

41. ADDITIONS to the FAUNA of the OLENELLUS-ZONE of the NORTH-WEST HIGHLANDS. By B. N. PEACH, Esq., F.R.S., F.G.S., of the Geological Survey of Scotland. (Communicated by permission of the Director-General of the Geological Survey. Read June 20th, 1894.)

[PLATES XXIX.-XXXII.]

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I. INTRODUCTION.

It is now two years since Mr. Horne and I communicated to this Society details of the discovery by the Geological Survey of *Olenellus* in the 'Furoid Beds' and Serpulite Grit of the west of Ross-shire, which in our opinion proved the Lower Cambrian age of those strata. The discovery has been followed up by the Survey, and through the kindness of Major Robertson, the shooting tenant, and of Mr. A. P. Purves, the agent for Mr. Mackenzie, the proprietor of the Dundonnell Forest, facilities were afforded to Mr. A. Macconochie, Fossil Collector of the Survey, which allowed him to make a more exhaustive search of the localities mentioned in our paper. The search resulted in his obtaining a considerable amount of new material.

While the work of the Survey was advancing in the region around the head of Loch Maree, prior to the discovery of *Olenellus* at Dundonnell, certain outcrops of the 'Furoid Beds' were considered fossiliferous, and were accordingly marked off to be further searched by the collector. One of these, situated in Glen Cruchallie, more commonly, though erroneously, known as Glen Logan, yielded Mr. Macconochie specimens of *Salterella* and *Hyolithes*, but no recognizable fragments of trilobite. The other outcrop, noticed by Mr. Greenly, occurs on the northern slopes of Meall a' Ghubhais at a height of between 1200 and 1300 feet, just over the tree-line, and about 4 miles north-west of Kenlochewe. As this locality is situated in the Sanctuary, or most carefully preserved part of the Kenlochewe Deer Forest, it could not be searched when Mr. Macconochie's services were available, owing to the approach of the stalking season.

Early in the field-work of last year, Messrs. Horne, Gunn, and Clough had occasion to visit this locality, in order to study the effects of movement on different members of the Torridonian Series, which have there been thrust over the Cambrian rocks and left as an outlier by denudation to form the upper part of Meall a' Ghubhais.

At the same time, they made a short search at this exposure of the 'Furoid Beds,' which, although they lie not far beneath the outcrop of the 'thrust-plane,' are comparatively free from disturbance. Mr. Horne found a fine specimen of *Acrothele subsidua*, a small brachiopod which is associated with the *Olenellus*-fauna in Utah and Nevada. Mr. Macconochie was soon afterwards despatched to Kenlochewe, and having had every facility afforded him by Mr. Cazalet, the tenant of the forest, soon struck upon the beds which yield *Olenellus*, and made a fine collection. He likewise returned to the outcrops in Glen Logan and proved the occurrence of *Olenellus* in the 'Furoid' Shales there; but, in consequence of the strata being much affected by post-Cambrian movements, the specimens are too indistinct for description. The collections thus secured were placed in my hands, as acting Palæontologist to the Geological Survey of Scotland, and, by permission of the Director-General, I now beg to lay before this Society as a sequel to the former paper¹ a description of the trilobite-remains.

II. DESCRIPTION OF A NEW SUB-GENUS AND SOME NEW SPECIES OF TRILOBITES.

The trilobite-remains in this collection consist of several hundred fragments, chiefly head-shields, a few nearly complete individuals with both head-shields and body-segments attached, several minor fragments affording good material for study, and a large number of pieces that may be called scraps. These various specimens enable me to complete the account of the structure of *Olenellus Lapworthi*, described by me from head-shields alone, as well as to announce the existence of other species of the genus. Moreover, the specimens include numerous head-shields and one almost complete individual that appears to belong to a separate sub-genus.

Genus OLENELLUS, Hall.²

OLENELLUS LAPWORTH, Peach. (Pl. XXIX. figs. 1, 2, 2 a; Pl. XXX. fig. 7.)

Head-shield described in a former paper.³ Body-segments, fourteen in number, all free, with well-embossed axes divided from the pleura by shallow axial furrows, and each bearing in the mid-line near the posterior margin a small tubercle or short spine. The pleura, which are wide, with thickened fulcral margins, well-marked fulcral grooves, and thickened posterior margins, are bent back suddenly upon themselves opposite the end of the fulcral groove, and terminate in a more or less produced, recurved spine. The axes, which, next to the head-shield, are nearly as wide as the occipital ring itself, carry their breadth down to the third segment; thence they diminish backward till the axis of the fourteenth segment is a little less than one half the breadth of the first.

¹ Quart. Journ. Geol. Soc. vol. xlviii. (1892) pp. 227-241.

² The genus *Olenellus* is here used in the restricted sense explained in my former paper, *op. cit.*

³ *Ibid.*

The relation of depth to breadth is nearly the same in all the axes, and varies in the proportion of 1 : 3 or 3 : 8. The pleura, in consequence of overlapping each other, are a little deeper than the corresponding axial portions. Those of segment No. 1 are directed slightly forward, and preserve their full breadth as far as the pleural angles of the head-shield, where they are abruptly truncated, their postero-lateral angles being each set with a short spine. In segment No. 2 the pleura are set at right angles to the general axis of the body, and extend to the tips of No. 1; but they are not so sharply truncated as in that segment, being bent back and ending in rather longer spines.

