiellus) asaphoides [Olenellus] Pompeckj [1901, p. 16]. = Elliptocephala asaphoides
 gigas [Olenellus] Peach [1894, p. 666, fig. 1, p. 667]. = Olenellus gigas
 gilberti [Olenellus] Holm [1887, pp. 514-515]. = Olenellus gilberti
 gilberti [Olenellus] Lesley [1889, p. 499, whole specimens represented by figs. 1 and 1a]. = Olenellus gilberti
 gilberti [Olenellus] Lesley [1889, p. 499, fig. 2a and cephalons represented by figs. 1, 1a, 1b,
 and 1f]. = Olenellus fremonti
 gilberti [Olenellus] McConnell [1887, p. 30D]. = Wanneria gracile

LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MESONACIDÆ, AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH—Cont'd

gilberti [Olenellus] Meek [1874, MS.]	== Olenellus gilberti
gilberti [Olenellus] Peach [1894, p. 671, pl. 32, figs. 9 and 10]	== Olenellus fremonti
gilberti [Olenellus] Walcott [1884, p. 29, pl. 9, fig. 16, and pl. 21, fig. 13]	== Callavia ? nevadensis
gilberti [Olenellus] Walcott [1884, p. 29, pl. 9, fig. 16a]	== Olenellus fremonti
gilberti [Olenellus] Walcott [1884, p. 29, pl. 21, fig. 14]	== Olenellus gilberti
gilberti [Olenellus] Walcott [1886, pp. 170-180, pl. 18, figs. 1, 1a-b; pl. 19, figs. 2, 2a, 2b, 2k; pl. 20, fig. 4; and pl. 21, figs. 1 and 1a]	== Olenellus gilberti
gilberti [Olenellus] Walcott [1886, pp. 170-180, pl. 18, fig. 1c; pl. 19, figs. 2c, 2h, 2i; pl. 20, figs. 1, 1a-1, 1k-m; and pl. 21, figs. 2 and 2a]	== Olenellus fremonti
gilberti [Olenellus] Walcott [1886, pp. 170-180, pl. 19, figs. 2c, 2d, 2f, and 2g]	== Callavia ? nevadensis
gilberti [Olenellus] Walcott [1891a, pl. 84, figs. 1, 1a-c; pl. 85, figs. 1b-d; and pl. 86, fig. 4]	== Olenellus gilberti
gilberti [Olenellus] Walcott [1891a, pl. 84, figs. 1d and 1f; pl. 85, figs. 1, 1a, and 1f; and pl. 86, figs. 1, 1a-1, 1k-m]	== Olenellus fremonti
gilberti [Olenellus] Walcott [1891a, pl. 84, figs. 1e and 1g; and pl. 85, figs. 1e and 1g]	== Callavia ? nevadensis
gilberti [Olenellus] Walcott [1908c, p. 189, 2 of section]	== Olenellus gilberti
gilberti [Olenellus] White [1874, p. 7]	== Olenellus gilberti
gilberti [Olenellus] White [1877, pp. 44-46, pl. 2, figs. 3a-e]	== Olenellus gilberti
gilberti [Olenus (Olenellus)] Gilbert [1875, pp. 182-183]	== Olenellus gilberti
gilberti var. [Olenellus] Walcott (new)	== Olenellus gilberti var.
gracile [Wanneria ?] Walcott (new)	== Wanneria ? gracile
halli [Wanneria] Walcott (new)	== Wanneria halli
Holmia Beecher [1897, p. 191]	== Holmia
Holmia Cole [1892, p. 344]	== Holmia
Holmia Frech [1897, p. 41]	== Holmia
Holmia Lindström [1901, p. 24]	== Holmia
Holmia Marcou [1890, pp. 365-366]	== Holmia
Holmia Matthew [1890, p. 160, footnote 1]	== Holmia

- Holmia Matthew [1899, p. 59] = Holmia
 Holmia Moberg [1899, pp. 314 and 318] = Holmia (in part) and Callavia (in part)
 Holmia Peach and Horne [1892, p. 236] = Holmia (in part) and Callavia (in part)
 Holmia Pompeckj [1901, pp. 14-17] = Holmia
 Holmia Weller [1900, pp. 50-51] = Holmia
 (Holmia) [Olenellus] Cole [1892, fig. 3, p. 343] = Holmia
 Holmia ? bröggeri Marcou [1890, pp. 370-371] = Callavia bröggeri
 Holmia bröggeri Peach [1894, pp. 672 and 673] = Callavia bröggeri
 (Holmia) bröggeri [Olenellus] Burr [1900, pp. 43-44] = Callavia crosbyi
 (Holmia) bröggeri [Olenellus] Grabau [1900, pp. 662-664, pl. 33, figs. 1a-j] = Callavia crosbyi
 (Holmia) bröggeri [Olenellus] Pompeckj [1901, pl. 1, fig. 10] = Callavia bröggeri
 (Holmia) bröggeri [Olenellus] Walcott [1891a, pp. 638-640, pl. 9f, fig. 1; pl. 92, figs. 1, 1a-h] = Callavia bröggeri
 (Holmia) calevi [Olenellus] Walcott [1891a, p. 635] = Callavia callavei
 (Holmia) callavei [Olenellus] Cole [1892, pp. 344 and 345] = Callavia callavei
 (Holmia) callavei [Olenellus] Lapworth [1891b, pp. 530-536, pl. 14, figs. 1-25, and pl. 15] = Callavia callavei
 (Holmia ?) cartlandi [Olenellus] Raw [1909, MS.] = Callavia cartlandi
 Holmia kjerulfi Lindström [1901, p. 57] = Holmia kjerulfi
 Holmia kjerulfi Marcou [1890, pp. 365-366] = Holmia kjerulfi
 Holmia kjerulfi Moberg [1899, p. 318, pl. 13, fig. 3] = Holmia kjerulfi
 (Holmia) kjerulfi [Olenellus] Cole [1892, p. 343, fig. 3] = Holmia kjerulfi
 (Holmia) kjerulfi [Olenellus] Frech [1897, pl. 1a, fig. 13] = Holmia kjerulfi
 (Holmia) kjerulfi [Olenellus] Walcott [1891a, p. 635, pl. 86, fig. 2, and pl. 93, fig. 2] = Holmia kjerulfi
 Holmia lundgreni Lindström [1901, p. 57] = Holmia lundgreni
 Holmia lundgreni Moberg [1899, pp. 321-329, pl. 14, figs. 1-14] = Holmia lundgreni
 Holmia rowei Walcott [1908c, p. 186, 1d and 2j of section] = not specifically identified
 Holmia rowei Walcott [1908c, pp. 187 and 188, 3 of section] = Wanneria ? gracile
 Holmia rowei Walcott [1908c, p. 189, 3 of section] = Olenellus argentus (in part) and Olenellus gilberti (in part)

LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MESONACIDÆ, AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH—Cont'd

Holmia rowei Walcott [1908c, p. 189, 12 of section].....	== Holmia rowei
(Holmia) walcottanus [Olenellus] Wanner [1901, pp. 267-269, pl. 31, figs. 1 and 2; pl. 32, figs. 1-4]	== Wanneria walcottanus
Holmia weeksi Walcott [1908c, p. 187, 2j of section].....	== Olenellus fremonti
Holmia weeksi Walcott [1908c, p. 189, 3 of section].....	== Wanneria ? gracile
Holmia weeksi Walcott [1908c, p. 189, 6 of section].....	== Olenellus fremonti
Holmia weeksi Walcott [1908c, p. 189, 11 of section].....	== not specifically identified
Holmia weeksi Walcott [1908c, p. 189, 12 of section].....	== Nevada weeksi
Holmia (Olenellus) Peach [1894, pp. 671-674].....	== Holmia (in part) and Callavia (in part)
Holmia (Olenellus) kjerulfi Peach [1894, p. 671, pl. 32, fig. 12].....	== Holmia kjerulfi
howelli [Olenellus] Meek [1874, MS.].....	== Olenellus gilberti
howelli [Olenellus] Walcott [1884, pp. 30-31, pl. 9, figs. 15, 15a-c; and pl. 21, figs. 1-9, 16-17].....	== Olenellus fremonti
howelli [Olenellus] White [1874, p. 81].....	== Olenellus gilberti
howelli [Olenellus] White [1877, pp. 47-48, pl. 2, figs. 4a-b].....	== Olenellus gilberti
howelli [Olenus (Olenellus)] Gilbert [1875, p. 183].....	== Olenellus gilberti
iddingsi [Olenellus] Holm [1887, p. 515].....	== Olenellus gilberti
iddingsi [Olenellus] Walcott [1884, p. 28, pl. 9, fig. 12].....	== Peachella iddingsi
iddingsi [Olenellus] Walcott [1886, p. 170, pl. 19, fig. 11].....	== Peachella iddingsi
iddingsi [Olenellus] Walcott [1891a, p. 636, pl. 84, fig. 21].....	== Peachella iddingsi
intermedius [Olenellus] Peach [1894, pp. 666-668, pl. 32, fig. 71].....	== Olenellus lapworthi
kjerulfi [Cephalacanthus] Lapworth [1891a, pp. 640-641].....	== Holmia kjerulfi
kjerulfi [Holmia] Lindström [1901, p. 571].....	== Holmia kjerulfi
kjerulfi [Holmia] Marcon [1890, pp. 365-366].....	== Holmia kjerulfi
kjerulfi [Holmia] Moberg [1890, p. 318, pl. 13, fig. 31].....	== Holmia kjerulfi
kjerulfi [Holmia (Olenellus)] Peach [1894, p. 671, pl. 32, fig. 121].....	== Holmia kjerulfi
kjerulfi [Paradoxides] Ford [1878, p. 130, footnote].....	== Holmia kjerulfi

- kjerulfi [Olenellus] Brügger [1878, p. 44]..... = Holmia kjerulfi
 kjerulfi [Olenellus] Holm [1887, pp. 499-512]..... = Holmia kjerulfi
 kjerulfi [Olenellus] Koken [1896, p. 7, fig. 2]..... = Holmia kjerulfi
 kjerulfi [Olenellus] Linnarsson [1883, pp. 18-20, pl. 3, figs. 12-17]..... = Holmia kjerulfi
 kjerulfi [Olenellus (Holmia)] Cole [1892, p. 343, fig. 3]..... = Holmia kjerulfi
 kjerulfi [Olenellus (Holmia)] Frech [1897, pl. 1a, fig. 13]..... = Holmia kjerulfi
 kjerulfi [Olenellus (Holmia)] Walcott [1891a, p. 635, pl. 86, fig. 2, and pl. 93, fig. 2]..... = Holmia kjerulfi
 kjerulfi [Olenellus (?)] Matthew [1886, pp. 472-473]..... = Holmia kjerulfi
 kjerulfi [Paradoxides ?] Ford [1881, pp. 255-258, fig. 10, p. 256]..... = Holmia kjerulfi
 kjerulfi [Paradoxides] Kjerulfi [1873, p. 83, figs. 1-5]..... = Holmia kjerulfi
 kjerulfi [Paradoxides] Linnarsson [1871, pp. 790-792, pl. 16, figs. 1-3]..... = Holmia kjerulfi
 kjerulfi [Paradoxides] Walcott [1886, p. 178, pl. 20, fig. 2]..... = Holmia kjerulfi
 kjerulfi [Paradoxides (Gen. ?)] Matthew [1888, pp. 75-76]..... = Holmia kjerulfi
 lapworthi [Olenellus] Peach [1894, pp. 662-664, pl. 29, figs. 1, 2, and 2a; pl. 30, fig. 7; and pl. 32, fig. 8]..... = Olenellus lapworthi
 lapworthi [Olenellus] Peach and Horne [1892, pp. 236-241, pl. 5, figs. 1-11]..... = Olenellus lapworthi
 lapworthi elongatus [Olenellus] Peach [1894, p. 664, pl. 29, figs. 3-6]..... = Olenellus lapworthi
 logani [Olenellus] Walcott (new)..... = Olenellus logani
 lundgreni [Holmia] Lindström [1901, p. 57]..... = Holmia lundgreni
 lundgreni [Holmia] Moberg [1899, pp. 321-329, pl. 14, figs. 1-14]..... = Holmia lundgreni
 lundgreni [Olenellus] Moberg [1892, p. 31]..... = Holmia lundgreni
 macrocephalus [Paradoxides] Barrantes [1861, pp. 276-277, pl. 5, fig. 7]..... = Olenellus thompsoni
 macrocephalus [Paradoxides] Emmons [1860, p. 87 and p. 280]..... = Olenellus thompsoni
 magnificus ? [Metadoxides] Grabau [1900, p. 670, pl. 34, figs. 4-6]..... = Callavia crosbyi
 Mesonacis Cole [1892, pp. 342-344]..... = Mesonacis
 Mesonacis Moberg [1899, p. 318]..... = Mesonacis
 Mesonacis Peach and Horne [1892, p. 236]..... = Elliptocephala (in part) and Mesonacis (in part)
 Mesonacis Walcott [1886, p. 158]..... = Mesonacis

LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MESONACIDÆ, AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH—Cont'd

- Mesonacis Walcott [1885, pp. 328-330]..... = Mesonacis
 Mesonacis Weller [1900, pp. 50-51]..... = Mesonacis
 (Mesonacis) [Eliptocephala] Beecher [1897, p. 192]..... = Mesonacis
 (Mesonacis) [Olenellus] Cole [1892, fig. 2, p. 343]..... = Mesonacis
 (Mesonacis) [Olenellus] Walcott [1891a, p. 637]..... = Eliptocephala (in part) and Mesonacis (in part)
 Mesonacis mickwitziae Peach [1894, p. 672, text fig. B, p. 673]..... = Mesonacis mickwitzii
 Mesonacis vermontana Moberg [1899, p. 318, pl. 13, fig. 4]..... = Mesonacis vermontana
 Mesonacis vermontanus Walcott [1885, pp. 328-330, figs. 1 and 2, p. 329]..... = Mesonacis vermontana
 Mesonacis vermontanus Walcott [1886, pp. 158-162, pl. 24, figs. 1, 1a-b]..... = Mesonacis vermontana
 (Mesonacis) asaphoides [Olenellus] Beecher [1895, p. 176, figs. 6-8, p. 175]..... = Eliptocephala asaphoides
 (Mesonacis) asaphoides [Olenellus] Burr [1900, p. 45]..... = Callavia crosbyi
 (Mesonacis) asaphoides [Olenellus] Clarke and Ruedemann [1903, pp. 730-732]..... = Eliptocephala asaphoides
 (Mesonacis) asaphoides ? [Olenellus] Grabau [1900, pp. 667-669, pl. 34, figs. 2a-b]..... = Callavia crosbyi
 (Mesonacis) asaphoides [Olenellus] Walcott [1890, p. 41]..... = Eliptocephala asaphoides
 (Mesonacis) asaphoides [Olenellus] Walcott [1891, pp. 637-638, pl. 86, figs. 3, 3a-b; pl. 88, figs. 1, 1a-g; pl. 89, figs. 1 and 1a; and pl. 90, figs. 1 and 1a]..... = Eliptocephala asaphoides
 (Mesonacis) bröggeri [Olenellus] Walcott [1889, pp. 378-380]..... = Callavia bröggeri
 (Mesonacis) bröggeri [Olenellus] Walcott [1890, p. 41]..... = Callavia bröggeri
 (Mesonacis) mickwitzii [Olenellus] Frech [1897, pl. 1a, fig. 8]..... = Mesonacis mickwitzii
 (Mesonacis) mickwitzii [Olenellus] Walcott [1891, p. 634, pl. 93, fig. 1]..... = Mesonacis mickwitzii
 (Mesonacis) vermontana [Olenellus] Cole [1892, pp. 340 and 341, fig. 2, p. 343]..... = Mesonacis vermontana
 (Mesonacis) vermontana [Olenellus] Walcott [1891a, p. 637, pl. 87, figs. 1, 1a-b]..... = Mesonacis vermontana
 Mesonacis [Olenellus] Peach [1894, pp. 671-674]..... = Eliptocephala (in part) and Mesonacis (in part)
 Mesonacis [Olenellus] asaphoides Peach [1894, p. 671; text fig. C, p. 673; and pl. 32, fig. 1]..... = Eliptocephala asaphoides
 Metadoxides magnificus ? Grabau [1900, p. 670, pl. 34, figs. 4-6]..... = Callavia crosbyi

- mickwitzi [Eliptocephalus (Schmidtia)] Marcou [1890, p. 363] = Mesonacis mickwitzi
 mickwitzi [Olenellus] Schmidt [1888, pp. 13-19, pl. 1, figs. 1-25] = Mesonacis mickwitzi
 mickwitzi [Olenellus] Schmidt [1889, pp. 191-195, 10 text figs., p. 193] = Mesonacis mickwitzi
 mickwitzi [Olenellus (Mesonacis)] Frech [1897, pl. 1a, fig. 8] = Mesonacis mickwitzi
 mickwitzi [Olenellus (Mesonacis)] Walcott [1891a, p. 634, pl. 93, fig. 1] = Mesonacis mickwitzi
 mickwitzi [Schmidtia] Moberg [1899, pp. 319-320, pl. 13, figs. 5a-c] = Mesonacis mickwitzi
 mickwitzi [Schmidtiellus] Moberg and Segerberg [1906, p. 35, footnote] = Mesonacis mickwitzi
 nevadensis [Mesonacis] Peach [1894, p. 672, text fig. B, p. 673] = Mesonacis mickwitzi
 nevadensis [Callavia?] Walcott (new) = Callavia ? nevadensis
 Nevada Walcott (new) = Nevada
 Nevada weeksi Walcott (new) = Nevada weeksi
 Olenelloides Beecher [1897, p. 191] = Olenelloides
 Olenelloides Moberg [1899, p. 320] = Olenelloides
 (Olenelloides) [Olenellus] Peach [1894, pp. 668-669, and 671-674] = Olenelloides
 Olenelloides armatus Moberg [1899, pp. 314 and 320, pl. 13, fig. 6] = Olenelloides armatus
 (Olenelloides) armatus [Olenellus] Peach [1894, pp. 669-670, pl. 32, figs. 1-6] = Olenelloides armatus
 Olenellus Beecher [1897, p. 191] = Olenellus
 Olenellus Bernard [1894, pp. 415-416] = Eliptocephala
 Olenellus Cole [1892, pp. 340-346] = Olenellus (in part), includes dis-
 cussion of many of the forms
 now placed in Mesonacidae
 Olenellus Ford [1878, p. 130, footnote] = Eliptocephala
 Olenellus Ford [1881, pp. 250-259] = Eliptocephala (in part), Mesona-
 cis (in part), and Olenellus (in
 part)
 Olenellus Hall [1862, p. 114] = Olenellus
 Olenellus Holm [1887, pp. 498-499] = includes many of the forms now
 referred to the Mesonacidae
 Olenellus Lindström [1901, pp. 12-18] = Eliptocephala

LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MESONACIDÆ, AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH—Cont'd

Olenellus Lindström [1901, p. 24].....	= Olenellus
Olenellus Marcou [1889, p. 74].....	= Olenellus
Olenellus Marcou [1890, p. 362].....	= Olenellus
Olenellus Moberg [1899, p. 317].....	= Olenellus
Olenellus Peach [1894, pp. 671-673].....	= Olenellus
Olenellus Peach and Horne [1892, p. 236].....	= Olenellus
Olenellus Pompeckj [1901, pp. 14-17].....	= Olenellus
Olenellus Walcott [1886, pp. 162-166].....	= Elliptocephala (in part), Olenellus (in part), Callavia (in part), and Peachella (in part)
Olenellus Walcott [1890, pp. 40-41].....	= Olenellus
Olenellus Walcott [1891a, pp. 633-635].....	= Olenellus (in part) and Callavia (in part)
Olenellus Weller [1900, pp. 50-51].....	= Olenellus (in part), discusses genus in broad sense
(Olenellus) [Holmia] Peach [1894, pp. 671-674].....	= Holmia (in part) and Callavia (in part)
(Olenellus) [Mesonacis] Peach [1894, pp. 671-674].....	= Elliptocephala (in part) and Mes- onacis (in part)
Olenellus argentus Walcott (new).....	= Olenellus argentus
Olenellus asaphoides Bernard [1894, pp. 415-416 and 423-424; fig. 3, p. 415; figs. 4a-c and 5, p. 416; and fig. 9, p. 423].....	= Elliptocephala asaphoides
Olenellus asaphoides Ford [1878, pp. 129-130].....	= Elliptocephala asaphoides
Olenellus asaphoides Ford [1881, pp. 250-259, figs. 1-3, p. 251].....	= Elliptocephala asaphoides
Olenellus asaphoides Holm [1887, p. 515].....	= Elliptocephala asaphoides
Olenellus asaphoides Lesley [1889, p. 489, 10 text figs.].....	= Elliptocephala asaphoides
Olenellus asaphoides Lindström [1901, pp. 12-18, text figs. 1-10, p. 13].....	= Elliptocephala asaphoides

- Olenellus asaphoides Matthew [1891, p. 289 and footnote]..... = *Elliptocephala asaphoides*
 Olenellus asaphoides Walcott [1884, pp. 36-37, pl. 21, figs. 10-12]..... = *Elliptocephala asaphoides*
 Olenellus asaphoides Walcott [1886, pp. 168-170, pl. 17, figs. 3-8 and 10; pl. 20, figs. 3, 3a-b; and pl. 25, fig. 81]..... = *Elliptocephala asaphoides*
 (Olenellus) asaphoides [Mesonacis] Peach [1894, p. 671; text fig. C, p. 673; and pl. 32, fig. 11]... = *Elliptocephala asaphoides*
 Olenellus bröggeri Bernard [1894, p. 423]..... = *Callavia bröggeri*
 Olenellus bröggeri Walcott [1888, p. 551]..... = *Callavia bröggeri*
 Olenellus callavei Lapworth [1888a, p. 485]..... = *Callavia callavei*
 Olenellus callavei Lapworth [1888b, p. 212]..... = *Callavia callavei*
 Olenellus canadensis Walcott [1908b, p. 242]..... = *Olenellus canadensis* (in part) and
 Olenellus gilberti (in part)
 Olenellus canadensis Walcott [1908c, p. 215]..... = *Olenellus canadensis* (in part) and
 Olenellus gilberti (in part)
 Olenellus claytoni Walcott [1908c, p. 189, 6 of section]..... = *Olenellus gilberti* (in part) and
 Olenellus claytoni (in part)
 Olenellus fremonti Walcott [1908c, p. 187]..... = *Olenellus fremonti*
 Olenellus gigas Peach [1894, p. 666, fig. 1, p. 667]..... = *Olenellus gigas*
 Olenellus gilberti Holm [1887, pp. 514-515]..... = *Olenellus gilberti*
 Olenellus gilberti Lesley [1889, p. 490, whole specimens represented by figs. 1 and 1a]..... = *Olenellus gilberti*
 Olenellus gilberti Lesley [1889, p. 490, fig. 2a and cephalons represented by figs. 1, 1a, 1b, and 1f] = *Olenellus fremonti*
 Olenellus gilberti McConnell [1887, p. 30D]..... = *Wanneria* ? *gracile*
 Olenellus gilberti Meek [1874, MS.]..... = *Olenellus gilberti*
 Olenellus gilberti Peach [1894, p. 671, pl. 32, figs. 9 and 10]..... = *Olenellus fremonti*
 Olenellus gilberti Walcott [1884, p. 29, pl. 9, fig. 16a]..... = *Olenellus fremonti*
 Olenellus gilberti Walcott [1884, p. 29, pl. 9, fig. 16, and pl. 21, fig. 13]..... = *Olenellus fremonti*
 Olenellus gilberti Walcott [1884, p. 29, pl. 21, fig. 14]..... = *Callavia* ? *nevadensis*
 Olenellus gilberti Walcott [1886, pp. 170-180, pl. 18, figs. 1, 1a-b; pl. 19, figs. 2, 2a, 2b, 2k; pl. 20, fig. 4; and pl. 21, figs. 1 and 1a]..... = *Olenellus gilberti*
 Olenellus gilberti Walcott [1886, pp. 170-180, pl. 18, fig. 1c; pl. 19, figs. 2c, 2h, 2i; pl. 20, figs. 1, 1a-i, 1k-m; and pl. 21, figs. 2 and 2a]..... = *Olenellus fremonti*

LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MESONACIDÆ, AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH—Cont'd

- Olenellus gilberti* Walcott [1886, pp. 170-180, pl. 19, figs. 2c, 2d, 2f, and 2g]..... = *Callavia* ? *nevadensis*
Olenellus gilberti Walcott [1891a, pl. 84, figs. 1, 1a-c; pl. 85, figs. 1b-d; and pl. 86, fig. 4]..... = *Olenellus gilberti*
Olenellus gilberti Walcott [1891a, pl. 84, figs. 1d and 1f; pl. 85, figs. 1, 1a, and 1f; and pl. 86, figs. 1, 1a-1, 1k-m]..... = *Olenellus fremonti*
Olenellus gilberti Walcott [1891a, pl. 84, figs. 1e and 1g; and pl. 85, figs. 1e and 1g]..... = *Callavia* ? *nevadensis*
Olenellus gilberti Walcott [1908c, p. 189, 2 of section 1]..... = *Olenellus gilberti*
Olenellus gilberti White [1874, p. 7]..... = *Olenellus gilberti*
Olenellus gilberti White [1877, pp. 44-46, pl. 2, figs. 3a-e]..... = *Olenellus gilberti*
(*Olenellus*) *gilberti* [Olenus] Gilbert [1875, pp. 182-183]..... = *Olenellus gilberti*
Olenellus gilberti var. *Walcott* (new)..... = *Olenellus gilberti* var.
Olenellus howelli Meek [1874, MS.1]..... = *Olenellus gilberti*
Olenellus howelli Walcott [1884, pp. 30-31, pl. 9, figs. 15, 15a-c; and pl. 21, figs. 1-9, 16-17]..... = *Olenellus fremonti*
Olenellus howelli White [1874, p. 8]..... = *Olenellus gilberti*
Olenellus howelli White [1877, pp. 47-48, pl. 2, figs. 4a-b]..... = *Olenellus gilberti*
(*Olenellus*) *howelli* [Olenus] Gilbert [1875, p. 183]..... = *Olenellus gilberti*
Olenellus iddingsi Holm [1887, p. 515]..... = *Peachella iddingsi*
Olenellus iddingsi Walcott [1884, p. 28, pl. 9, fig. 12]..... = *Peachella iddingsi*
Olenellus iddingsi Walcott [1886, p. 170, pl. 19, fig. 1]..... = *Peachella iddingsi*
Olenellus iddingsi Walcott [1891a, p. 636, pl. 84, fig. 2]..... = *Peachella iddingsi*
Olenellus intermedius Peach [1894, pp. 666-668, pl. 32, fig. 7]..... = *Olenellus lapworthi*
Olenellus kjerulfii Brøgger [1878, p. 44]..... = *Holmia kjerulfii*
Olenellus kjerulfii Holm [1887, pp. 499-512]..... = *Holmia kjerulfii*
Olenellus kjerulfii Koken [1896, p. 7, fig. 2]..... = *Holmia kjerulfii*
Olenellus kjerulfii Linnarsson [1883, pp. 18-20, pl. 3, figs. 12-17]..... = *Holmia kjerulfii*
Olenellus (?) *kjerulfii* Matthew [1886, pp. 472-473]..... = *Holmia kjerulfii*
(*Olenellus*) *kjerulfii* [Holmia] Peach [1894, p. 671, pl. 32, fig. 12]..... = *Holmia kjerulfii*

- Olenellus lapworthi Peach [1894, pp. 662-664, pl. 29, figs. 1, 2, and 2a; pl. 30, fig. 7; and pl. 32, fig. 8] = *Olenellus lapworthi*
- Olenellus lapworthi Peach and Horne [1892, pp. 236-241, pl. 5, figs. 1-11] = *Olenellus lapworthi*
- Olenellus lapworthi elongatus Peach [1894, p. 664, pl. 29, figs. 3-6] = *Olenellus lapworthi*
- Olenellus logani Walcott (new) = *Olenellus logani*
- Olenellus lundgreni Moberg [1892, p. 3] = *Holmia lundgreni*
- Olenellus mickwitzi Schmidt [1888, pp. 13-19, pl. 1, figs. 1-25] = *Mesonacis mickwitzi*
- Olenellus mickwitzi Schmidt [1889, pp. 191-195, 10 text figs., p. 193] = *Mesonacis mickwitzi*
- Olenellus reticulatus Peach [1894, pp. 665-666, text fig. A, p. 673; pl. 30, figs. 1-6, 8-14; and pl. 31, figs. 1-7] = *Olenellus reticulatus*
- Olenellus thompsoni Billings [1865, p. 11] = *Predumias transitans*
- Olenellus thompsoni Cole [1892, p. 343] = *Olenellus thompsoni*
- Olenellus thompsoni Ford [1881, fig. 12, p. 258] = *Olenellus thompsoni*
- Olenellus thompsoni Frech [1897, pl. 1a, fig. 7] = *Olenellus thompsoni*
- Olenellus thompsoni Hall [1862b, p. 114] = *Olenellus thompsoni*
- Olenellus thompsoni Holm [1887, p. 514] = *Olenellus thompsoni*
- Olenellus thompsoni Lesley [1886, p. 491, 3 text figs.] = *Olenellus thompsoni*
- Olenellus thompsoni Lindström [1901, p. 12] = *Olenellus thompsoni*
- Olenellus thompsoni Moberg [1899, pp. 314 and 317, pl. 13, fig. 2] = *Olenellus thompsoni*
- Olenellus thompsoni Walcott [1886, pp. 167-168, pl. 17, fig. 1] = *Olenellus thompsoni crassimarginatus*
- Olenellus thompsoni Walcott [1886, pp. 167-168, pl. 17, figs. 2, 4, and 9; pl. 22, fig. 1; and pl. 23, fig. 1] = *Olenellus thompsoni*
- Olenellus thompsoni Walcott [1891a, pl. 82, figs. 1 and 1a; and pl. 83, figs. 1 and 1a] = *Olenellus thompsoni*
- Olenellus thompsoni Walcott [1891a, pl. 83, fig. 1b] = *Olenellus thompsoni crassimarginatus*
- Olenellus thompsoni ? Weller [1900, pp. 49-51, pl. 1, figs. 9-10] = *Predumias transitans*
- Olenellus thompsoni Whitfield [1884, pp. 151-153, pl. 15, fig. 1] = *Predumias transitans*
- Olenellus thompsoni crassimarginatus Walcott (new) = *Olenellus thompsoni crassimarginatus*

LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MESONACIDÆ, AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH—Cont'd

Olenellus torelli Moberg [1892, p. 3].	== Mesonacis torelli
Olenellus vermontana Billings [1865, p. 11].	== Mesonacis vermontana
Olenellus vermontana Hall [1862b, p. 114].	== Mesonacis vermontana
Olenellus vermontana Whitfield [1884, pp. 152-153, pl. 15, figs. 2-4].	== Pedeumias transitans
Olenellus vermontanus Ford [1881, fig. 13, p. 258].	== Mesonacis vermontana
Olenellus vermontanus Holm [1887, pp. 515-516].	== Mesonacis vermontana
Olenellus walcottii Walcott [1891a, pp. 636-637, pl. 88, fig. 2].	== Olenellus ?? walcottii
Olenellus walcottii Grabau [1900, p. 669].	== Olenellus ?? walcottii
Olenellus sp. Burr [1900, p. 45].	== Callavia burri
Olenellus sp. Grabau [1900, pp. 665-667, pl. 34, figs. 1a-b].	== Callavia burri
Olenellus sp. Moberg [1892, p. 4].	== Olenellus ?, sp. undt.
Olenellus ? sp. n. Moberg [1899, pp. 338-339, pl. 15, figs. 18-19].	== Olenellus ?, sp. undt.
Olenellus ? sp. undt. Walcott (new).	== Olenellus ?, sp. undt.
Olenellus (Eliiptocephalus) Ford [1877, pp. 265-272].	== Eliiptocephala
Olenellus (Eliiptocephalus) asaphoides Ford [1877, pp. 265-272, pl. 4, figs. 1-10].	== Eliiptocephala asaphoides
Olenellus (Georgiellus) Pompeckj [1901, p. 16].	== Eliiptocephala
Olenellus (Georgiellus) asaphoides Pompeckj [1901, p. 16].	== Eliiptocephala asaphoides
Olenellus (Holmia) Cole [1892, fig. 3, p. 343].	== Holmia
Olenellus (Holmia) bröggeri Burr [1900, pp. 43-44].	== Callavia crosbyi
Olenellus (Holmia) bröggeri Grabau [1900, pp. 662-664, pl. 33, figs. 1a-j].	== Callavia crosbyi
Olenellus (Holmia) bröggeri Pompeckj [1901, pl. 1, fig. 10].	== Callavia bröggeri
Olenellus (Holmia) bröggeri Walcott [1891a, pp. 638-640, pl. 91, fig. 1; pl. 92, figs. 1, 1a-h].	== Callavia bröggeri
Olenellus (Holmia) calveii Walcott [1891a, p. 635].	== Callavia callavei
Olenellus (Holmia) callavei Cole [1892, pp. 344 and 345].	== Callavia callavei
Olenellus (Holmia) callavei Lapworth [1891b, pp. 530-536, pl. 14, figs. 1-25, and pl. 15].	== Callavia callavei
Olenellus (Holmia ?) cartlandi Raw [1909, MS].	== Callavia cartlandi
Olenellus (Holmia) kjerulfi Cole [1892, p. 343, fig. 3].	== Holmia kjerulfi

- Olenellus (Holmia) kjerulfi Frech [1897, pl. 1a, fig. 13]..... = Holmia kjerulfi
 Olenellus (Holmia) kjerulfi Walcott [1891a, p. 635, pl. 86, fig. 2, and pl. 93, fig. 21]..... = Holmia kjerulfi
 Olenellus (Holmia) walcottianus Wanner [1901, pp. 267-269, pl. 31, figs. 1 and 2; pl. 32, figs. 1-4]. = Wanneria walcottianus
 Olenellus (Mesonacis) Cole [1892, fig. 3, p. 343]..... = Mesonacis
 Olenellus (Mesonacis) Walcott [1891a, p. 637]..... = Elliptocephala (in part) and Mesonacis (in part)
 Olenellus (Mesonacis) asaphoides Beecher [1895, p. 176, figs. 6-8, p. 175]..... = Elliptocephala asaphoides
 Olenellus (Mesonacis) asaphoides Burr [1900, p. 45]..... = Callavia crosbyi
 Olenellus (Mesonacis) asaphoides ? Grabau [1900, pp. 667-669, pl. 34, figs. 2a-b]..... = Callavia crosbyi
 Olenellus (Mesonacis) asaphoides Walcott [1890, p. 41]..... = Elliptocephala asaphoides
 Olenellus (Mesonacis) asaphoides Walcott [1891a, pp. 637-638, pl. 86, figs. 3, 3a-b; pl. 88, figs. 1, 1a-g; pl. 89, figs. 1 and 1a; and pl. 90, figs. 1 and 1a]..... = Elliptocephala asaphoides
 Olenellus (Mesonacis) asaphoides Clarke and Ruedemann [1903, pp. 730-732]..... = Elliptocephala asaphoides
 Olenellus (Mesonacis) bröggeri Walcott [1889, pp. 378-380]..... = Callavia bröggeri
 Olenellus (Mesonacis) bröggeri Walcott [1890, p. 41]..... = Callavia bröggeri
 Olenellus (Mesonacis) mickwitzi Frech [1897, pl. 1a, fig. 81]..... = Mesonacis mickwitzi
 Olenellus (Mesonacis) mickwitzi Walcott [1891a, p. 634, pl. 93, fig. 1]..... = Mesonacis mickwitzi
 Olenellus (Mesonacis) vermontana Cole [1892, p. 340 and 341, fig. 2, p. 343]..... = Mesonacis vermontana
 Olenellus (Mesonacis) vermontana Walcott [1891a, p. 637, pl. 87, figs. 1, 1a-b]..... = Mesonacis vermontana
 Olenellus (Olenelloides) Peach [1894, pp. 668-669 and 671-674]..... = Olenelloides
 Olenellus (Olenelloides) armatus Peach [1894, pp. 669-670, pl. 32, figs. 1-6]..... = Olenelloides armatus
 Olenellus (Olenus) asaphoides Ford [1871a, p. 33]..... = Elliptocephala asaphoides
 Olenellus (Olenus) asaphoides Ford [1871b, p. 210]..... = Elliptocephala asaphoides
 Olenus Hall [1847, p. 256, footnote]..... = Elliptocephala
 Olenus Hall [1859a, p. 59]..... = Olenellus
 Olenus Hall [1859b, p. 525]..... = Olenellus
 Olenus asaphoides Fitch [1849, p. 865]..... = Elliptocephala asaphoides
 Olenus asaphoides Hall [1847, pp. 256-257, pl. 67, figs. 2a-c]..... = Elliptocephala asaphoides
 (Olenus) asaphoides [Olenellus] Ford [1871a, p. 33]..... = Elliptocephala asaphoides
 (Olenus) asaphoides [Olenellus] Ford [1871b, p. 210]..... = Elliptocephala asaphoides

LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MIESONACIDÆ, AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH—Cont'd

Olenus thompsoni Hall [1859a, p. 59, fig. 1, p. 60].....	= Olenellus thompsoni
Olenus thompsoni Hall [1859b, pp. 525-526, fig., p. 526].....	= Olenellus thompsoni
Olenus vermontana Hall [1859a, pp. 60-61, fig. 2, p. 60].....	= Mesonacis vermontana
Olenus vermontana Hall [1859b, p. 527, text fig.].....	= Mesonacis vermontana
Olenus (Olenellus) gilberti Gilbert [1875, pp. 182-183].....	= Olenellus gilberti
Olenus (Olenellus) howelli Gilbert [1875, p. 183].....	= Olenellus gilberti
Prædeumias Walcott (new).....	= Prædeumias
Prædeumias transitans Walcott (new).....	= Prædeumias transitans
Paradoxides Emmons [1860, p. 88].....	= Olenellus
Paradoxides Ford [1878, p. 130, footnote].....	= Holmia (in part) and Elliptocephala (in part)
Paradoxides asaphoides Barrande [1861, pp. 273-276, pl. 5, figs. 4-5].....	= Elliptocephala asaphoides
Paradoxides asaphoides Emmons [1860, p. 87, legend of fig. 70].....	= Olenellus thompsoni
(Paradoxides) asaphoides [Elliptocephalus] Emmons [1860, p. 280].....	= Olenellus thompsoni
Paradoxides brachycephalus Emmons [1860, first edition, p. 87].....	= Olenellus thompsoni
Paradoxides kjerulfi Ford [1878, p. 130, footnote].....	= Holmia kjerulfi
Paradoxides ? kjerulfi Ford [1881, pp. 255-258, fig. 10, p. 256].....	= Holmia kjerulfi
Paradoxides kjerulfi Kjerulf [1873, p. 83, figs. 1-5].....	= Holmia kjerulfi
Paradoxides kjerulfi Linnarsson [1871, pp. 790-792, pl. 16, figs. 1-3].....	= Holmia kjerulfi
Paradoxides kjerulfi Walcott [1886, p. 178, pl. 20, fig. 2].....	= Holmia kjerulfi
Paradoxides macrocephalus Barrande [1861, pp. 276-277, pl. 5, fig. 7].....	= Olenellus thompsoni
Paradoxides macrocephalus Emmons [1860, p. 87 and p. 280].....	= Olenellus thompsoni
Paradoxides thompsoni Barrande [1861, p. 276, pl. 5, fig. 6].....	= Olenellus thompsoni
Paradoxides thompsoni Billings [1861, p. 11].....	= Prædeumias transitans
Paradoxides thompsoni Emmons [1860, p. 280].....	= Olenellus thompsoni
Paradoxides vermontana Barrande [1861, pp. 277-278, pl. 5, fig. 8].....	= Mesonacis vermontana
Paradoxides vermontana Billings [1861, p. 11].....	may = Mesonacis vermontana

- Paradoxides vermonti Emmons [1866, p. 280, note A]. = Mesonacis vermontana
 Paradoxides walcotti Shaler and Foerste [1888, pp. 36-37, pl. 2, fig. 12]. = Olenellus ? ? walcotti
 Paradoxides (Gen. ?) kjerulfi Matthew [1888, pp. 75-76]. = Holmia kjerulfi
 Peachella Walcott (new) = Peachella
 reticulatus [Olenellus] Peach [1894, pp. 665-666, text fig. A, p. 673; pl. 30, figs. 1-6, 8-14; and
 pl. 31, figs. 1-7].
 rowei [Holmia] Walcott [1908c, p. 186, 1d and 2] of section]. = Olenellus reticulatus
 rowei [Holmia] Walcott [1908c, pp. 187 and 188, 3 of section]. = not specifically identified
 rowei [Holmia] Walcott [1908c, p. 189, 3 of section]. = Wanneria ? gracile
 reticulatus [Olenellus] Walcott [1908c, p. 189, 3 of section]. = Olenellus argenteus (in part) and
 Olenellus gilberti (in part)
 rowei [Holmia] Walcott [1908c, p. 189, 12 of section]. = Holmia rowei
 Schmidtia Bals-Criv = Protozoan
 Schmidtia Moberg [1899, p. 319 and footnote]. = Mesonacis
 Schmidtia Volborth [1860]. = Brachiopod
 (Schmidtia) [Eliptocephalus] Marcou [1899, p. 363]. = Mesonacis (in part) and Zaccan-
 thoides (in part)
 Schmidtia mickwitzi Moberg [1899, pp. 319-320, pl. 13, figs. 5a-c]. = Mesonacis mickwitzi
 (Schmidtia) mickwitzi [Eliptocephalus] Marcou [1899, p. 363]. = Mesonacis mickwitzi
 Schmidtia ? torelli Moberg [1899, pp. 330-338, pl. 15, figs. 1-17]. = Mesonacis mickwitzi
 (Schmidtia) vermontana [Eliptocephalus] Marcou [1899, p. 363]. = Mesonacis torelli
 Schmidtiellus Moberg, Moberg and Segerberg [1906, p. 35, footnote]. = Mesonacis vermontana
 Schmidtiellus mickwitzi Moberg, Moberg and Segerberg [1906, p. 35, footnote]. = Mesonacis
 thompsoni [Barrandia] Hall [1866, pp. 115-116, fig., p. 116]. = Mesonacis mickwitzi
 thompsoni [Barrandia] Hall [1861, pp. 369-370]. = Olenellus thompsoni
 thompsoni [Barrandia] Hall [1862a, pl. 13, fig. 1]. = Olenellus thompsoni
 thompsoni [Eliptocephala] Miller [1889, p. 546, fig. 1003]. = Olenellus thompsoni
 thompsoni [Olenellus] Billings [1865, p. 11]. = Olenellus thompsoni
 thompsoni [Olenellus] Cole [1892, p. 343]. = Pædeumias transitanis
 thompsoni [Olenellus] Ford [1881, fig. 12, p. 258]. = Olenellus thompsoni
 thompsoni [Olenellus] Frech [1897, pl. 1a, fig. 71]. = Olenellus thompsoni
 thompsoni [Olenellus] Hall [1862b, p. 114]. = Olenellus thompsoni

LIST (ARRANGED BY GENERA, SUBGENERA, AND SPECIES) OF THE FORMS NOW PLACED IN THE MESONACIDÆ, AS THEY OCCUR IN THE LITERATURE, WITH THE PRESENT REFERENCE OF EACH—Cont'd

thompsoni [Olenellus] Holm [1887, p. 514].....	= Olenellus thompsoni
thompsoni [Olenellus] Lesley [1889, p. 491, 3 text figs.].....	= Olenellus thompsoni
thompsoni [Olenellus] Lindström [1901, p. 121].....	= Olenellus thompsoni
thompsoni [Olenellus] Moberg [1899, pp. 314 and 317, pl. 13, fig. 2].....	= Olenellus thompsoni
thompsoni [Olenellus] Walcott [1886, pp. 167-168, pl. 17, fig. 1].....	= Olenellus thompsoni crassimarginatus
thompsoni [Olenellus] Walcott [1886, pp. 167-168, pl. 17, figs. 2, 4, and 9; pl. 22, fig. 1; and pl. 23, fig. 1].....	= Olenellus thompsoni
thompsoni [Olenellus] Walcott [1891a, pl. 82, figs. 1 and 1a; and pl. 83, figs. 1 and 1a].....	= Olenellus thompsoni
thompsoni [Olenellus] Walcott [1891a, pl. 83, fig. 1b].....	= Olenellus thompsoni crassimarginatus
thompsoni ? [Olenellus] Weller [1900, pp. 49-51, pl. 1, figs. 9-10].....	= Pædeumias transitans
thompsoni [Olenellus] Whitfield [1884, pp. 151-153, pl. 15, fig. 1].....	= Pædeumias transitans
thompsoni [Olenus] Hall [1859a, p. 59, fig. 1, p. 60].....	= Olenellus thompsoni
thompsoni [Olenus] Hall [1859b, pp. 525-526, fig., p. 526].....	= Olenellus thompsoni
thompsoni [Paradoxides] Barrande [1861, p. 276, pl. 5, fig. 6].....	= Olenellus thompsoni
thompsoni [Paradoxides] Billings [1861, p. 11].....	= Pædeumias transitans
thompsoni [Paradoxides] Emmons [1860, p. 280].....	= Olenellus thompsoni
thompsoni crassimarginatus [Olenellus] Walcott (new).....	= Olenellus thompsoni crassimarginatus
torelli [Olenellus] Moberg [1892, p. 31].....	= Mesonacis torelli
torelli [Schmidtia ?] Moberg [1899, pp. 330-338, pl. 15, figs. 1-17].....	= Mesonacis torelli
transitans [Pædeumias] Walcott (new).....	= Pædeumias transitans
vermontana [Barrandia] Hall [1860, p. 117, text fig.].....	= Mesonacis vermontana
vermontana [Barrandia] Hall [1861, p. 370].....	= Mesonacis vermontana (in part) and Pædeumias transitans (in part)

vermontana [Barrandia] Hall [1862a, pl. 13, fig. 2].	== Mesonacis vermontana
vermontana [Barrandia] Hall [1862a, pl. 13, figs. 4 and 5].	== Pedeumias transians
vermontana [Eliptocephalus (Schmidtia)] Marcou [1890, p. 363].	== Mesonacis vermontana
vermontana [Mesonacis] Moberg [1899, p. 318, pl. 13, fig. 4].	== Mesonacis vermontana
vermontana [Olenellus] Billings [1865, p. 11].	== Mesonacis vermontana
vermontana [Olenellus] Hall [1862b, p. 114].	== Mesonacis vermontana
vermontana [Olenellus] Whitfield [1884, pp. 152-153, pl. 15, figs. 2-4].	== Pedeumias transians
vermontana [Olenellus (Mesonacis)] Cole [1892, p. 340 and 341, fig. 2, p. 343].	== Mesonacis vermontana
vermontana [Olenellus (Mesonacis)] Walcott [1891a, p. 637, pl. 87, figs. 1, 1a-b].	== Mesonacis vermontana
vermontana [Olenus] Hall [1859a, pp. 60-61, fig. 2, p. 60].	== Mesonacis vermontana
vermontana [Olenus] Hall [1859b, p. 527, text fig. 1].	== Mesonacis vermontana
vermontana [Paradoxides] Barrande [1861, pp. 277-278, pl. 5, fig. 8].	== Mesonacis vermontana
vermontana [Paradoxides] Billings [1861, p. 11].	== Mesonacis vermontana
vermontanus [Mesonacis] Walcott [1885, pp. 328-330, figs. 1 and 2, p. 329].	== Mesonacis vermontana
vermontanus [Mesonacis] Walcott [1886, pp. 158-162, pl. 24, figs. 1, 1a-b].	== Mesonacis vermontana
vermontanus [Olenellus] Ford [1881, fig. 13, p. 258].	== Mesonacis vermontana
vermontanus [Olenellus] Holm [1887, pp. 515-516].	== Mesonacis vermontana
vermonti [Paradoxides] Emmons [1860, p. 280, note A].	== Mesonacis vermontana
walcottanus [Olenellus (Holmia)] Wanner [1901, pp. 267-269, pl. 31, figs. 1 and 2; pl. 32, figs. 1-4].	== Wanneria walcottanus
walcotti [Olenellus] Grabau [1900, p. 669].	== Olenellus ?? walcotti
walcotti [Olenellus] Walcott [1891a, pp. 636-637, pl. 88, fig. 2].	== Olenellus ?? walcotti
walcotti [Paradoxides] Shaler and Foerste [1888, pp. 36-37, pl. 2, fig. 12].	== Olenellus ?? walcotti
Wanneria Walcott (new).	== Wanneria
Wanneria ? gracile Walcott (new).	== Wanneria ? gracile
Wanneria halli Walcott (new).	== Wanneria halli
weeksii [Holmia] Walcott [1908c, p. 187, 2] of section].	== Olenellus fremonti
weeksii [Holmia] Walcott [1908c, p. 189, 3 of section].	== Wanneria ? gracile
weeksii [Holmia] Walcott [1908c, p. 189, 6 of section].	== Olenellus fremonti
weeksii [Holmia] Walcott [1908c, p. 189, 11 of section].	== not specifically identified
weeksii [Holmia] Walcott [1908c, p. 189, 12 of section].	== Nevadia weeksii
weeksii [Nevadia] Walcott (new).	== Nevadia weeksii

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DESCRIPTION OF PLATE 23

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<i>Nevadia weeksi</i> , new genus and new species (See pl. 44)	257

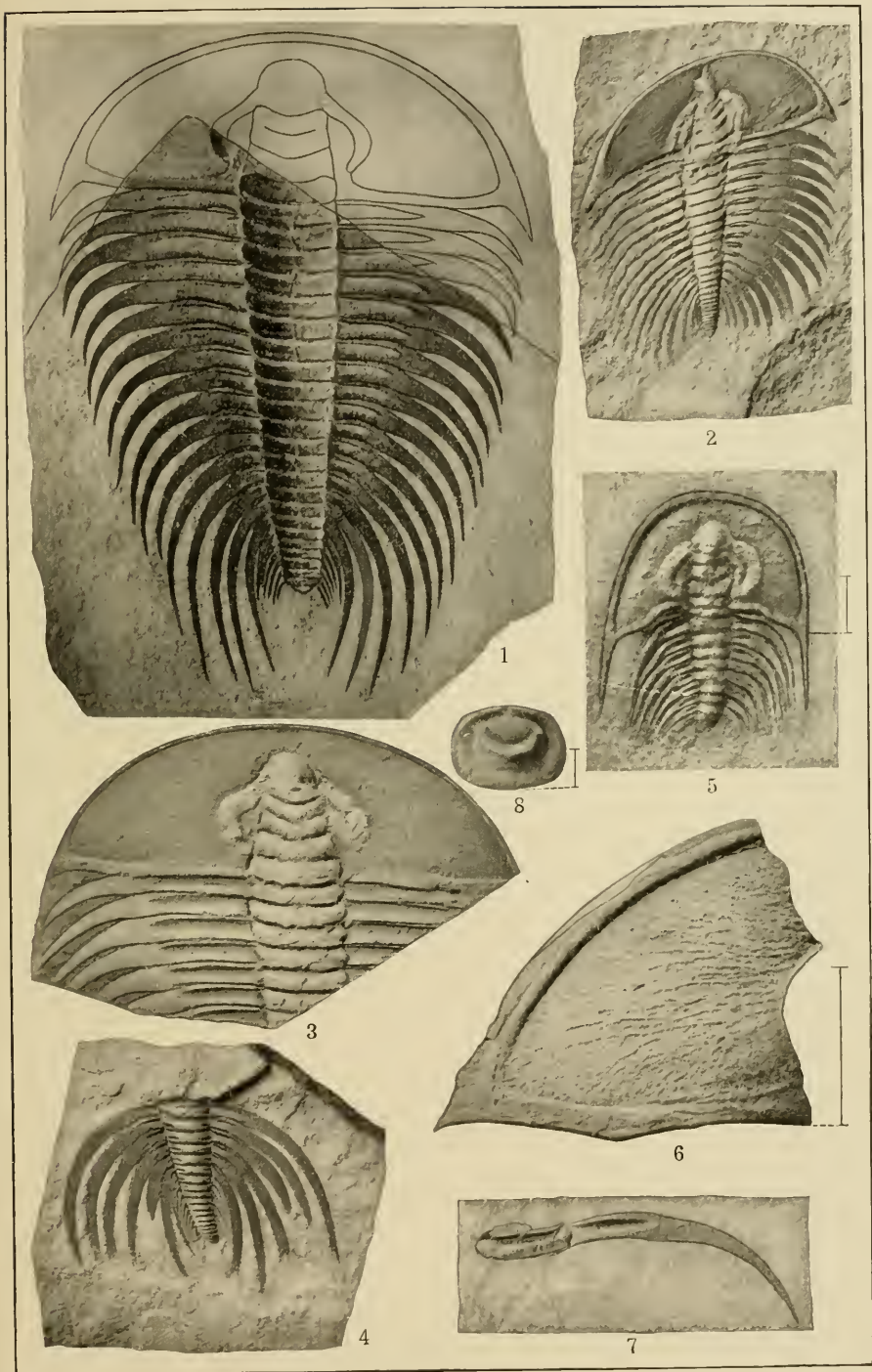
FIG. 1. A large specimen of the dorsal shield preserving nearly the entire thorax and a portion of the cephalon. The cephalon has been restored in outline from specimens represented by figs. 2 and 3. Two-thirds natural size. U. S. National Museum, Catalogue No. 56792a.

2. A nearly perfect individual showing fifteen thoracic segments in the anterior portion of the thorax and eleven in the posterior portion. Natural size. U. S. National Museum, Catalogue No. 56792b.

The difference between the posterior portion and anterior portion of the thoracic segments is also shown by fig. 4.

3. A specimen that has been slightly distorted by compression, showing the cephalon and a few thoracic segments. Natural size. U. S. National Museum, Catalogue No. 56792c.
4. Posterior portion of the thorax. This shows five segments of the anterior portion and ten segments of the posterior portion of the thorax. Natural size. U. S. National Museum, Catalogue No. 56792d.
5. Cephalon and portion of the thorax. $\times 4$. This represents the smallest specimen found of this species. U. S. National Museum, Catalogue No. 56792e.
6. Enlargement of the lateral cheeks of a cephalon between the eye and the outer anterior and posterior borders. This illustrates very perfectly the venation extending outward from the base of the eye lobe. $\times 2$. U. S. National Museum, Catalogue No. 56792f.
7. Portion of a thoracic segment illustrating the central axis, the pleural lobes and extension. Natural size. U. S. National Museum, Catalogue No. 56792g.
8. Pygidium ($\times 2$) that is associated with specimens of this species and *Holmia rowei* [pl. 29]. U. S. National Museum, Catalogue No. 56792h.

The specimens represented by figs. 1-8 are from locality (1f), 16 miles south of Silver Peak, Nevada.



LOWER CAMBRIAN TRILOBITES

DESCRIPTION OF PLATE 24

Elliptocephala usaphoides Emmons (See pls. 25 and 44)..... 269

PAGE

FIG. 1. A nearly entire specimen from the type locality (35*b*), one mile west of North Greenwich, Washington County, New York. The spines on the five posterior thoracic segments have been restored from another specimen. Two-thirds natural size. U. S. National Museum, Catalogue No. 18350*a*.

2. Pygidium and seven posterior thoracic segments of the specimen represented by fig. 1 but without the five dorsal spines. Natural size. U. S. National Museum, Catalogue No. 18350*a*.

Figs. 1 and 2 are copied from Walcott, 1891*a*, pl. 89, figs. 1 and 1*a*.

3. A small, nearly entire dorsal shield with the third thoracic segment prolonged into long spines. $\times 4$. Collection New York State Museum, Albany.

4. A dorsal shield 8 mm. in length with 13 segments. Whether the last segment (?) is the pygidium or a turned in segment cannot be determined. $\times 3$. Collection New York State Museum, Albany.

5. Cephalon and 13 segments of young individual in which the third thoracic segment is not prolonged beyond the others. $\times 2$. The glabella is broadened and the entire cephalon shortened by compression and crushing. Collection New York State Museum, Albany.

Figures 3, 4, and 5 are copied from Walcott, 1891*a*, pl. 88, figs. 1*b*, 1*c*, and 1*d*, respectively.

6. Cephalon 5 mm. in length that was used as the base for fig. 1*f*, pl. 88 of Walcott [1891*a*]. $\times 2$. Restored to the right of the line crossing the drawing. Locality (38) near South Granville, Washington County, New York. U. S. National Museum, Catalogue No. 15413*a*.

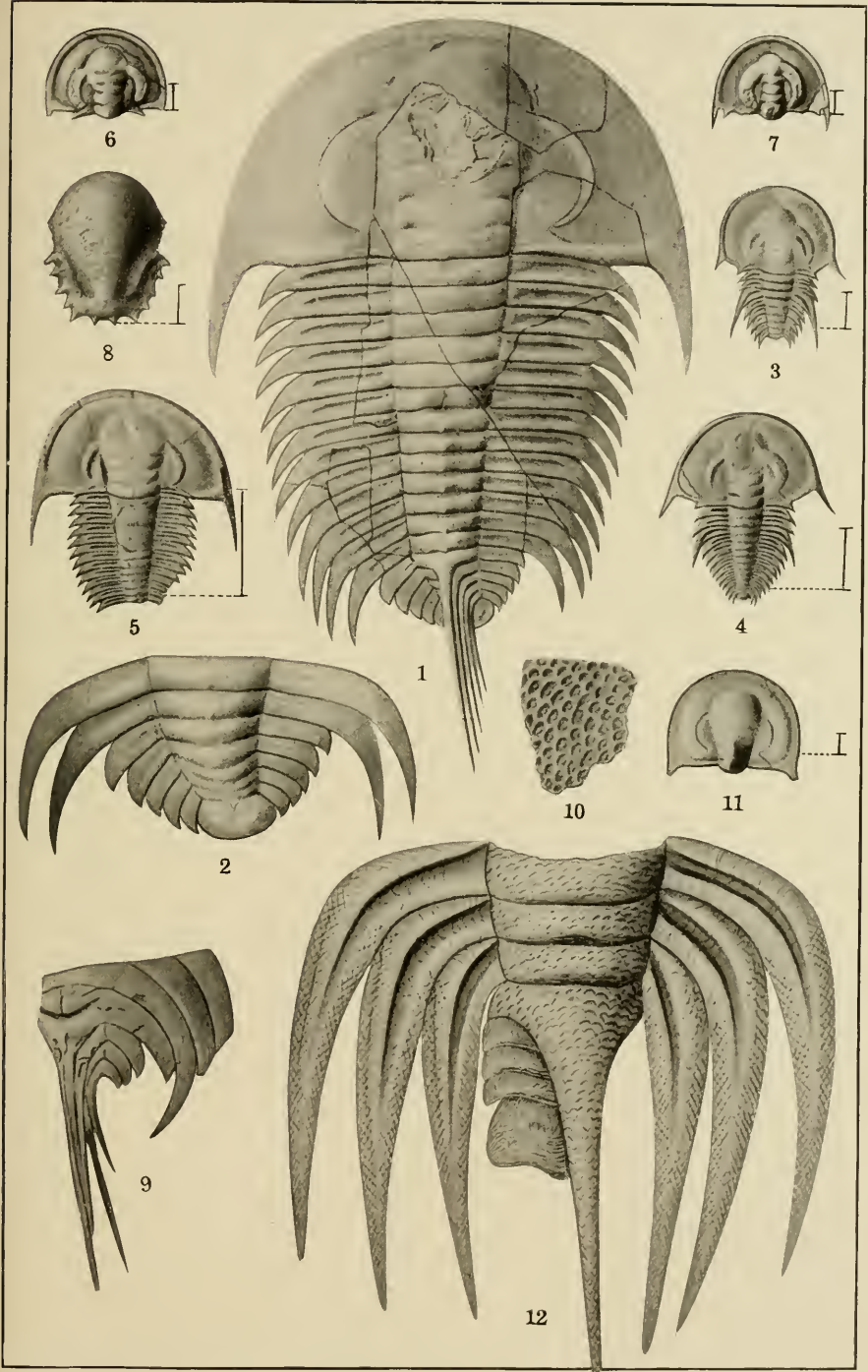
7. A cephalon 3 mm. in length with glabella much like that of fig. 6. $\times 3$. Locality (38*a*), near North Granville, Washington County, New York. U. S. National Museum, Catalogue No. 15413*b*.

8. Form of hypostoma associated with this species at several localities. $\times 4$. This specimen is from locality (33), in the township of Greenwich, Washington County, New York. U. S. National Museum, Catalogue No. 15413*c*.

Figure 8 is drawn from the specimen illustrated by Walcott, 1891*a*, pl. 88, fig. 1*g*.

9. A fragment preserving four of the posterior spine bearing thoracic segments. Natural size. Locality (35*b*), near North Greenwich, Washington County, New York. U. S. National Museum, Catalogue No. 18350*b*.

This figure is copied from Walcott, 1891*a*, pl. 90, fig. 1*a*.



LOWER CAMBRIAN TRILOBITES

- Elliptocephala asaphoides* Emmons (continued) : PAGE
10. Enlargement of the reticulated surface of a portion of the outer cheek of an old and large individual. $\times 6$. Locality (27), near Troy, Rensselaer County, New York. U. S. National Museum, Catalogue No. 15413*d*.
Figure 10 is copied from Walcott, 1886, pl. 25, fig. 8.
- Olenellus* ?? *walcotti* (Shaler and Foerste)..... 341
- FIG. 11. Type specimen from locality (326*d*) at North Attleborough, Massachusetts. The glabella is crushed so as to make it narrow at the base.
This specimen was first figured by Shaler and Foerste, 1888, pl. 2, fig. 12; it is redrawn in fig. 11 of this paper.
- Pædumias transitans*, new genus and new species (See pls. 25, 32, 33, 34, 41, and 44)..... 304
- FIG. 12. Enlargement of the seven posterior segments and pygidium of the specimen represented by fig. 1, pl. 33. This clearly shows the difference in the surface sculpture of the *Olenellus* thoracic segments and that of the three *Pædumias* rudimentary segments and pygidium. $\times 3$. U. S. National Museum, Catalogue No. 56808*a*.

DESCRIPTION OF PLATE 25

PAGE

Elliptocephala asaphoides Emmons (See pls. 24 and 44)..... 269

- FIG. 1. A young stage (Paraprotaspis) in which the pygidium is outlined and the genal and intergenal spines united. $\times 16$.
2. Cephalon with the genal and intergenal spines slightly separated. $\times 10$.
3. Cephalon with the genal and intergenal spines widely separated but with the genal angles carried slightly forward. $\times 10$. See figs. 3 and 4, pl. 30.
4. Cephalon with transverse posterior margin and normal form of genal spines. $\times 7$.
5. Cephalon with more strongly developed glabella, otherwise much like fig. 4. $\times 7$.
6. Cephalon with short intergenal spines and strongly marked glabella. $\times 5$.
7. Cephalon much like that of fig. 5, but without intergenal spine. $\times 7$.
8. Usual form of fully developed cephalon. $\times 2$.

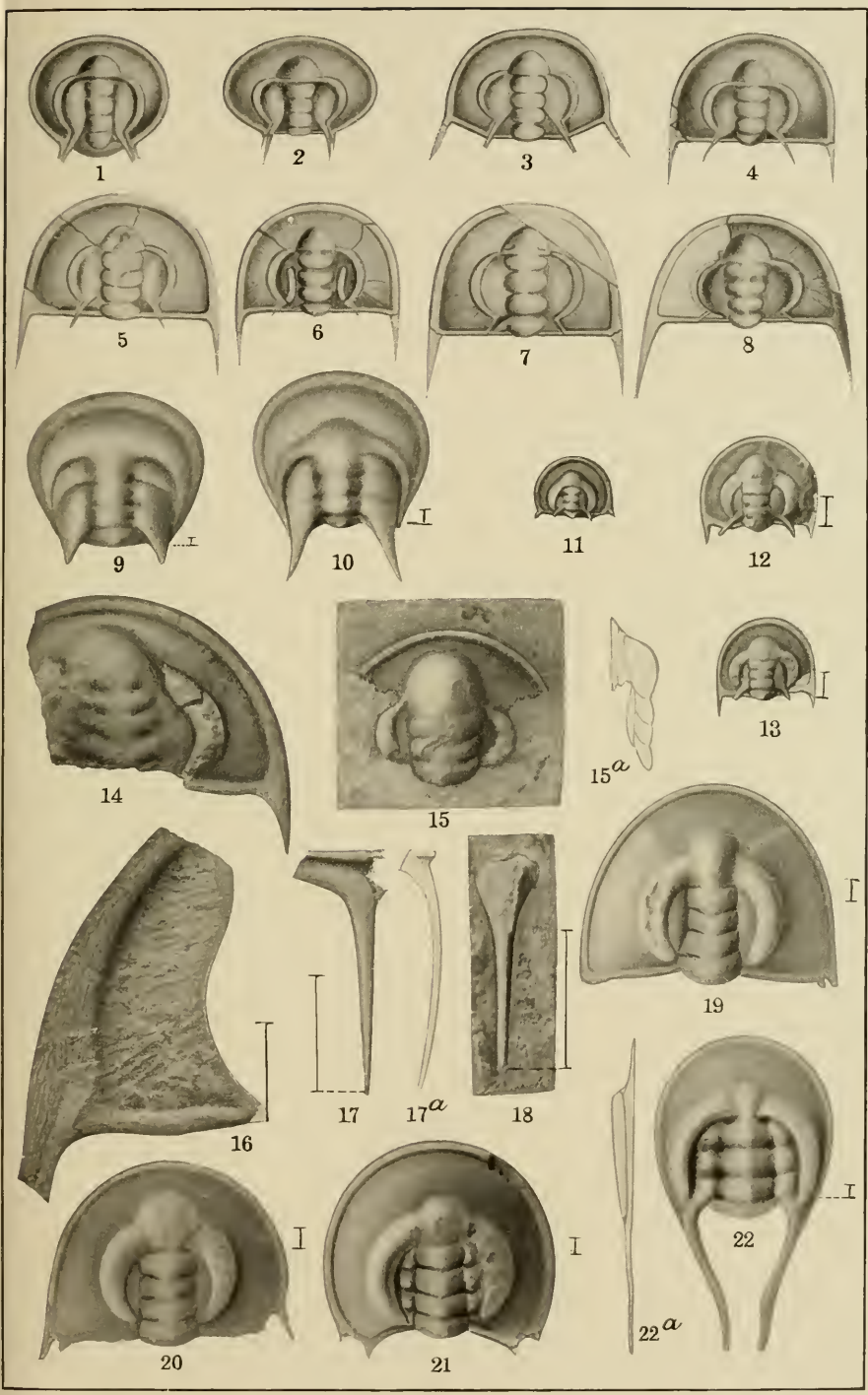
The above described figs. 1 to 8 were drawn for me by Mr. S. W. Ford from material in his collection obtained from the vicinity of the City of Troy, New York. The drawings are somewhat diagrammatic, but they serve to illustrate progressive development of the form of the cephalon. The Ford collection is now at the New York State Museum in Albany.

Our fig. 9 represents a somewhat younger stage than Ford's fig. 1; fig. 10 corresponds to Ford's fig. 2.

9. The youngest stage (Paraprotaspis) of growth of this species observed. $\times 25$. Length four-fifths of one millimeter. U. S. National Museum, Catalogue No. 15413c.
10. A cephalon 1.75 mm. in length. $\times 15$. U. S. National Museum, Catalogue No. 15413f.

Figures 9 and 10 are drawn from the same specimens as those illustrated by Walcott, 1886, pl. 17, figs. 5 and 6, respectively. The specimens are both from locality (27), near Troy, Rensselaer County, New York.

11. A cephalon 2 mm. in length that is slightly more advanced in development than fig. 2. $\times 10$. This cephalon comes in between figs. 2 and 3 of the Ford series. Locality (29a), near Schodack Landing, Rensselaer County, New York. U. S. National Museum, Catalogue No. 15413g.
12. A cephalon 4 mm. in length with glabella expanded toward its anterior lobe. $\times 3$. Compare with fig. 7, pl. 24, which has a very narrow glabella at its anterior lobe. This is about the same stage as fig. 5 of Ford's series. Locality (27), near Troy, Rensselaer County, New York. U. S. National Museum, Catalogue No. 15413h.



Elliptocephala asaphoides Emmons (continued):

PAGE

13. A small convex cephalon. $\times 3$. Locality (38a), near North Granville, Washington County, New York. U. S. National Museum, Catalogue No. 15413i.
14. A large flattened cephalon from the limestone in locality (36), 3.5 miles north of Cambridge, Washington County, New York. This approaches in form the specimens from the shale at Greenwich [pl. 24, fig. 1]. Natural size. U. S. National Museum, Catalogue No. 15413j.
15. Top and side view of a somewhat compressed cephalon in limestone for comparison with the cephalon of fig. 1, pl. 24, which is flattened in the shale. Natural size. Locality (45b), near Low Hampton, Washington County, New York. U. S. National Museum, Catalogue No. 15413k.
16. Marginal borders, base of genal spine, and portion of cheek showing surface markings. $\times 3$. Locality (29a), near Scho-dack Landing, Rensselaer County, New York. U. S. National Museum, Catalogue No. 15414a.
- 17 and 17a. Top and side view of a thoracic spine occurring in limestone. $\times 2$. Locality (38a), North Granville, Washington County, New York. U. S. National Museum, Catalogue No. 15413l.
18. Thoracic spine. $\times 1.5$. From locality (27), near Troy, Rensselaer County, New York. U. S. National Museum, Catalogue No. 15413m.

This spine was illustrated as the telson of this species by Walcott, 1886, pl. 17, fig. 3.

Pædeumias transitans, new genus and new species (See pls. 24, 32, 33, 34, 41, and 44)..... 305

Figs. 19, 20, and 21. Small cephalons showing genal and intergenal spines, cylindrical glabella, large eye lobes, and in fig. 21 the rounding-in of the genal angles. No. 20, $\times 9$; No. 21, $\times 8$; and No. 22, $\times 13$. U. S. National Museum, Catalogue Nos. 56809a, 56809b, and 56809c, respectively.

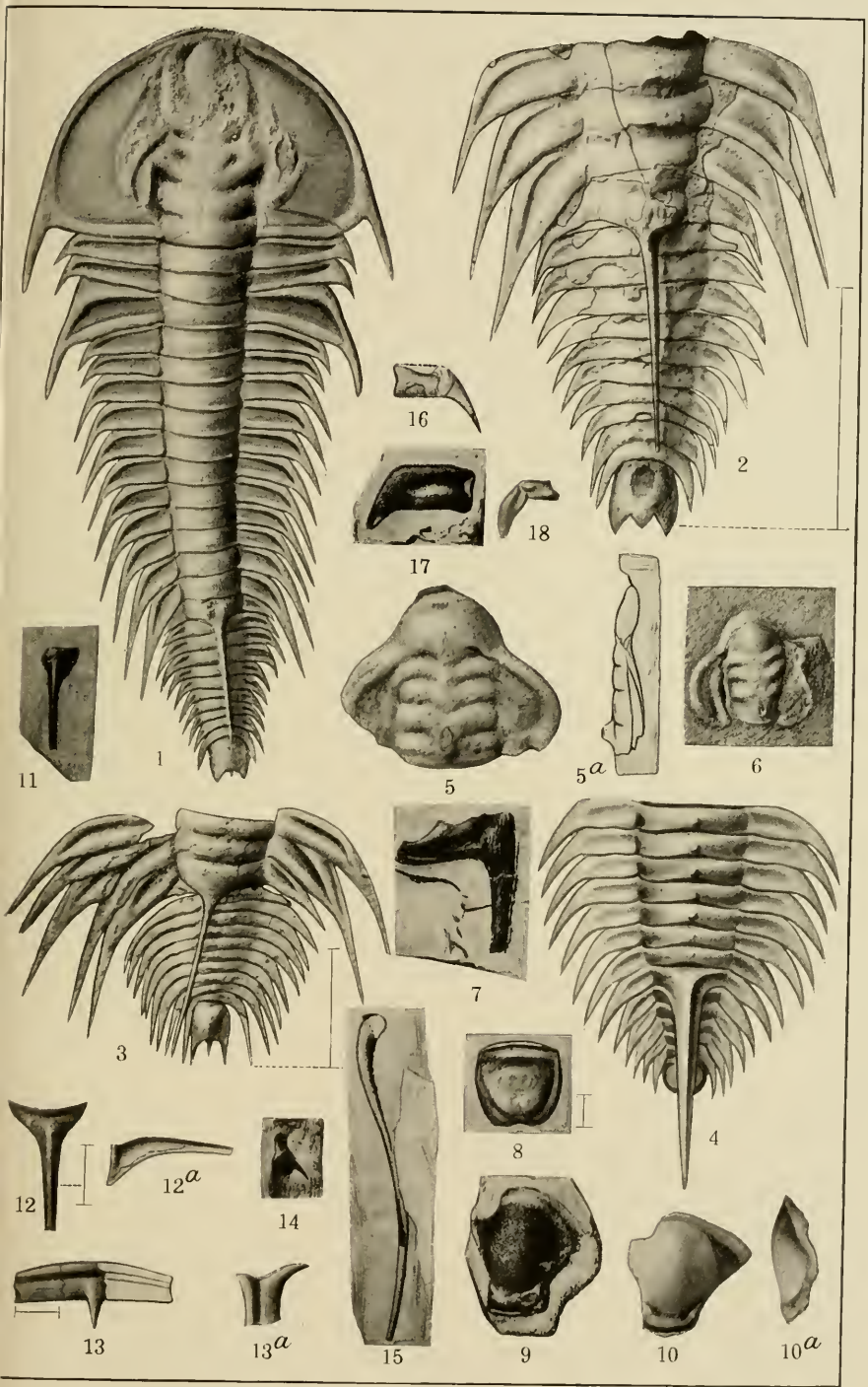
22. Cephalon with strong protaspis characters. The genal and intergenal spines are practically merged into single spines and the frontal lobe of the glabella nearly merged into the eye lobes. $\times 30$. U. S. National Museum, Catalogue No. 56809d.

The genal and intergenal spines in the young cephalons of *Elliptocephala asaphoides* have the same tendency as those of this species [see pl. 25, figs. 9 and 10].

The specimens illustrated by figs. 20-22 are from locality (56c), near Helena, Shelby County, Alabama.

DESCRIPTION OF PLATE 26

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|--|------|
| <i>Mesonacis vermontana</i> (Hall) (See pl. 44)..... | 264 |
| <p>FIG. 1. An entire dorsal shield from the type locality (25) at Georgia, Vermont, showing 14 thoracic segments of the <i>Olenellus</i> type, the spine bearing segment, and ten segments of the <i>Mesonacis</i> type. Natural size. U. S. National Museum, Catalogue No. 15399a.</p> | |
| <p>2. Posterior portion of the specimen represented in fig. 1.
 The specimen represented by figs. 1 and 2 has been figured by Walcott [1885, figs. 1 and 2, p. 329; 1886, pl. 24, figs. 1, 1a-b; and 1891a, pl. 87, figs. 1, 1a-b].</p> | |
| <p>3. Pygidium, ten <i>Mesonacis</i> thoracic segments, the spine bearing, and two <i>Olenellus</i>-like segments, of a broad form of <i>Mesonacis vermontana</i> 6 cm. in length. $\times 2$. This is very much like the posterior portion of fig. 1. Same locality (25) as fig. 1. U. S. National Museum, Catalogue No. 15399b.</p> | |
| <i>Mesonacis</i> ? <i>mickwitzii</i> (Schmidt)..... | 262 |
| <p>FIG. 4. Portion of the thorax with seven segments in advance of the spine bearing segment and five between the latter and the pygidium.
 This figure is a copy of the figure given by Schmidt, 1888, pl. 1, fig. 1, with the exception that the cephalon is not attached as it was theoretically placed there by Schmidt.</p> | |
| <i>Mesonacis torelli</i> (Moberg)..... | 264 |
| <p>FIG. 5. Drawn from a plaster cast of the cephalon figured by Moberg [1899, pl. 15, fig. 1a]. Natural size. The cast is in the U. S. National Museum, Catalogue No. 24631a.</p> | |
| <p>5a. Side view of the specimen represented by fig. 5, showing base of cephalic spine.
 Figure 5a is copied from Moberg, 1899, pl. 15, fig. 1b.</p> | |
| <p>6. Central portions of a cephalon. Natural size. U. S. National Museum, Catalogue No. 56793a.</p> | |
| <p>7. Genal angle and spine. $\times 1.5$.
 Figure 7 is copied from Moberg, 1899, pl. 15, fig. 4.</p> | |
| <p>8. Drawn from a plaster cast of the pygidium figured by Moberg [1899, pl. 15, fig. 14]. $\times 2$. Cast in U. S. National Museum, Catalogue No. 24631b.</p> | |
| <p>9. Hypostoma. $\times 1.5$.
 Figure 9 is copied from Moberg [1899, pl. 15, fig. 6]. The specimen is redrawn in figs. 10 and 10a of this plate.</p> | |
| <p>10 and 10a. Top and side view of a plaster cast of the hypostoma figured by Moberg and copied in fig. 9 of this plate. $\times 1.5$. Cast in U. S. National Museum, Catalogue No. 24631c.</p> | |
| <p>11. Thoracic spine. $\times 1.5$. [After Moberg, 1899, pl. 15, fig. 15.] Cast in U. S. National Museum, Catalogue No. 24631d.</p> | |



LOWER CAMBRIAN TRILOBITES

Mesonacis torelli (Moberg) (continued) :

- 12 and 12a. Thoracic spine, top and side view. $\times 2$. U. S. National Museum, Catalogue No. 56793b.
- 13 and 13a. Fragment of the axial lobe of a thoracic segment with a short, strong, median spine. $\times 2$. U. S. National Museum, Catalogue No. 56793c.
14. Fragment of the axial lobe of a thoracic segment viewed in the same position as that of fig. 13a. [After Moberg, 1899, pl. 15, fig. 12.] Cast in U. S. National Museum, Catalogue No. 24631e.
15. A long spine. $\times 1.5$. [After Moberg, 1899, pl. 15, fig. 16.] Cast in U. S. National Museum, Catalogue No. 24631f.
- 16 and 17. Pleuræ from the anterior portion of the thorax. $\times 1.5$. Figure 16 represents the under side partly concealed by the matrix and fig. 17 the upper or outer side. [After Moberg, 1899, pl. 15, figs. 8 and 7, respectively.]
18. Fragment of a posterior thoracic segment. $\times 1.5$. [After Moberg, 1899, pl. 15, fig. 10.]

All of the specimens represented by figs. 5-18 are from locality (321v), near Bjorkelunda, Sweden.

The originals from which Moberg's figures were drawn are in the collections of the Geological Institution of the University of Lund, Sweden.

DESCRIPTION OF PLATE 27

	PAGE
<i>Callavia bröggeri</i> (Walcott) (See pl. 44)	279

FIG. 1. Restoration of the dorsal shield of this species, based on a large number of partially preserved fragments in the limestone and numerous nearly entire specimens compressed in the shale. The specimens in the limestone show the convexity and those in the shale the general proportion and number of segments. Two-thirds natural size. Locality (41), Conception Bay, Newfoundland. U. S. National Museum, Catalogue No. 18331.

2. Hypostoma in shale attached to the doublure. Natural size. Locality (41), Conception Bay, Newfoundland. U. S. National Museum, Catalogue No. 18331a.

3. Portion of a cheek in limestone with the genal and intergenal spines. Natural size. Locality (42), Conception Bay, Newfoundland. U. S. National Museum, Catalogue No. 18331b.

4. A small, imperfectly preserved convex cephalon in shale. Natural size. Same locality as fig. 2. U. S. National Museum, Catalogue No. 18331c.

5. Fragments of the posterior four thoracic segments and pygidium compressed in the shale. Natural size. Same locality as fig. 2. U. S. National Museum, Catalogue No. 18331d.

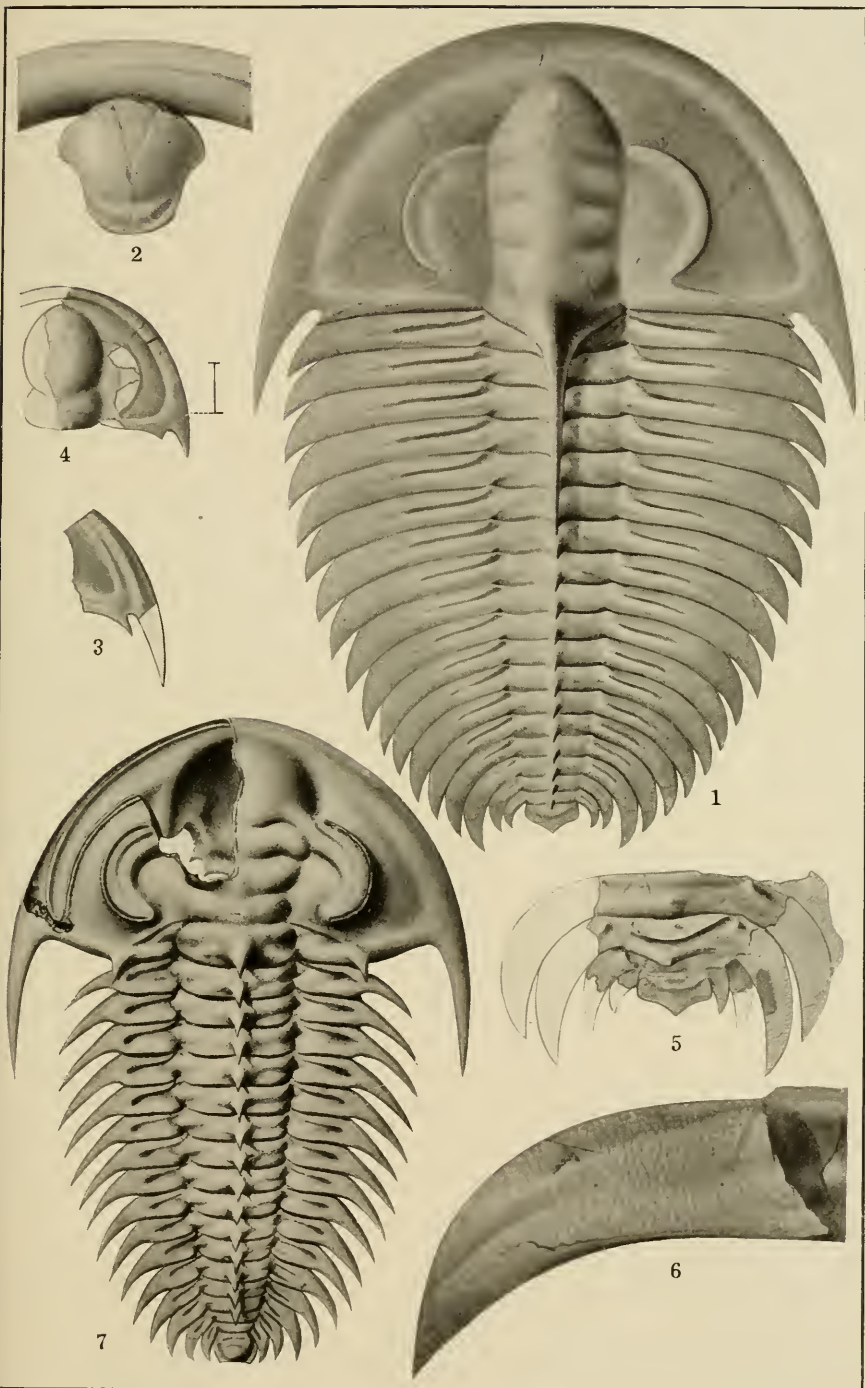
6. Falcate extension of the pleural lobe of a thoracic segment. $\times 2$. Same locality as fig. 2. U. S. National Museum, Catalogue No. 18331e.

Figures 1 to 6 are reproduced from drawings illustrating this species in the Tenth Ann. Report U. S. Geol. Survey. [Walcott, 1891] as follows: fig. 1 = pl. 91, fig. 1; fig. 2 = pl. 92, fig. 1e; fig. 3 = pl. 92, fig. 1h; fig. 4 = pl. 92, fig. 1g; fig. 5 = pl. 92, fig. 1c; fig. 6 = pl. 92, fig. 1d.

<i>Holmia kjerulfi</i> (Linnarsson) (See pl. 44)	288
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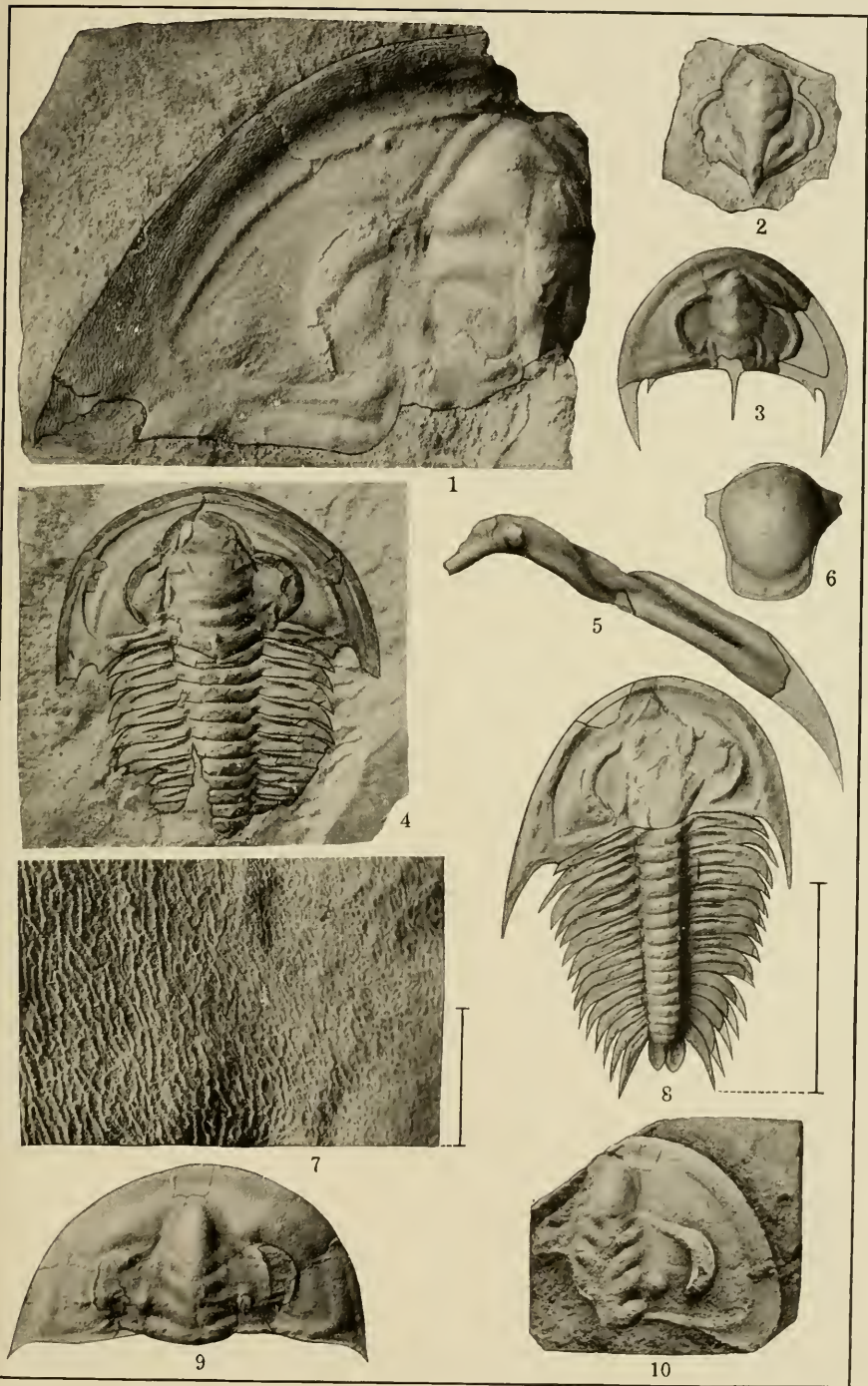
FIG. 7. An entire adult dorsal shield with the glabella cut away so as to show the outline of the hypostoma. $\times 2$.

Figure 7 is copied from Holm, 1887, pl. 14, fig. 2.



DESCRIPTION OF PLATE 28

- | | PAGE |
|---|------|
| <i>Callavia crosbyi</i> , new species..... | 284 |
| <p>FIG. 1. Portion of a large cephalon showing some of the characteristic features of the species. Natural size. U. S. National Museum, Catalogue No. 56798a.</p> | |
| <p>2. Fragments of a cephalon showing an accidental contraction of the posterior portion of the glabella. Natural size. U. S. National Museum, Catalogue No. 56798b.</p> | |
| <p>3. A cephalon preserving the convexity, entire eye lobes and general characters more perfectly than usual, owing to the compression in the matrix of nearly all other specimens. Natural size. U. S. National Museum, Catalogue No. 56798c.</p> | |
| <p>4. A specimen preserving the cephalon and a number of the thoracic segments. Natural size. U. S. National Museum, Catalogue No. 56798d.</p> | |
| <p>5. Portion of a large thoracic segment. Natural size. U. S. National Museum, Catalogue No. 56798e.</p> | |
| <p>6. A partially restored hypostoma. Natural size. U. S. National Museum, Catalogue No. 56798f.</p> | |
| <p>7. Enlargement of highly ornamented surface of the outer border and portion of the side of the cephalon. Natural size. U. S. National Museum, Catalogue No. 56798a.</p> | |
| <p>8. A specimen preserving the cephalon, sixteen segments of the thoracic axis, and a distorted pygidium. $\times 2$. The thoracic axis and pygidium have been compressed from the sides and thus narrowed nearly one-third. U. S. National Museum, Catalogue No. 56798g.</p> | |
| <p style="padding-left: 40px;">The specimens represented by figs. 1-8 are all from locality (9n), near North Weymouth, Massachusetts.</p> | |
| <i>Callavia burri</i> , new species..... | 280 |
| <p>FIG. 9. A very well preserved cephalon in the collection of the Museum of Comparative Zoology, Cambridge, Massachusetts. Natural size. Cast in U. S. National Museum, Catalogue No. 56795a.</p> | |
| <p>10. A portion of a cephalon showing the palpebral lobe, tubercle between the palpebral lobe and glabella and the marginal rim. Natural size. U. S. National Museum, Catalogue No. 56795b.</p> | |
| <p style="padding-left: 40px;">The specimens represented by figs. 9-10 are from locality (9n), near North Weymouth, Massachusetts.</p> | |



LOWER CAMBRIAN TRILOBITES

DESCRIPTION OF PLATE 29

Holmia rowei, new species. PAGE 292

FIGS. 1 and 2. Two flattened specimens of the cephalon showing strong marginal rim, genal spines, and occipital spine. Natural size. U. S. National Museum, Catalogue Nos. 56801a and 56801b, respectively.

3. A nearly entire specimen of the dorsal shield with seventeen thoracic segments, the cephalon, and a portion of the pygidium. Natural size. U. S. National Museum, Catalogue No. 56801c.

4. A portion of the thorax preserving seventeen segments and showing the form of the termination of the segments. $\times 2$. U. S. National Museum, Catalogue No. 56801d.

5. A portion of the cephalon and thorax. Note the very long genal spine. Natural size. U. S. National Museum, Catalogue No. 56801e.

6. A nearly entire cephalon. $\times 2$. U. S. National Museum, Catalogue No. 56801f.

7. Enlargement of a portion of the outer surface of the cheek of the cephalon showing scattered tubercles. $\times 9$. U. S. National Museum, Catalogue No. 56801g.

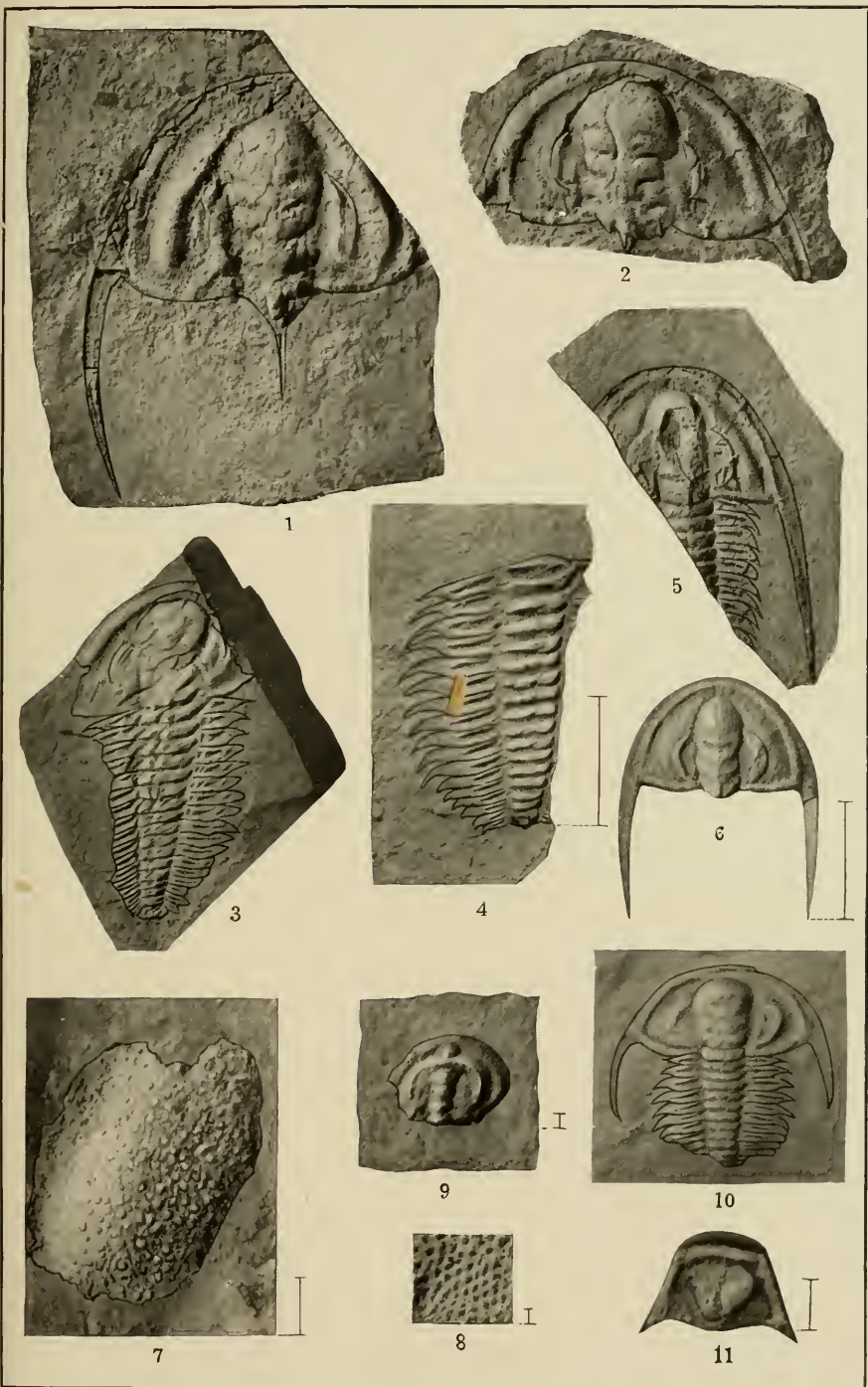
8. Enlargement of a portion of the surface of the cheek on which the reticulated net work formed by narrow ridges is very clearly shown. $\times 12$. U. S. National Museum, Catalogue No. 56801h.

9. Fragment of a minute cephalon showing a young stage of growth. $\times 12$. Compare with young of *Wanneria halli* (pl. 31, figs. 5 and 8), *Elliptocephala asaphoides* (pl. 25, figs. 9 and 10), and *Pædeumias transitans* (pl. 25, fig. 21). U. S. National Museum, Catalogue No. 56801i.

10. A small specimen of the cephalon with a portion of the thorax. Natural size. U. S. National Museum, Catalogue No. 56801j.

11. The only entire pygidium found in the collection. $\times 2$. U. S. National Museum, Catalogue No. 56801k.

All the specimens represented on this plate are from locality (1f), 10 miles south of Silver Peak and three miles northeast of Barrel Spring, Nevada.



LOWER CAMBRIAN TRILOBITES

DESCRIPTION OF PLATE 30

PAGE

Wanneria walcottanus (Wanner) (See pls. 31 and 44) 302

FIG. 1. An entire adult specimen flattened in the shales and with the test largely exfoliated. Natural size. U. S. National Museum, Catalogue No. 56807a.

2. A well preserved flattened cephalon. Natural size. U. S. National Museum, Catalogue No. 56807b.

3 and 4. Small cephalons showing the increase in the size of the eye in the younger stages of growth. Natural size. In *Wanneria halli* (pl. 31) this feature of the cephalon is more fully illustrated. U. S. National Museum, Catalogue Nos. 56807c and 56807d, respectively.

5. Hypostoma crushed and displaced from its true position in relation to the doublure of the cephalon. Natural size. U. S. National Museum, Catalogue No. 56807e.

6. Cast of the under side of the doublure of the cephalon, with casts of the spines along its posterior margin. Natural size. U. S. National Museum, Catalogue No. 56807f.

7. An unusually well preserved hypostoma with six spines on each postero-lateral margin. Natural size. U. S. National Museum, Catalogue No. 56807g.

The specimens represented by figs. 5, 6, and 7 were figured by Wanner [1901, pl. 32, figs. 2, 1, and 3, respectively].

8. Distorted pygidium of an adult individual from near York, Pennsylvania. $\times 3$. U. S. National Museum, Catalogue No. 56807h.

9. Cast of the under side of the genal spine and the doublure. $\times 2$. Note the cast of the small spines on the margin of the doublure. U. S. National Museum, Catalogue No. 56807i.

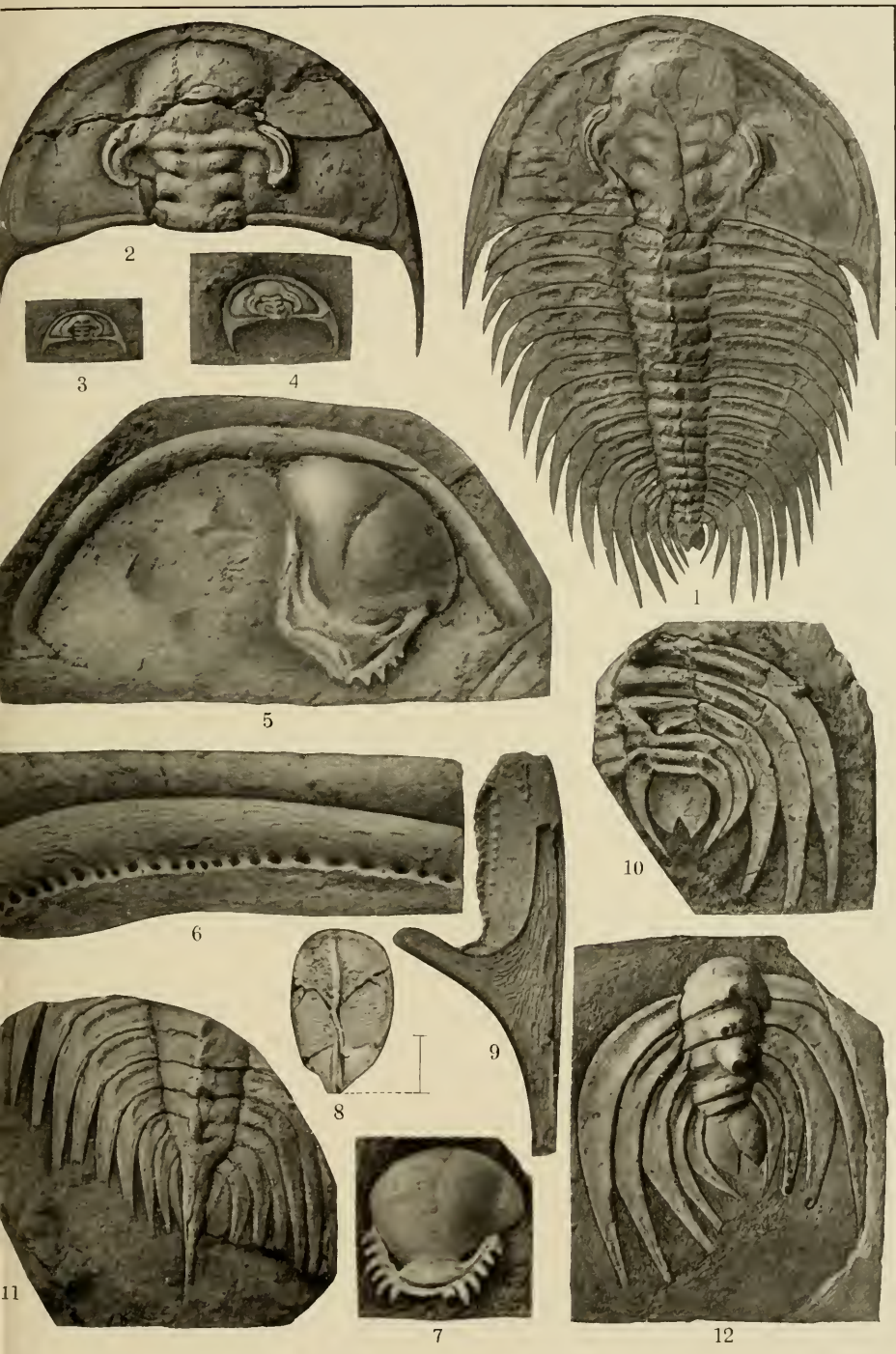
10. Matrix of a pygidium and five posterior thoracic segments. $\times 2$. Note the cast of the median spine at the third segment from the pygidium. U. S. National Museum, Catalogue No. 56807j.

11. Posterior portion of a large individual preserving a strong spine on the axial lobe of the third thoracic segment from the pygidium, also, a small spine on the fourth segment. Natural size. U. S. National Museum, Catalogue No. 56807k.

12. Pygidium and five posterior thoracic segments with base of strong spine on third segment and small spine on fourth segment from the pygidium. $\times 2$. U. S. National Museum, Catalogue No. 56807l.

The specimens represented by figs. 5-7, 9-12, were collected by Prof. A. Wanner. The greatest addition to our information of the species is furnished by figs. 11 and 12.

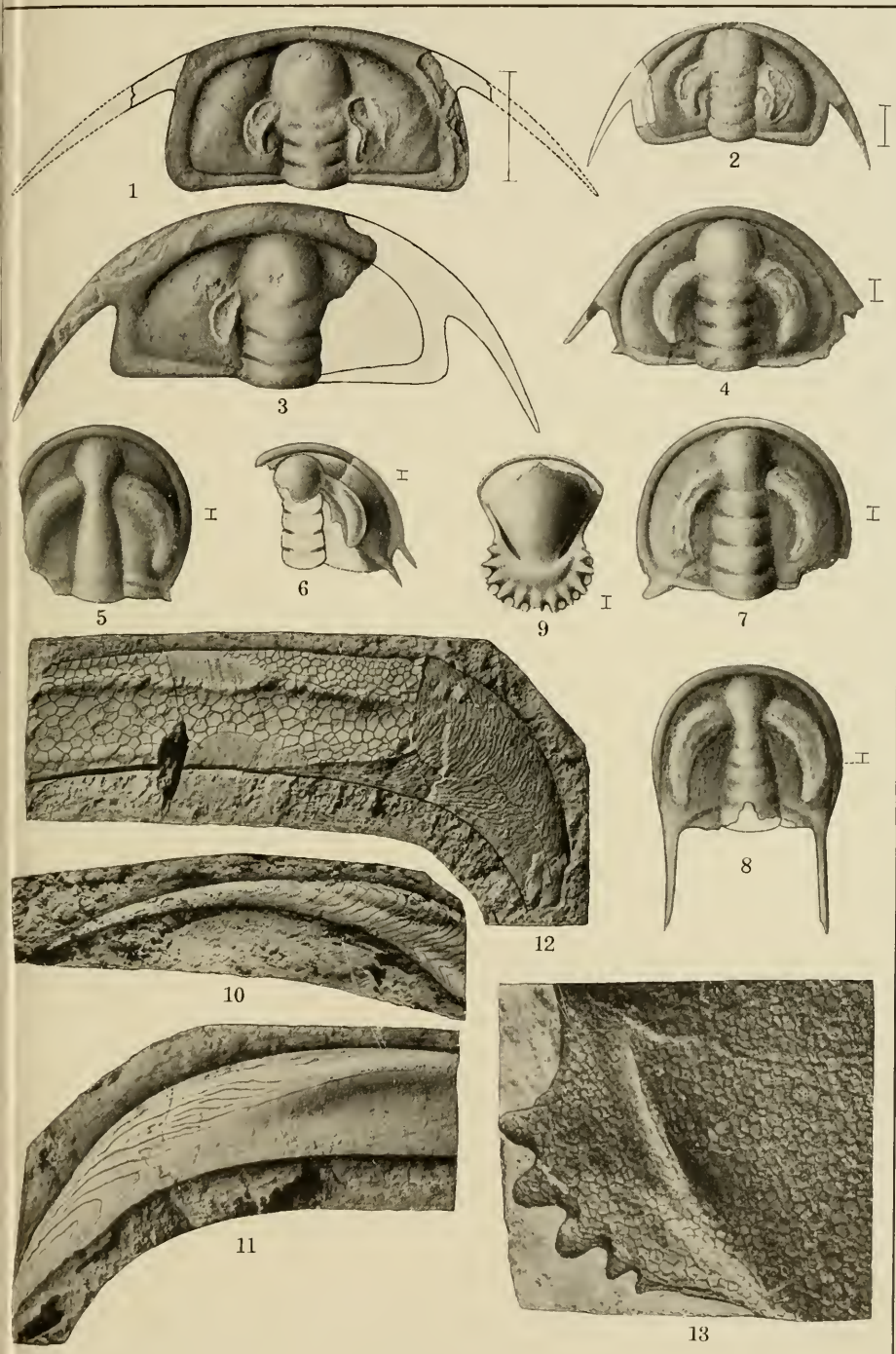
All of the specimens represented on this plate are from locality (8q), 2 miles northwest of the city of York, Pennsylvania.



LOWER CAMBRIAN TRILOBITES

DESCRIPTION OF PLATE 31

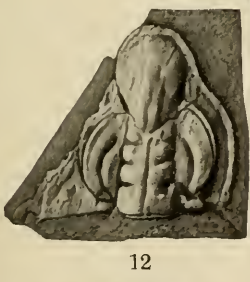
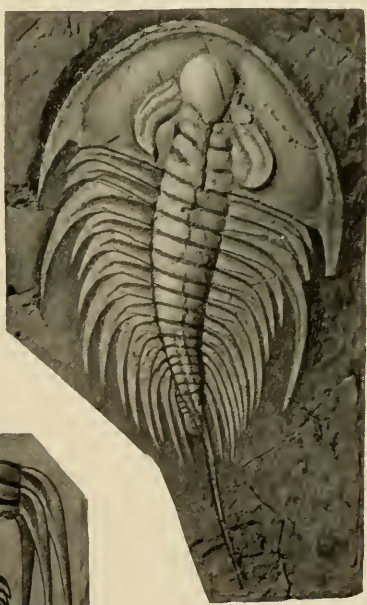
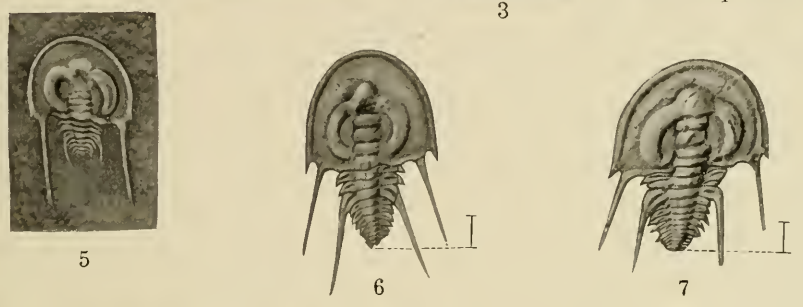
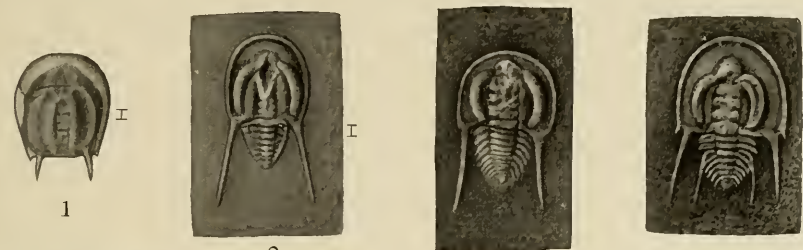
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|---|------|
| <i>Wanneria halli</i> , new species..... | 301 |
| <p>Figs. 1, 2, and 3. Cephalons with genal angles and spines in advance of the posterior margin of the head and with intergenal angles almost right angles. No. 1, $\times 1.25$; No. 2, $\times 3$; No. 3, natural size. U. S. National Museum, Catalogue Nos. 56806a, 56806b, and 56806c, respectively.</p> | |
| <p>4. A small cephalon with short, minute intergenal spine at the intergenal angle. Glabella cylindrical, eye lobe large. $\times 8$. U. S. National Museum, Catalogue No. 56806d.</p> | |
| <p>5, 7, and 8. Minute cephalons showing rounded-in genal angles, large eye lobes, and contraction of the glabella at the eye lobes. No. 5, $\times 24$; No. 6, $\times 6$; No. 7, $\times 16$. Compare with the younger stages of growth of <i>Elliptocephala asaphoides</i> (pl. 25) and <i>Pædeumias transitans</i> (pls. 25 and 32). U. S. National Museum, Catalogue Nos. 56806e, 56806g, and 56806h, respectively.</p> | |
| <p>6. Fragment of a minute cephalon with strong eye lobe, minute genal and intergenal spines. $\times 16$. U. S. National Museum, Catalogue No. 56806f.</p> | |
| <p>9. Hypostoma associated with this species in Alabama. $\times 12$. U. S. National Museum, Catalogue No. 56806i.</p> | |
| <p>10. Under side or doublure of the extension of the pleuræ beyond the body line of a thoracic segment. $\times 2$. U. S. National Museum, Catalogue No. 56806j.</p> | |
| <p>11. Upper side of the pleural lobe of a thoracic segment. $\times 3$. U. S. National Museum, Catalogue No. 56806k.</p> | |
| <p style="padding-left: 40px;">All the specimens represented by figs. 1-11 are from locality (56c) north of Helena, Shelby County, Alabama.</p> | |
| <i>Wanneria walcottanus</i> (Wanner) (See pls. 30 and 44)..... | 302 |
| <p>FIG. 12. Enlargement of the pleural lobe of a thoracic segment. $\times 2$. This specimen was illustrated by Wanner [1901, pl. 31, fig. 2]. U. S. National Museum, Catalogue No. 56807m.</p> | |
| <p>13. A portion of the postero-lateral part of an hypostoma ($\times 6$), showing surface markings and five of the short obtuse marginal spines. U. S. National Museum, Catalogue No. 56807n.</p> | |
| <p style="padding-left: 40px;">The specimens represented by figs. 12 and 13 are from locality (8q), 2 miles northwest of York, Pennsylvania.</p> | |



DESCRIPTION OF PLATE 32

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| <i>Padeumias transitans</i> , new genus and new species (See pls. 24, 25, 33, 34, 41, and 44) | 395 |
| FIG. 1. A cephalon 1 mm. in length, exclusive of the intergenal spines. $\times 16$. U. S. National Museum, Catalogue No. 56810a. | |
| 2. A dorsal shield with five thoracic segments and pygidium, 1.5 mm. in length, exclusive of the long intergenal spines. $\times 12$. U. S. National Museum, Catalogue No. 56810b. | |
| 3. A dorsal shield with seven or eight thoracic segments and pygidium, 1.75 mm. in length, exclusive of the intergenal spines. $\times 10$. U. S. National Museum, Catalogue No. 56810c. | |
| 4. A dorsal shield 3.5 mm. in length with ten segments, pygidium, and large third thoracic segment. $\times 6$. U. S. National Museum, Catalogue No. 56810d. | |
| 5. A dorsal shield of about the same size as that represented by fig. 4, that has a very narrow thorax. $\times 6$. U. S. National Museum, Catalogue No. 56810e. | |
| 6. A dorsal shield 4.25 mm. in length, exclusive of spines, with 12 thoracic segments and large third segment with pleura very much prolonged. Pygidium broken away. $\times 4$. U. S. National Museum, Catalogue No. 56810f. | |
| 7. A dorsal shield 4.25 mm. in length, but shortened by compression, with 13 thoracic segments and a small pygidium. $\times 4$. U. S. National Museum, Catalogue No. 56810g. | |
| 8. Two small and very distinct cephalons. $\times 4$. U. S. National Museum, Catalogue No. 56810h. | |
| 9. This figure is to illustrate the natural curvature of the spine on the fifteenth thoracic segment. Natural size. U. S. National Museum, Catalogue No. 56810i. | |
| 10. An entire specimen of the dorsal shield from York, Pennsylvania, showing four very narrow segments and a plate-like pygidium beneath the large spine on the fifteenth segment. Natural size. U. S. National Museum, Catalogue No. 56810j. | |
| 11. Displaced pygidium and two posterior rudimentary segments of a dorsal shield in which the spine bearing segment is broken away. $\times 3$. U. S. National Museum, Catalogue No. 56810k. | |
| 12. A cephalon compressed laterally so as to crowd the outer rim in about the eyes and anterior portion of the glabella. Natural size. U. S. National Museum, Catalogue No. 56810l. | |
| 13. A cephalon compressed longitudinally and broadened. Natural size. U. S. National Museum, Catalogue No. 56810m. | |

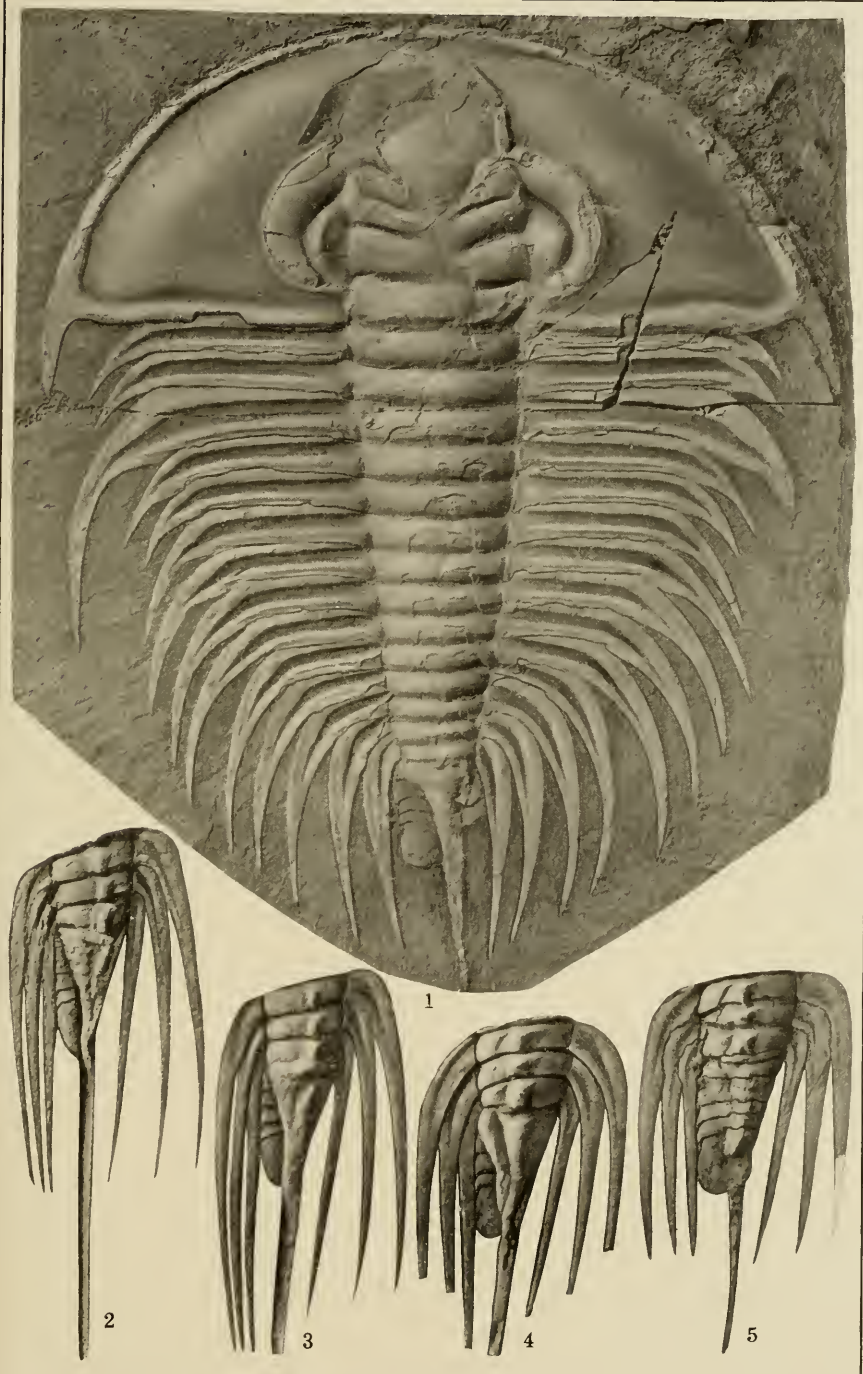
All of the specimens represented on this plate are from locality (8q), northwest of the City of York, Pennsylvania. Most of them were collected by Prof. Atreus Wanner.



DESCRIPTION OF PLATE 33

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|--|------|
| <i>Pædeumias transitans</i> , new genus and new species (See pls. 24, 25, 32, 34, 41, and 44)..... | 305 |
| FIG. 1. A large, broad specimen with three rudimentary thoracic segments posterior to the fifteenth spine bearing segment. Natural size. The posterior three segments and pygidium are illustrated on plate 24. From locality (25), Parkers quarry, Georgia, Vermont. U. S. National Museum, Catalogue No. 56808a. | |
| 2. Posterior portion of a dorsal shield from which the upper portion of the great spine of the fifteenth thoracic segment has been removed. It shows the pygidium, four rudimentary segments, and the impression of the under side of the great spine. $\times 3$. U. S. National Museum, Catalogue No. 56810i. | |
| 3. Photograph from cast in natural matrix of posterior segments, telson, and traces of rudimentary segments and pygidium represented by fig. 2. $\times 3$. U. S. National Museum, Catalogue No. 56810n. | |
| 4. View of another specimen similar to that represented by fig. 3. $\times 3$. This is the exterior of the great spine that is removed in fig. 5. U. S. National Museum, Catalogue No. 56810o. | |
| 5. This is the posterior portion of the dorsal shield that is the reverse of the matrix from which the cast represented by fig. 4 was taken. The telson is broken away so as to show the fifteenth segment to which the great spine was attached, and joined to this the first, second, and third rudimentary segments and the plate pygidium. $\times 3$. U. S. National Museum, Catalogue No. 56810p. | |

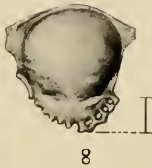
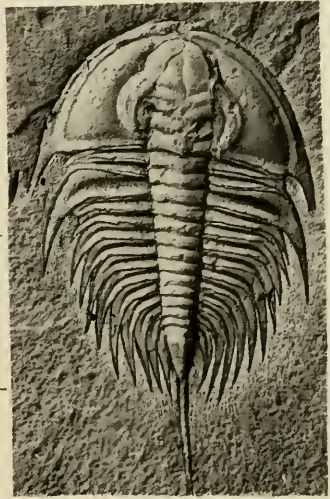
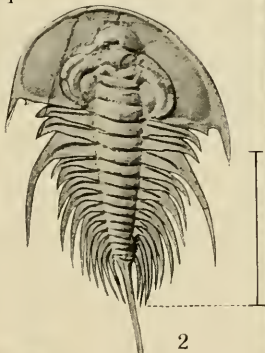
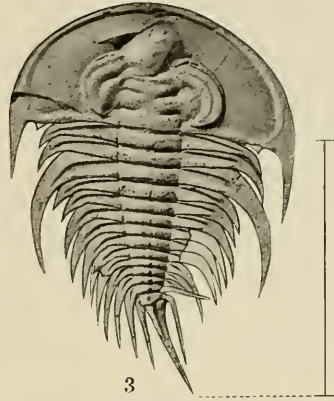
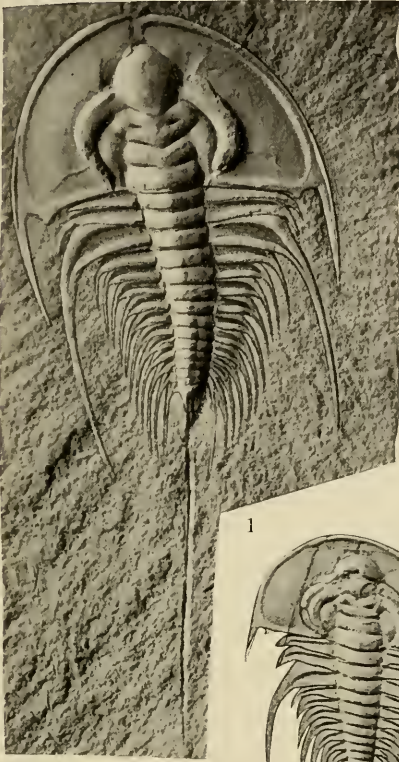
The specimens represented by figs. 2-5 were collected by Prof. Atreus Wanner from locality (8q), 2 miles northwest of York, Pennsylvania.



LOWER CAMBRIAN TRILOBITES

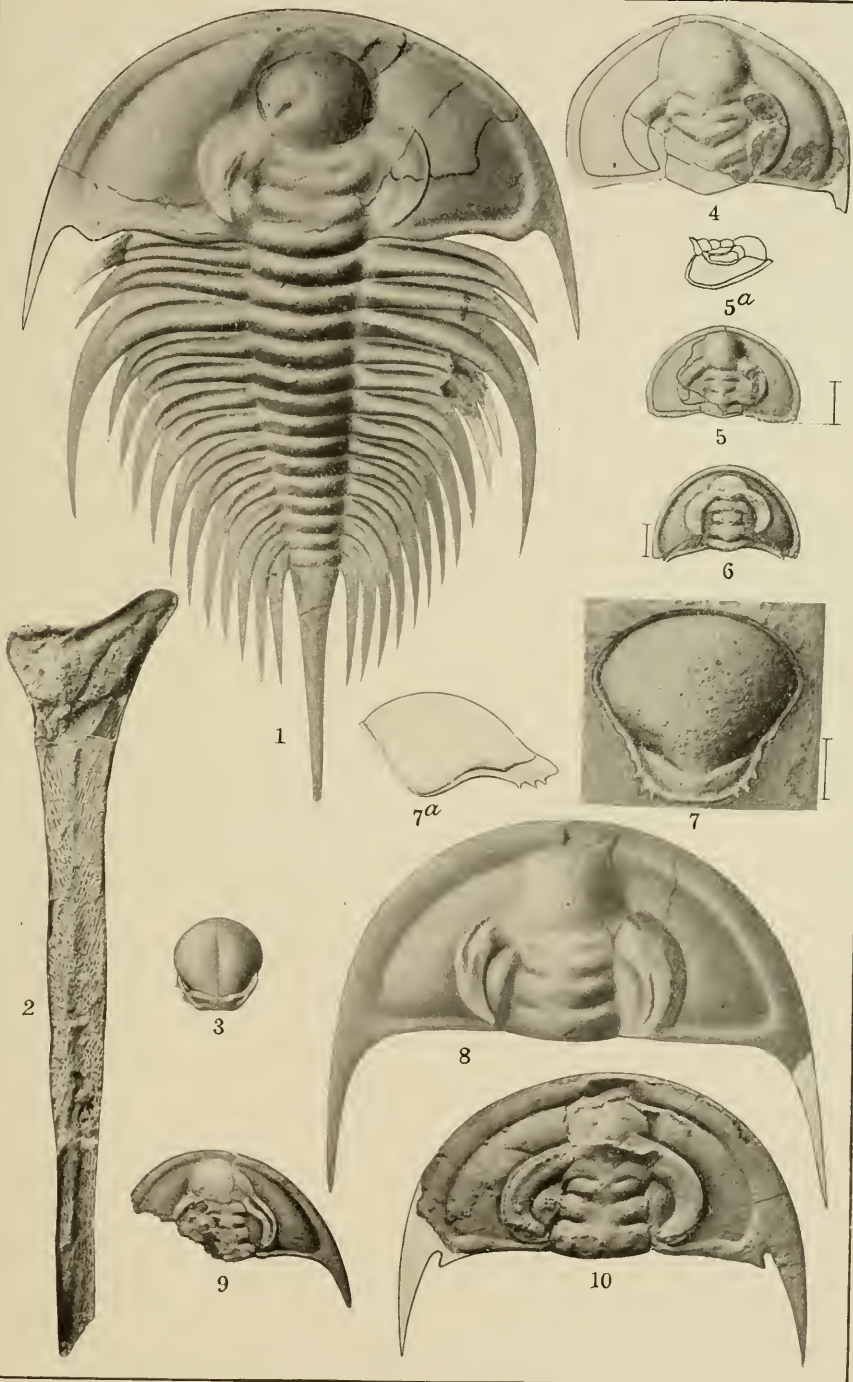
DESCRIPTION OF PLATE 34

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| <i>Pæcumias transitans</i> , new genus and new species (See pls. 24, 25, 32, 33, 41, and 44)..... | 305 |
| FIG. 1. Elongate form of dorsal shield from locality (25), at Parkers quarry, Georgia, Vermont. $\times 2$. U. S. National Museum, Catalogue No. 56808b. | |
| 2. Elongate form of dorsal shield from York. $\times 2$. U. S. National Museum, Catalogue No. 56810q. | |
| 3. Broad form of dorsal shield from York. $\times 1.5$. U. S. National Museum, Catalogue No. 56810r. | |
| 4. A dorsal shield 12 mm. in length with 13 thoracic segments and long terminal telson from York. $\times 3$. U. S. National Museum, Catalogue No. 56810s. | |
| 5. Hypostoma attached to doublure by a narrow median support. From York. $\times 2$. U. S. National Museum, Catalogue No. 56810t. | |
| 6. Cephalon with the doublure and hypostoma separated and turned back on the line of the intergenal spines. From York. $\times 2$. U. S. National Museum, Catalogue No. 56810u. | |
| 7. Hypostoma attached to doublure by a narrow median support. From York. $\times 3$. U. S. National Museum, Catalogue No. 56810v. | |
| The specimens represented by figs. 2-7 are from locality (8q) 2 miles northwest of York, Pennsylvania. | |
| 8. Hypostoma from locality (17a) near Montevallo, Alabama, showing perforated posterior margin. $\times 3$. U. S. National Museum, Catalogue No. 56811a. | |
| <i>Olenellus thompsoni</i> (Hall) (See pls. 35 and 44)..... | 336 |
| FIG. 9. A flattened dorsal shield from locality (25), Parkers quarry, Georgia, Vermont. Natural size. U. S. National Museum, Catalogue No. 15418a. | |
| Figure 9 is redrawn from the specimen figured by Walcott, 1886, pl. 17, fig. 2. | |



DESCRIPTION OF PLATE 35

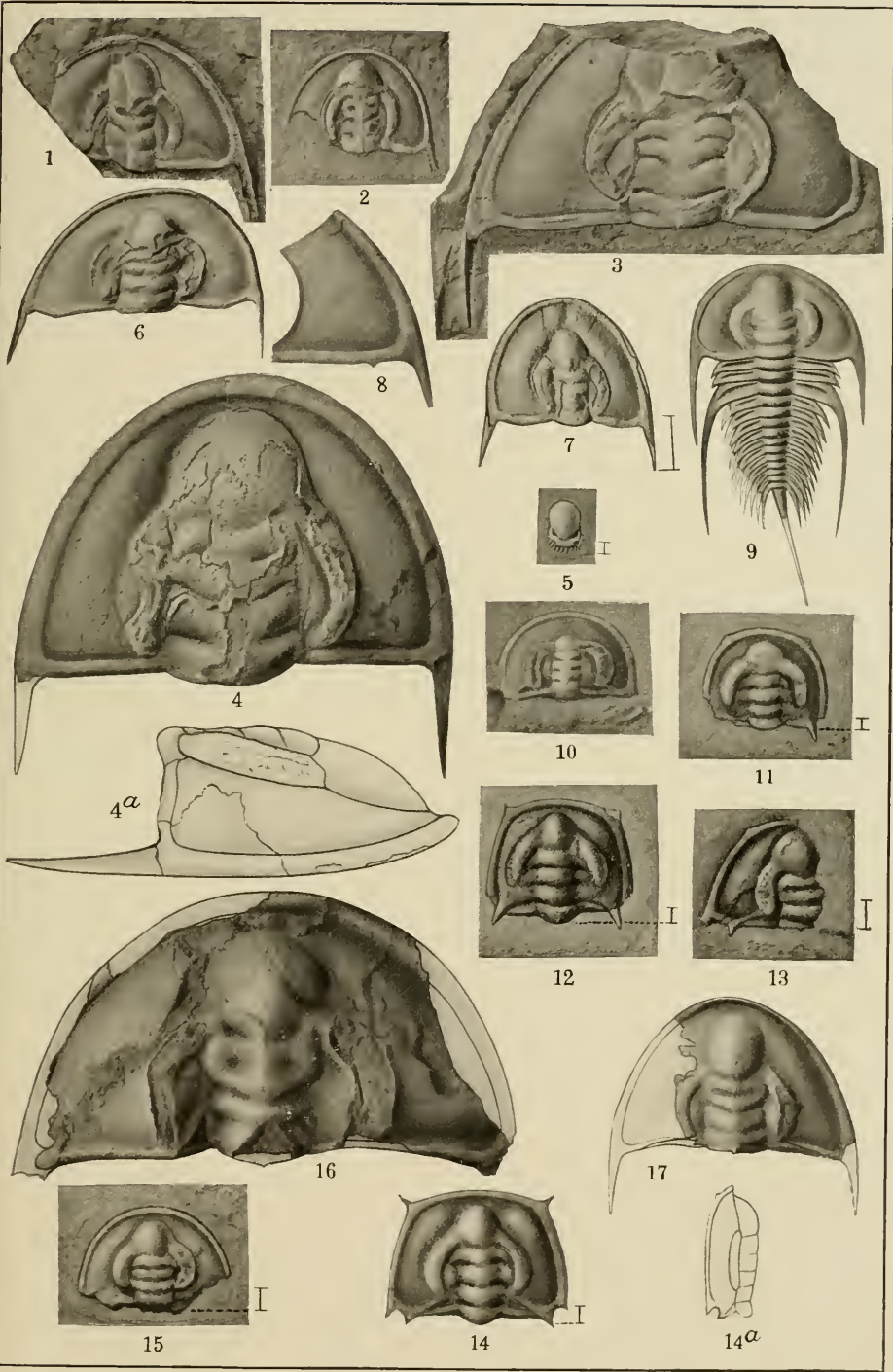
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| <i>Olenellus thompsoni</i> (Hall) (See pls. 34 and 44)..... | 336 |
| <p>FIG. 1. Dorsal shield from the type locality (25), at Parkers quarry, Georgia, Vermont. Reduced to two-thirds of natural size. This figure was published [Walcott, 1886, pl. 23, fig. 1] with a space between the glabella and marginal border. The glabella is crushed down even with the surface of the cheeks and the draftsman left out the line indicating the margin of the anterior glabella lobe. The same is true of fig. 1, pl. 22. Figures 2 and 9, pl. 17, represented the correct position of the glabella. U. S. National Museum, Catalogue No. 15418b.</p> | |
| <p>2. A large crushed telson from locality (8q), 2 miles northwest of the City of York, Pennsylvania. \times 1.5. U. S. National Museum, Catalogue No. 56835a.</p> | |
| <p>3. Hypostoma that occurs on the inside of a cephalon. Only the base of some of the postero-marginal spines can be seen and the median support, if ever present, is now broken off. Locality (25), Parkers quarry, Georgia, Vermont. \times 2. U. S. National Museum, Catalogue No. 15418c.</p> | |
| <p>4. Top view of a convex cephalon from the calcareous sandstone at locality (25a), near Swanton, Vermont. A restoration based on the specimen represented by this figure was given by Walcott, 1886, pl. 17, fig. 9. Natural size. U. S. National Museum, Catalogue No. 15419a.</p> | |
| <p>5 and 6. Two small cephalons from the Rome sandstone, locality (46), west of Cleveland, Tennessee, in which the natural convexity of the cephalon is preserved. This is outlined in 5a. U. S. National Museum, Catalogue Nos. 26983a and 26983b, respectively.</p> | |
| <p>7 and 7a. Top and side view (\times 3) of a very convex hypostoma from the same locality (46) as the specimens represented by figs. 5 and 6. U. S. National Museum, Catalogue No. 26983c.</p> | |
| <i>Olenellus thompsoni crassimarginatus</i> , new variety..... | 340 |
| <p>FIG. 8. A flattened cephalon formerly referred to <i>Olenellus thompsoni</i> Hall. Natural size. From locality (25), Parkers quarry, Georgia, Vermont. U. S. National Museum, Catalogue No. 56836a.</p> | |
| <p>Figure 8 is copied from Walcott, 1886, pl. 17, fig. 1.</p> | |
| <p>9 and 10. Cephalons from locality (8q), 2 miles northwest of the City of York, Pennsylvania. Natural size. U. S. National Museum, Catalogue Nos. 56837a and 56837b, respectively.</p> | |



LOWER CAMBRIAN TRILOBITES

DESCRIPTION OF PLATE 36

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|---|------|
| <i>Olenellus gilberti</i> Meek (See pl. 43)..... | 324 |
| <p>Figs. 1, 2, and 3. Cephalons crushed and flattened in a dark argillaceous shale from locality (31a), near Pioche, Lincoln County, Nevada. U. S. National Museum, Catalogue Nos. 15411a, 15411b, and 15411c, respectively.</p> <p>These are the specimens to which Meek assigned the name <i>Olenellus gilberti</i>. They were figured by White, 1877, pl. 2, figs. 3b, 3c, and 3a, respectively.</p> | |
| 4 and 4a. Top and side views of a cephalon preserving its convexity in a granular limestone from the same locality as that given for figs. 1-3. Natural size. U. S. National Museum, Catalogue No. 15411d. | |
| <p>This is the specimen upon which Meek based the species <i>Olenellus howelli</i>. It was figured by White, 1877, pl. 2, figs. 4a-b.</p> | |
| 5. Small hypostoma $\times 3$, associated with specimens of the cephalon of this species at locality (1p), south of Silver Peak, Esmeralda County, Nevada. U. S. National Museum, Catalogue No. 56825a. | |
| 6 and 7. Cephalons compressed and distorted in fine arenaceous shale. $\times 2$. Drawn from specimens found in locality (1y), Clayton Valley, Esmeralda County, Nevada. U. S. National Museum, Catalogue Nos. 56826a and 56826b, respectively. | |
| 8. Cast of the inside of the cheek and genal spine and a small intergenal spine. Natural size. Locality (1p), south of Silver Peak, Esmeralda County, Nevada. U. S. National Museum, Catalogue No. 56825b. | |
| 9. A compressed and slightly distorted dorsal shield. Natural size. Locality (30), 8 miles west of Pioche, Nevada. U. S. National Museum, Catalogue No. 15416a. | |
| <p>This figure was published by Walcott, 1886, pl. 21, figs. 1, 1a; and 1891, pl. 94, figs. 1, 1a. In these publications the anterior lobe of the glabella was extended to the front border by error of the draftsman.</p> | |
| 10. A small cephalon 2 mm. in length. $\times 6$. Locality (1m), south of Silver Peak, Esmeralda County, Nevada. U. S. National Museum, Catalogue No. 56827a. | |
| 11. A cephalon in which the antero-lateral angles are developed. $\times 10$. U. S. National Museum, Catalogue No. 56828a. | |
| 12. A slightly larger cephalon than that represented by fig. 1, with large intergenal spines, slightly developed genal angles, and antero-lateral angles and spines. $\times 10$. U. S. National Museum, Catalogue No. 56828b. | |
| 13. Fragment of a small cephalon $\times 4$, showing intergenal ridge crossing the posterior margin. U. S. National Museum, Catalogue No. 56828c. | |



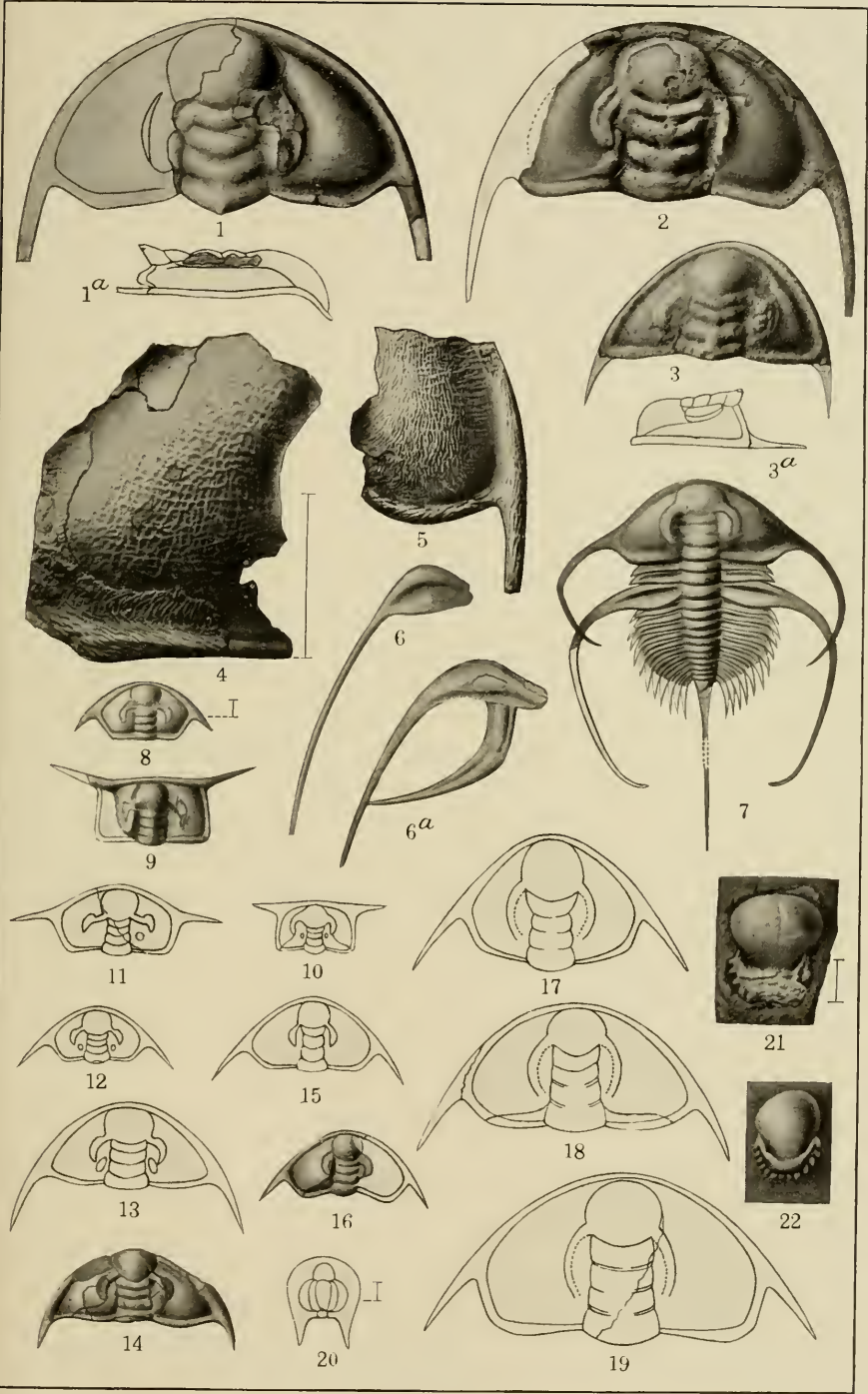
Olenellus gilberti Meek (continued):

- 14 and 14a. Top and side view of a small cephalon with fine antero-lateral and intergenal spines. $\times 8$. U. S. National Museum, Catalogue No. 56828d.
15. Small cephalon $\times 4$, in which the antero-lateral angles have disappeared and the palpebral lobes become relatively shorter. U. S. National Museum, Catalogue No. 56828c.
16. A large cephalon doubtfully referred to this species. Natural size. U. S. National Museum, Catalogue No. 56829a.
17. Fragment of a cephalon that appears to belong to this species. Natural size. U. S. National Museum, Catalogue No. 56829b.

The specimens represented by figs. 11-15 are from locality (35l), Ptarmigan Pass, Alberta; those by figs. 15-17 from locality (35f), above railway tunnel, Mt. Stephen, British Columbia, on the main line of the Canadian Pacific Railway.

DESCRIPTION OF PLATE 37

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| <i>Olenellus fremonti</i> , new species (See pl. 41)..... | 320 |
| FIGS. 1 and 1a. Top view and side outline of a fragmentary cephalon.
Natural size. Locality (14l), 15 miles east of Resting Springs,
California. U. S. National Museum, Catalogue No. 56818a. | |
| 2. Cephalon from locality (52), Prospect Mountain, Eureka District,
Nevada. Natural size. U. S. National Museum, Catalogue No.
56819a. | |
| 3 and 3a. Top view and side outline of a strongly convex cephalon.
Natural size. Locality (176), Deep Spring Valley, Nevada. U.
S. National Museum, Catalogue No. 56820a. | |
| 4. Cast of interior surface of the test of a broad cheek showing
the strongly reticulated surface. $\times 2$. Locality (14p), west
of Resting Springs, California. U. S. National Museum, Cata-
logue No. 56821a. | |
| 5. Enlargement of the outer surface of the broad cheek, the
border, and genal spine. $\times 2$. Same locality as fig. 4. U. S.
National Museum, Catalogue No. 56821b. | |
| 6 and 6a. Examples of the enlarged pleuræ of the third thoracic
segment. Natural size. From locality (52), the Eureka Dis-
trict, Nevada. U. S. National Museum, Catalogue Nos. 56819b
and 56819c, respectively.
Figure 6 is copied from Walcott, 1886, pl. 19, fig. 2i; where
it was labeled <i>Olenellus howelli</i> ; and fig. 6a is copied from
Walcott, 1884, pl. 9, fig. 15c, where the specimen is labeled
<i>Olenellus gilberti</i> . | |
| 7. Longitudinally compressed form of a nearly entire specimen of
the dorsal shield from locality (30), western side of the High-
land Range, Lincoln County, Nevada. Natural size. U. S.
National Museum, Catalogue No. 56822a.
Figure 7 is copied from Walcott, 1886, pl. 21, figs. 2 and 2a, a
slight change being made in the cephalon, the eyes being much
too long in the original figure. The form was assigned [1886
and 1891a] to <i>Olenellus gilberti</i> . | |
| 8. A small cephalon with short eyes and an ocular ridge. Genal
angles advanced about one-half the length of the cephalon.
$\times 6$. Locality (52), Prospect Peak, Eureka District, Nevada.
U. S. National Museum, Catalogue No. 56819d.
Figure 8 is copied from Walcott, 1884, pl. 9, fig. 15b, where
it is labeled <i>Olenellus howelli</i> . | |
| 9. Cephalon with the genal spines on a line with the anterior
margin and with the intergenal angles. Eyes short and con-
nected with anterior lobe of the glabella by ocular ridges.
Natural size. The specimen represented is from a limestone
at the south end of the Timpahute Range, Nevada (locality | |



LOWER CAMBRIAN TRILOBITES

Olenellus fremonti, new species (continued):

313g). Associated fragments of other cephalons show the genal spines located in the same relative positions as those shown by figs. 10 to 13 from locality (51), Prospect Peak, Nevada. U. S. National Museum, Catalogue No. 56819e.

Figure 9 is copied from Walcott, 1886, pl. 20, fig. 1f, where it is labeled *Olenellus gilberti*.

This specimen is redrawn ($\times 6$) on pl. 41, fig. 8.

10. Cephalon from locality (52) in the Eureka District, Nevada, that is very much like fig. 9. Natural size. U. S. National Museum, Catalogue No. 56819f.

11, 12, and 13. Outlines of specimens of the cephalon with the genal spines and intergenal angles more and more like the normal type of cephalon as shown by figs. 7 and 14. The eyes are short and connected with the glabella by an ocular ridge. Natural size. Locality (52), Prospect Mountain, Eureka District, Nevada. U. S. National Museum, Catalogue Nos. 56819g, 56819h, and 56819i, respectively.

Figures 10, 11, 12, and 13 are copied from Walcott, 1884, pl. 21, figs. 2, 4, 3, and 6, respectively, where the forms are labeled *Olenellus howelli*.

14. A cephalon with short eye lobes, ocular ridges, and normal genal angles. Natural size. Locality (52), Prospect Mountain, Eureka District, Nevada. U. S. National Museum, Catalogue No. 56819j.

Figure 14 is copied from Walcott, 1884, pl. 9, fig. 15, where it is labeled *Olenellus howelli*.

15. A cephalon without distinct ocular ridge connecting the glabella and eye lobes. Natural size. Locality (52), Prospect Mountain, Eureka District, Nevada. U. S. National Museum, Catalogue No. 56819k.

Figure 15 is copied from Walcott, 1884, pl. 21, fig. 5, where it is labeled *Olenellus howelli*.

16. A cephalon 9 mm. in length that has the outline shown by fig. 12 but with the eyes close to the glabella. Natural size. Locality (52), Prospect Mountain, Eureka District, Nevada. U. S. National Museum, Catalogue No. 56819l.

Figure 16 is copied from Walcott, 1884, pl. 9, fig. 15a, where it is labeled *Olenellus howelli*.

17. A narrow, convex, cephalon with elongate eye lobes of the adult type and with genal angles advanced as in small cephalons shown by figs. 11 and 12. Natural size. Locality (51), Prospect Mountain, Eureka District, Nevada. U. S. National Museum, Catalogue No. 56819m.

18. Cephalon with the genal spine on the left side in advance of that on the right side. Natural size. Locality (52), Eureka District, Nevada. U. S. National Museum, Catalogue No. 56819n.

Olenellus fremonti, new species (continued):

PAGE

19. Broad form of cephalon with the same characters as that shown by fig. 17. Natural size. Locality (52), Eureka District, Nevada. U. S. National Museum, Catalogue No. 56819*a*.
 Figures 17, 18, and 19 are copied from Walcott, 1884, pl. 21, figs. 7, 9, and 8, respectively, where the forms are labeled *Olenellus howelli*.
20. Outline of a small weathered specimen of a minute cephalon that is doubtfully referred to this species from locality (313*g*), Groom District, south end of Timpahute Range, between Nye and Lincoln Counties, Nevada. U. S. National Museum, Catalogue No. 56823*a*.
 Figure 20 is copied from Walcott, 1886, pl. 19, fig. 2*e*, where it is labeled *Olenellus gilberti*.
21. Hypostoma ($\times 3$) associated with the cephalons represented by figs. 10-19 at locality (52), Eureka District, Nevada. U. S. National Museum, Catalogue No. 56819*b*.
22. Hypostoma associated with specimens of the cephalon of this species at locality (176), Deep Spring Valley, California. Natural size. U. S. National Museum, Catalogue No. 56820*b*.

DESCRIPTION OF PLATE 38

Olenellus canadensis, new species. 316

FIG. 1. A large cephalon, partially restored in outline. The intergenal angle is not usually present in this species. Natural size. Locality (35*h*), Mt. Bosworth, British Columbia. U. S. National Museum, Catalogue No. 56814*a*.

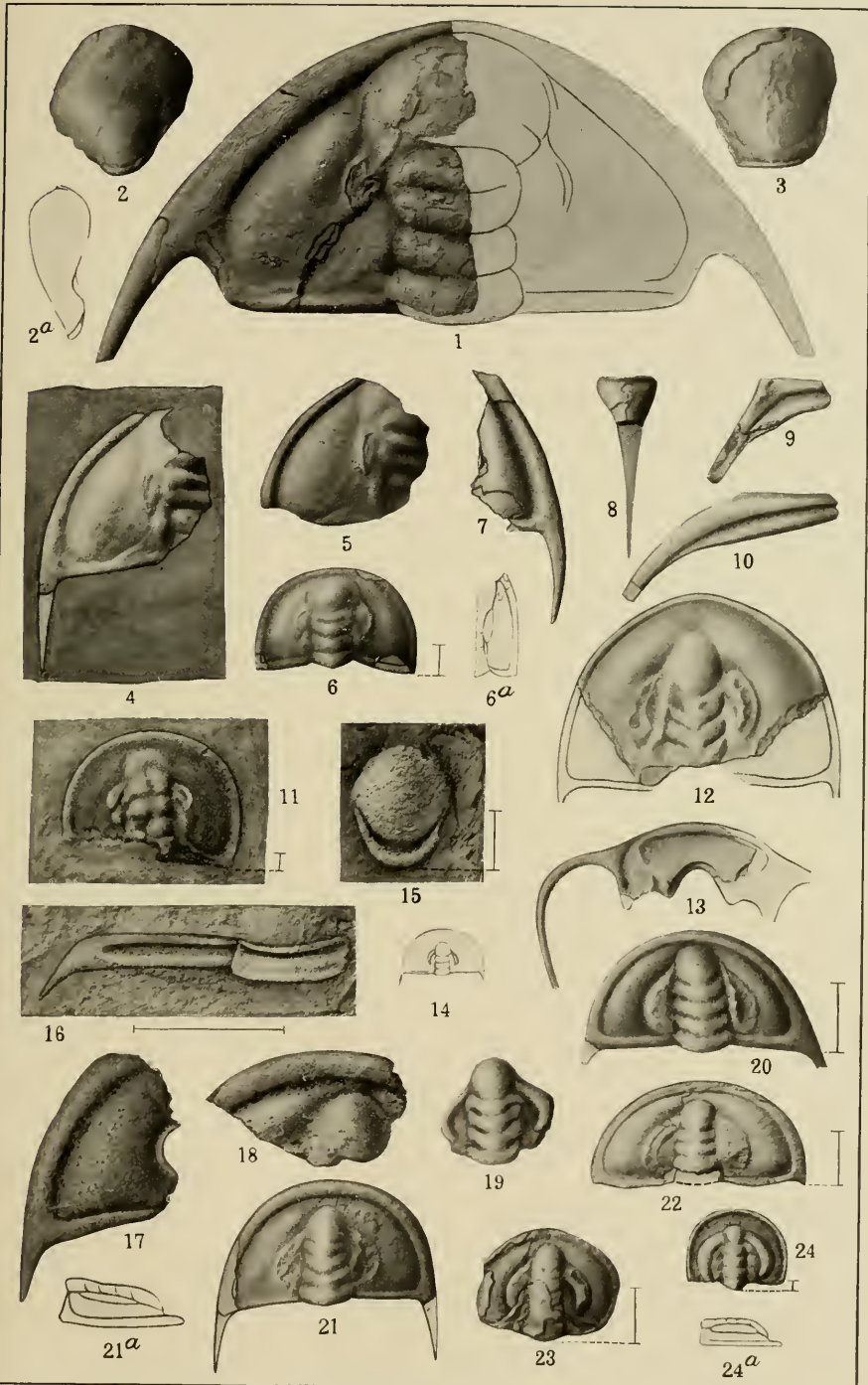
2 and 3. Illustrations of the hypostoma found associated with the cephalon. Natural size. 2 = locality (35*h*), Mt. Bosworth; 3 = locality (35*f*), Mt. Stephen; both in British Columbia. 2*a* shows the convexity of the hypostoma. U. S. National Museum, Catalogue Nos. 56815*a* and 56814*b*, respectively.

4. Fragment of a cephalon, showing the genal angle extending into a spine. Natural size. Locality (35*h*), Mt. Bosworth, British Columbia. U. S. National Museum, Catalogue No. 56814*c*.

5. Fragment of a cephalon, showing the eye lobe and tubercle back of it. Natural size. Locality (35*h*), Mt. Bosworth, British Columbia. U. S. National Museum, Catalogue No. 56814*d*.

6 and 6*a*. A small cephalon in which the marginal border is narrow. $\times 3$. Locality (35*h*), Mt. Bosworth, British Columbia. U. S. National Museum, Catalogue No. 56814*e*.

7. Fragments of a side of a cephalon with genal spine preserved. Natural size. Locality (35*f*), Mt. Stephen, British Columbia. U. S. National Museum, Catalogue No. 56815*b*.



LOWER CAMBRIAN TRILOBITES

- Olenellus canadensis*, new species (continued): PAGE
8. Fragment of the telson. Natural size. Locality (35*h*), Mt. Bosworth, British Columbia. U. S. National Museum, Catalogue No. 56814*f*.
- 9 and 10. Fragments of the pleural lobe of thoracic segments. Natural size. 9 = locality 58*y*; 10 = locality 35*h*; both on Mt. Bosworth, British Columbia. U. S. National Museum, Catalogue Nos. 56816*a* and 56814*g*, respectively.
11. A minute cephalon associated with this species and referred to it. $\times 8$. Locality (35*l*), Ptarmigan Pass, Alberta. U. S. National Museum, Catalogue No. 56817*a*.
- Callavia* ? *nevadensis*, new species. 285
- FIG. 12. Portion of a cephalon showing the broad frontal limb, narrow glabella, and relatively short eye lobe as compared with *Olenellus gilberti*. Natural size. Locality (52), Prospect Mountain, Eureka District, Nevada. U. S. National Museum, Catalogue No. 56799*a*.
- Figure 12 is copied from Walcott, 1884, pl. 9, fig. 16, where this specimen is referred to *Olenellus gilberti*.
13. Fragments of the under side of a cephalon in which the genal angles are carried far forward as in *O. fremonti* (pl. 37, figs. 8-12). Natural size. Locality (313*g*), south end of Timpahute Range, Nevada. U. S. National Museum, Catalogue No. 56800*a*.
- Figure 13 is copied from Walcott, 1886, pl. 19, fig. 2*d*, where the specimen is referred to *Olenellus gilberti*.
14. Outline of a small cephalon showing broad frontal limb and normal type of genal angles. Natural size. Locality (51), summit of Prospect Mountain, Eureka District, Nevada. U. S. National Museum, Catalogue No. 56799*b*.
- Figure 14 copied from Walcott, 1884, pl. 21, fig. 13, where the specimen is referred to *Olenellus gilberti*.
- Wanneria* ? *gracile*, new genus and new species. 298
- FIG. 15. An hypostoma associated with specimens of the cephalon of this species. $\times 2$. Locality (177), west of Deep Spring Valley, Inyo County, California. U. S. National Museum, Catalogue No. 56802*a*.
16. A thoracic segment associated with the hypostoma illustrated by fig. 15. This has the pleural furrow of *Wanneria* but the spinous termination is more like that of *Holmia*. Same locality as fig. 15. U. S. National Museum, Catalogue No. 56802*b*.
17. Left side of cephalon showing strong border, and slender genal spine. $\times 1.5$. U. S. National Museum, Catalogue No. 56803*a*.
18. Fragment of the front part of the cephalon. $\times 1.5$. U. S. National Museum, Catalogue No. 56803*b*.

Wanneria ? gracile, new genus and new species (continued):

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19. Central part of the cephalon illustrating the glabella and palpebral lobes. Natural size. U. S. National Museum, Catalogue No. 56803c.
20. A cephalon slightly distorted by lateral compression. $\times 1.5$. U. S. National Museum, Catalogue No. 56803d.
The specimens illustrated by figs. 17-20 are from locality (60b), the sandstones at Vermilion Pass, Alberta.
21. A cast in a fine quartzitic sandstone from California of a very perfect cephalon showing the heavy marginal border and the slender glabella. Natural size. Locality (14p), near Resting Springs, Inyo County, California. U. S. National Museum, Catalogue No. 56804a.
22. A cephalon that appears to have the adult characters of the species. $\times 1.5$. U. S. National Museum, Catalogue No. 56805a.
23. Central portion of the cephalon of a small specimen in which the genal angles are rounded inward. $\times 2$. U. S. National Museum, Catalogue No. 56805b.
24. A minute cephalon exclusive of spines. $\times 10$. U. S. National Museum, Catalogue No. 56804b.

Figures 22-24 represent specimens from locality (1v), a fine arenaceous shale at Barrel Spring, Silver Peak Quadrangle, Esmeralda County, Nevada.

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Olenellus lapworthi Peach..... 331

FIG. 1. Dorsal shield. $\times 2$. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M4080d. Cast in U. S. National Museum, Catalogue No. 56830a.

Figure 1 is redrawn from the specimen figured by Peach, 1894, pl. 29, fig. 3.

2. Cephalon. $\times 1.5$. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M495f. Cast in U. S. National Museum, Catalogue No. 56830b.
3. Cephalon. $\times 2$. U. S. National Museum, Catalogue No. 56831a.
4. A small cephalon. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M2611e. Cast in U. S. National Museum, Catalogue No. 56830c.
5. Imperfect dorsal shield, 6.25 mm. in length. $\times 3$. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M4198d. Cast in U. S. National Museum, Catalogue No. 56830d.



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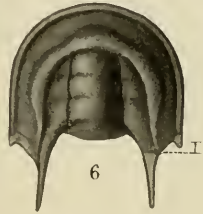
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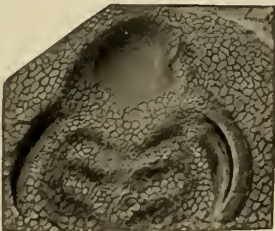
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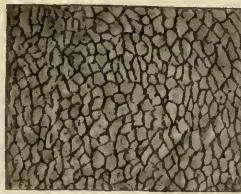
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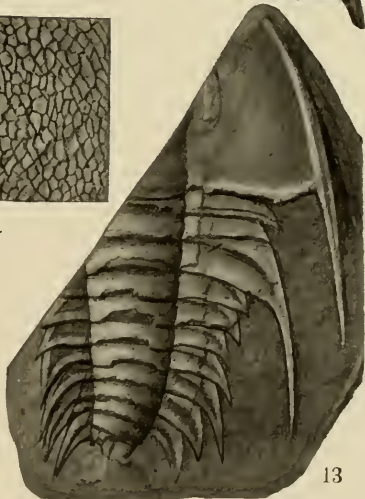
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13

Olenellus lapworthi Peach (continued):

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6. Cephalon 1.2 mm. in length. $\times 15$. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M515f. Cast in U. S. National Museum, Catalogue No. 56830e.
7. Hypostoma associated with this species. $\times 3$. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M494f. Cast in U. S. National Museum, Catalogue No. 56830f. The specimens represented by figures 1-7 are all from shales on the northern slope of Meal a' Ghubhais, 1,200 to 1,300 feet above Loch Maree, Ross-shire, Scotland.

Olenellus reticulatus Peach..... 335

FIG. 8. Small, broken cephalon. $\times 8$. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M510f. Cast in U. S. National Museum, Catalogue No. 56834a.

9. Portion of cephalon. Natural size. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M4076d. Cast in U. S. National Museum, Catalogue No. 56834b.

Figure 9 is redrawn from the specimen illustrated by Peach, 1894, pl. 30, fig. 1.

10. Photographic enlargement ($\times 1.5$) of a portion of the cephalon figured by Peach, 1894, pl. 30, fig. 2. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M4104d. Cast in U. S. National Museum, Catalogue No. 56834c.

The specimen is compressed laterally so as to force the eye lobes in toward the glabella.

11. Portion of the surface of the specimen represented in fig. 10. $\times 3$.
12. Cephalon with short palpebral lobe and strong outer border. $\times 2$. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M4141d. Cast in U. S. National Museum, Catalogue No. 56834d.

13. Portions of cephalon and thorax. $\times 2$. Specimen in Royal Scottish Museum, Edinburgh, Scotland. Cast in U. S. National Museum, Catalogue No. 56834e.

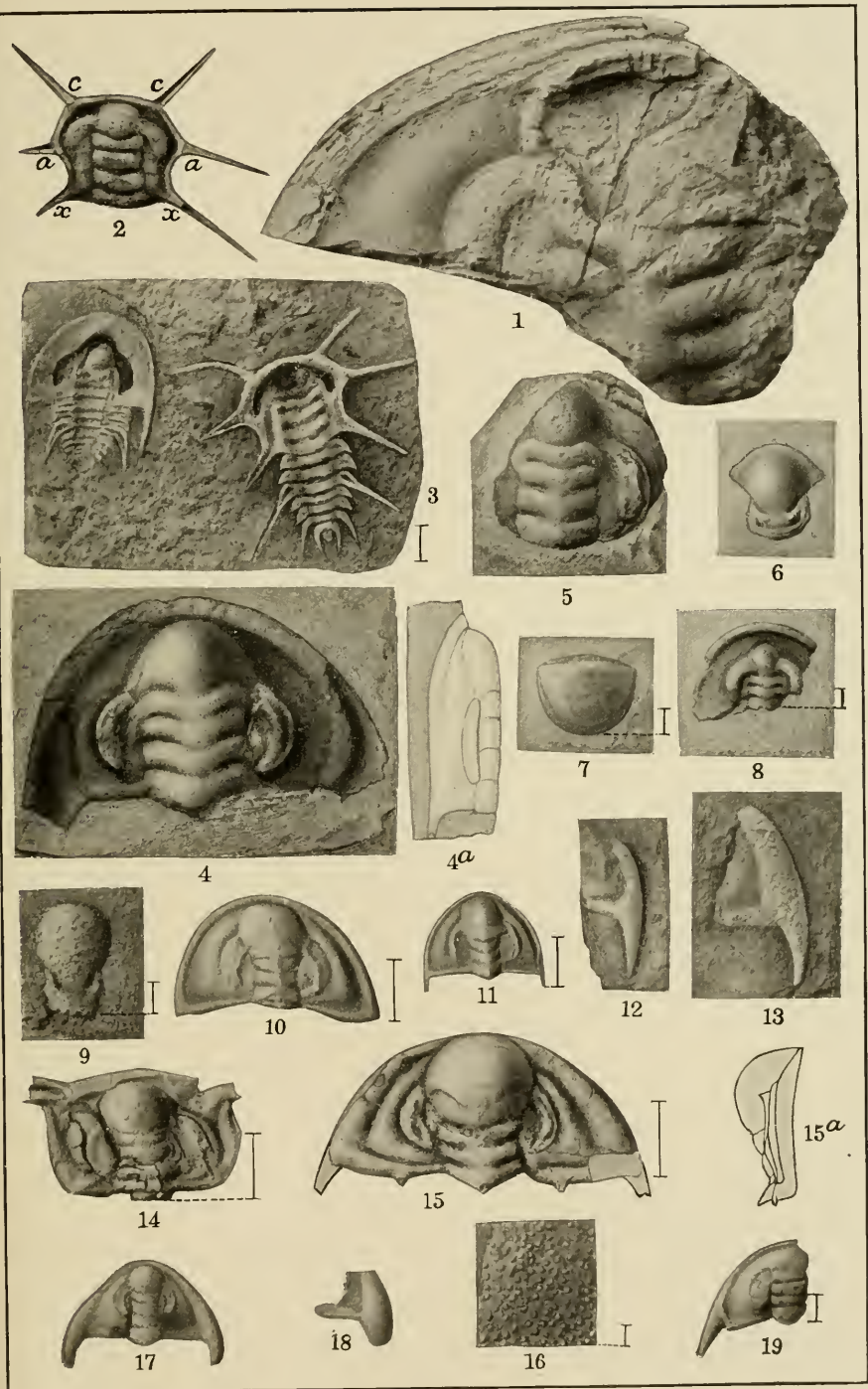
The specimens represented by figures 8-13 are all from shales on the northern slope of Meal a' Ghubhais, 1,200 to 1,300 feet above Loch Maree, Ross-shire, Scotland.

Olenellus?, sp. undt..... 342

FIG. 14. A minute cephalon from the same locality as that given for *Olenellus lapworthi* and *O. reticulatus*. $\times 10$. Specimen in Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M4157d. Cast in U. S. National Museum, Catalogue No. 56838a.

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| <i>Olenellus gigas</i> Peach..... | 323 |
| <p>FIG. 1. The type specimen. Natural size. From the northern slope of Meal a' Ghubhais, above Loch Maree, Ross-shire, Scotland. Specimen in Royal Scottish Museum, Edinburgh, Scotland. Cast in U. S. National Museum, Catalogue No. 56824a.</p> <p>Figure 1 is drawn from the specimen represented by Peach, 1894, p. 667, fig. 1.</p> | |
| <i>Olenelloides armatus</i> Peach..... | 347 |
| <p>FIG. 2. Cephalon 2.5 mm. in length ($\times 6$) from the same locality as <i>Olenellus gigas</i>. <i>xx</i> = intergenal spines. <i>aa</i> = genal spines. Specimen in the Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M2636e. Cast in U. S. National Museum, Catalogue No. 56839a.</p> <p>3. Natural matrix of an entire specimen 5 mm. in length ($\times 5$) from the same locality as <i>Olenellus gigas</i>. Specimen in the Royal Scottish Museum, Edinburgh, Scotland, Catalogue No. M4201d. Cast in U. S. National Museum, Catalogue No. 56839b.</p> <p>A matrix of a small dorsal shield of <i>Olenellus lapworthi</i> occurs on the same piece of shale and is shown on the left side.</p> | |
| <i>Holmia lundgreni</i> Moberg..... | 290 |
| <p>FIGS. 4 and 4a. Drawn from a plaster cast of the cephalon represented by Moberg, 1899, pl. 14, figs. 2a-b. Natural size. Original in the collection of the Geologic Institution of the University of Lund, Sweden. Cast in the U. S. National Museum, Catalogue No. 24630a.</p> <p>5. Central portions of a cephalon showing glabella very distinctly. Natural size. U. S. National Museum, Catalogue No. 24630b.</p> <p>6. An hypostoma illustrated from a cast taken in a natural mould. Natural size. U. S. National Museum, Catalogue No. 24630c.</p> <p>7. Pygidium. $\times 3$. The test is exfoliated. U. S. National Museum, Catalogue No. 24630d.</p> <p>The specimens represented by figs. 4 to 7 are from locality (390v), near Tunbyholm, Sweden.</p> | |
| <i>Olenellus gilberti</i> var..... | 331 |
| <p>FIG. 8. Fragment of a cephalon ($\times 4$) associated with <i>Olenellus canadensis</i> and <i>O. gilberti</i>. Locality (35l), Ptarmigan Pass, Alberta. U. S. National Museum, Catalogue No. 56830a.</p> | |



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- Olenellus* ? *claytoni*, new species. 319
- FIG. 9. An hypostoma associated with this species. The back margin appears to be denticulated. $\times 4$. Locality (1*k*). U. S. National Museum, Catalogue No. 56813*a*.
10. A cephalon flattened by compression in arenaceous shale. $\times 2$. Locality (1*i*). U. S. National Museum, Catalogue No. 56813*b*.
11. A cephalon slightly distorted by lateral compression. $\times 2$. Locality (1*i*). U. S. National Museum, Catalogue No. 56813*c*.
The specimens represented by figs. 9 to 11 are from localities (1*i* and 1*k*), both near Barrel Spring, Silver Peak Quadrangle, Nevada.
- Olenellus* *argentus*, new species. 314
- FIG. 12. Under side of genal spine showing rounded doublure. Natural size. U. S. National Museum, Catalogue No. 56812*a*.
13. Dorsal view of a genal spine and portions of the marginal borders and broad cheek. Natural size. U. S. National Museum, Catalogue No. 56812*b*.
14. A small head with the genal angle on a line with the front of the glabella. $\times 2$. U. S. National Museum, Catalogue No. 56812*c*.
- 15 and 15*a*. Top view and side outline of a cephalon, showing the heavy marginal rim and large spherical anterior lobe of the glabella. $\times 2$. U. S. National Museum, Catalogue No. 56812*d*.
16. Enlargement of the surface. $\times 6$. U. S. National Museum, Catalogue No. 56812*e*.
The specimens represented by figs. 12 to 17 are from locality (1*r*), 3 miles north of Valcaldia Spring, Esmeralda County, Nevada.
- Peachella* *iddingsi* (Walcott). 343
- FIG. 17. Illustration of the type specimen of the species. $\times 2$. U. S. National Museum, Catalogue No. 15407*a*.
This specimen was first figured by Walcott, 1884, pl. 9, fig. 12. In both instances the broken portions have been restored from other specimens.
18. Under side of a genal spine and connected parts of the cheek. Natural size. U. S. National Museum, Catalogue No. 15407*b*.
19. A small cephalon, $\times 2$, with a more slender spine than that of the larger cephalon represented by fig. 17. U. S. National Museum, Catalogue No. 15407*c*.
The specimens represented by figs. 17-19 are from locality (52), Prospect Peak, Eureka District, Nevada.

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Olenellus cf. *gilberti* (See pl. 36).¹

FIG. 1. A large cephalon showing the cast of the inner surface of the cheek and with the left side restored beyond the broken line. Natural size. Compare with figs. 3 and 16, pl. 36; also with fig. 2, pl. 39. Cast in U. S. National Museum, Catalogue No. 56833a.

2. A small cephalon. $\times 2$. Cast in U. S. National Museum, Catalogue No. 56833b.

3. A broken cephalon preserving the left palpebral lobe. Natural size. Cast in U. S. National Museum, Catalogue No. 56833c.

4. A telson referred to this species. $\times 3$. Cast in U. S. National Museum, Catalogue No. 56833d.

The four specimens represented by figs. 1-4 are from the conglomerate limestone at Bic, and are now in the Museum of the Geological Survey of Canada.

Olenellus logani, new species..... 333

FIGS. 5, 5a, and 5b. Top, side, and front views of a small and very perfect cephalon. Top view $\times 6$, other views $\times 2.5$. Cast in U. S. National Museum, Catalogue No. 56832a.

6. A cephalon $\times 2$, with right side restored in outline. Cast in U. S. National Museum, Catalogue No. 56832b.

(See note under fig. 7.)

Pædecumias transitans, new genus and new species (See pls. 24, 25, 32, 33, 34, and 44)..... 305

FIG. 7. Top and side views of a large cephalon. Natural size. Cast in U. S. National Museum, Catalogue No. 56842a.

The specimens represented by figs. 5, 6, and 7 are from l'Anse au Loup, Labrador, and are now in the Museum of the Geological Survey of Canada (5 = catalogue No. 414d; 6 = 414e; and 7 = 416).

Olenellus fremonti, new species (See pl. 37)..... 320

FIG. 8. Enlargement of the specimen represented by fig. 9, pl. 37, to show surface, glabellar lobes, and union of palpebral ridges with glabella. $\times 6$. U. S. National Museum, Catalogue No. 56819e.

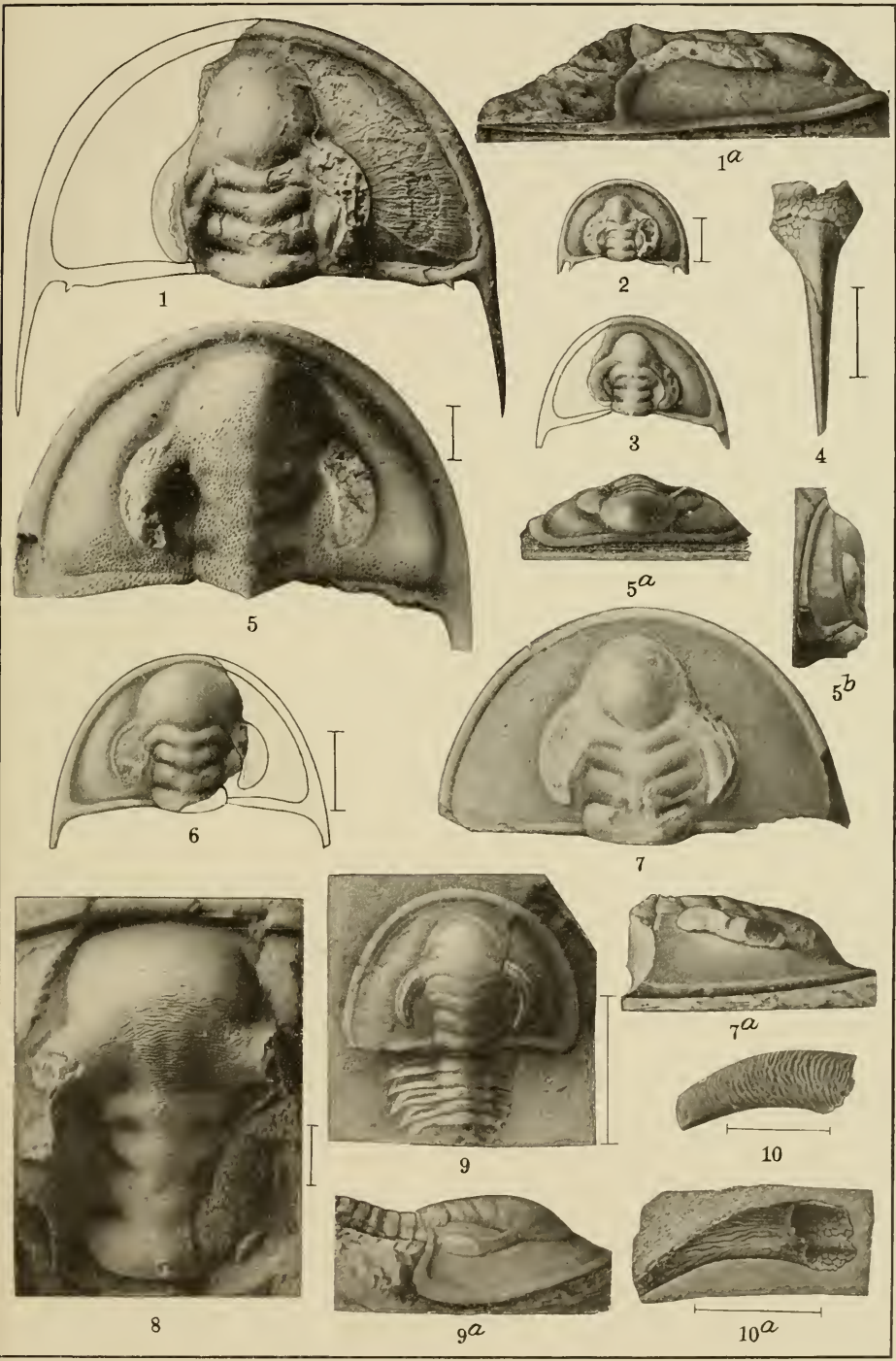
Callavia bicensis, new species..... 277

FIGS. 9 and 9a. Top and side views ($\times 1.5$) of a cephalon and 5 thoracic segments from locality (2r), 2 miles west of Bic, Quebec, Canada. U. S. National Museum, Catalogue No. 56794a.

Callavia, sp. undt..... 279

FIGS. 10 and 10a. Ends of pleuræ ($\times 2$) associated with the specimen represented by figs. 9 and 9a. U. S. National Museum, Catalogue Nos. 56843a and 56843b. respectively.

¹No reference to this form occurs in the text.



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DESCRIPTION OF PLATE 42

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<i>Callavia callavei</i> Lapworth.....	282

FIG. 1. The right hand side of this figure is a photograph of a specimen natural size. The left side is a photograph of the same specimen reversed and joined to the other with great care from measurements of the glabella. The central part of the cheek was broken out and has been recemented, as also the posterior of the two cracks across the margin. The cheek is slightly bent downwards along a line running about midway between the glabella and lateral margin; when this is allowed for, the head is 3 to 4 mm. wider. The very oblique lighting gives a false impression of strength to the 3d and 4th glabellar furrows.

Original in the collection of the University Museum, Birmingham, England. Cast in the U. S. National Museum, Catalogue No. 56796a, to which it was presented by Mr. Frank Raw.

This specimen was collected in Comley quarry, on Little Caradoc, near Church Stretton, Central Shropshire, England.

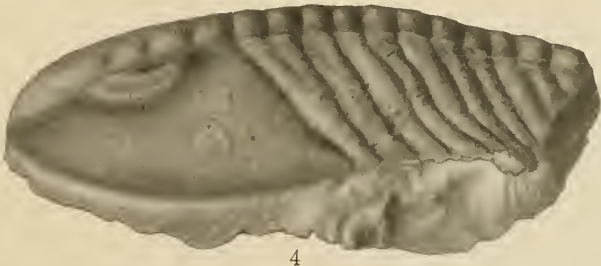
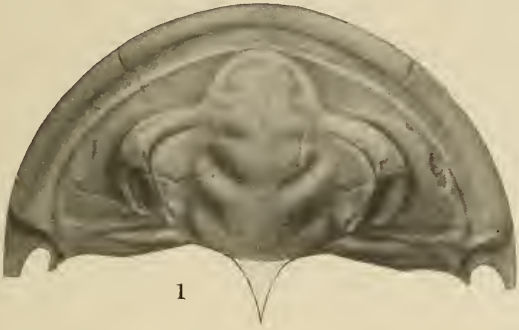
2. Side view of cephalon represented in fig. 1 showing the convexity, form of the glabella, cheek, border, and intergenal spine. Natural size.

<i>Callavia cartlandi</i> Raw (MS.).....	282
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FIG. 3. The type specimen

4. Side view of the specimen represented by fig. 3. Natural size.

The specimen represented by figs. 3 and 4 was collected at the same locality as the specimen of *Callavia callavei* represented in figs. 1 and 2. Original in the collection of the University Museum, Birmingham, England. Cast in the U. S. National Museum, Catalogue No. 56797a, to which it was presented by Mr. Frank Raw.



LOWER CAMBRIAN TRILOBITES

DESCRIPTION OF PLATE 43

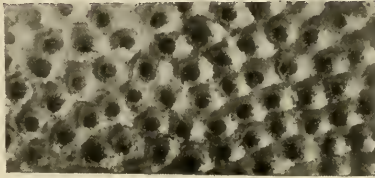
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| <i>Limulus polyphemus</i> | 239 |
| <p>FIG. 1. Inner surface of the test of the eye of adult <i>Limulus</i> showing cones with a minute opening at the apex. $\times 6$. The sharp apex of the cones is shown near the edges where they are seen more in profile.</p> | |
| <p>2. Exterior of the same eye of which the interior is shown by fig. 1. The pits and ridges of the test between them is finely shown. $\times 7$.</p> | |
| <p>3. A portion of the outer surface of the eye represented by fig. 2 enlarged to 25 diameters.</p> | |
| <p>4. Enlargement of the outer surface of the eye on a cephalon 7 mm. in length. $\times 25$. This represents the eye in a younger stage of growth than that represented by figs. 2 and 3 where the pits have ridges between them that are flatter and broader and more like those of <i>Olenellus gilberti</i> as shown by fig. 5.</p> | |
| <i>Olenellus gilberti</i> Meek (See pl. 36) | 239 |
| <p>FIG. 5. Enlargement of the visual surface, palpebral lobe, and portion of the glabella, $\times 75$, of the cephalon represented by fig. 6. There are 42 openings on the portion of the visual surface exposed. These openings and the ridges separating them are similar in appearance to those of the eye of young specimens of <i>Limulus polyphemus</i> as shown by fig. 4.</p> | |
| <p>6. A small cephalon. $\times 50$. The right eye of this is shown in fig. 5.</p> | |
| <p>The specimen represented by figs. 5 and 6 is from the limestone at (351), Ptarmigan Pass, Alberta (see pl. 36, figs. 11-16). U. S. National Museum,* Catalogue No. 56828f.</p> | |



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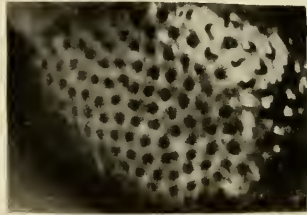
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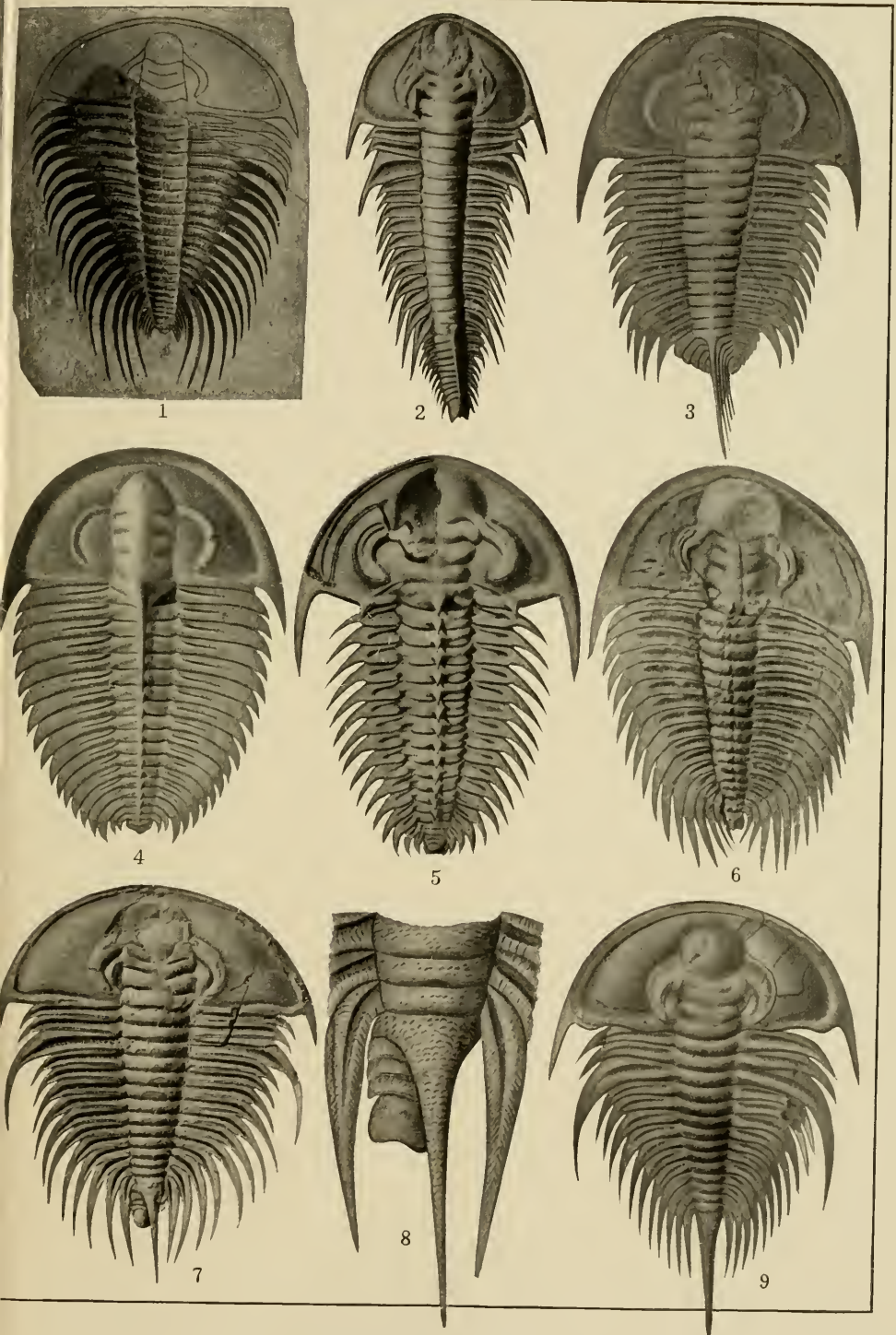
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Enlargement of the posterior portion of fig. 7 showing the rudimentary segments and pygidium beneath the telson-like segment.	
9. <i>Olenellus thompsoni</i> Hall (pl. 35).....	336

The above series of figures is reproduced in order to illustrate the variation in the principal genera of the Mesonacidae, also in order that the student may at a glance note the changes from the most primitive form *Nevadia* (fig. 1) through one line of descent, as represented by figs. 2, 3, and 7, to *Olenellus* (fig. 9).

On another line of descent the figures serve to illustrate through figs. 1, 3, 4, 5, and 6 the probable line of descent from *Nevadia* (fig. 1) to *Holmia* (fig. 5) and on to *Paradoxides*.



LOWER CAMBRIAN TRILOBITES

INDEX

NOTE.—The first reference to each of the species described in this paper gives the page upon which the description begins and the figure references. References to the description of certain parts or features of a species are only given in the index if the description occurs outside of the detailed description of the species. For instance: the description of the pygidium of a certain species will be found in the description of that species and there will be no specific reference in the index to the pygidium unless it is described or discussed at some other point in the paper.

The list on pages 351-371 may be regarded as a completely cross-referenced index to the synonymy in this paper, and only the actual references as they occur in the synonymy will be found in this index.

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