The pleura of segment No. 3 form a most conspicuous feature. They gradually expand from the axis outward till they attain double its breadth opposite the pleural spines of the preceding segment, beyond which they suddenly bend off at almost right angles, taper rapidly, and are continued into more or less flattened spines nearly as long as the pleura themselves. The fulcral ridges and grooves are also more pronounced on this segment than on any other.

In consequence of the great expansion of the pleura of segment No. 3, those of No. 4 are directed slightly backward. They are much narrower and shorter than the pleura of the former segment, their fulcral points being well within its posterior curves. Like those of No. 1, they terminate abruptly, but their spines are a little longer than in that segment. In No. 5 the pleura are set more distinctly backward, and are a little longer in proportion to the size of the axis than those of No. 4; their terminal spines also are somewhat longer.

In segment No. 6 there is a sudden increase in the size of the pleura, especially in the spines, that reminds one of No. 3. The succeeding four segments are all much like No. 6 in appearance, though the pleura of each are set at a smaller angle to the axis than the immediately preceding ones, and the spines are each in turn more bent inward towards their tips in order to prevent overlapping.

The hindermost four segments have their pleura set at an increasingly acute angle to the axis, till the posterior margins of those of the fourteenth segment almost coincide in direction with it, while their spines rapidly and successively become smaller.

The telson has not been observed in place, but it is presumed that it is styliiform, precisely as in the variety of this species which will be subsequently described. The whole of the parts are more or less marked by the peculiar reticulated pattern described in my former paper (*op. cit.* p. 239, pl. v. fig. 2 b). This sculpture is most conspicuous on the glabella and cheeks, and on the anterior portion of the axes and the pleura of the body-segments. In this species it is small, compared with the size of the animal.

The chief character which distinguishes *Olenellus Lapworthi* from

all the American species as yet described is that the posterior angles of the eye-lobes are set much farther out from the edge of the glabella in this species—a character which it shares in common with all the other species in the collection under review. From *Olenellus Thompsoni* and *O. Gilberti*, which it most nearly approaches, it is further distinguished by the line of tubercles ranging from the occiput, and extending down the axes of all the segments.

TABLE OF MEASUREMENTS OF *Olenellus Lapworthi*.

	M. 4085 ^d . Pl. XXIX. fig. 1.	M. 4078 ^d . Pl. XXIX. figs. 2 & 2a.
	mm.	mm.
Length of head-shield and first ten segments of body	25	
Length of head-shield and body-segments, exclusive of telson ...	.....	20
Length of head-shield	13	9
Breadth of do.	26	20

The figures at the top of the columns are the registered numbers of the specimens in the books of the Geological Survey of Scotland.

OLENELLUS LAPWORTHI, var. *ELONGATUS*, nov. (Pl. XXIX. figs. 3–6.)

This name is proposed to include the more elongated forms of this species. Fig. 3, Pl. XXIX., represents a nearly complete specimen enlarged two diameters. In general contour of the body, it is somewhat more elongated than *O. Lapworthi*. Its specially distinguishing feature, however, is the unusually developed pleural spines of the third body-segment, which not only extend much farther backward than in that species, but are curved inward in the same manner as in *Olenellus Gilberti*, a species found on the side of the Rocky Mountains opposite to that wherein *O. Thompsoni* has been found. Like the former, it appears to have terminated in a long spear-like telson, portion of which is seen in fig. 3, Pl. XXIX., which is too imperfect to show the details of its configuration or to indicate its probable length.

Several fragments of the third body-segment of this form are preserved in the collection under review. The test of this variety is ornamented with a sculpturing similar to that of *O. Lapworthi*. A portion of a labrum which seems to belong to this variety is reproduced in Pl. XXIX. fig. 5, magnified two diameters.

The specimen from which fig. 3, Pl. XXIX., was taken gives the following measurements:—

Full length without telson	22 mm.
" with " 	25 "
Length of carapace	10 "
Breadth of do.	19 "
" body across third segment ...	14 "

OLENELLUS RETICULATUS, sp. nov. (Pl. XXX. figs. 1-6, 8-14;
Pl. XXXI. figs. 1-7.)

In the collection under review there are numerous remains of an *Olenellus* of much larger size than *O. Lapworthi*, which in many other respects it greatly resembles. 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 styliform, and tapers rapidly at first and then decreasingly. Its articulation with the last free segment is well shown in the specimen from which Pl. XXX. fig. 12 was taken. Projecting from the posterior margin of the axis of the fourteenth free segment, at about $\frac{1}{2}$ 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.

A detached labrum which may have belonged to an individual of this species is shown, nat. size, in Pl. XXX. fig. 13.

There appears to be a considerable range in the configuration of different individuals of this species. Pl. XXXI. fig. 3 represents an elongated form which appears to have been even further elongated, and in fact distorted after having been embedded in the rock.

Pl. XXXI. figs. 1 and 2 show what appears to be a broader form, but it has been distorted first by having the first two free segments 'telescoped' into the head-shield, and by having the body folded upon itself at the eighth free segment, the dorsal tubercle of which is well seen against the matrix at the fold. By a fortunate breaking-away of part of the test which adheres to the counterpart, the pleura of the hindermost segments and the greater portion of the telson can be observed at a lower level in the matrix. Since it has been embedded, the specimen has been further broadened and distorted by faulting of the matrix.

TABLE OF MEASUREMENTS OF *Olenellus reticulatus*.

	M. 4076 ^d . Pl. XXX. fig. 1.	M. 4104 ^d . Pl. XXX. fig. 2.	M. 4161 ^d . Pl. XXX. fig. 4.	M. 4142 ^d . Pl. XXXI. figs. 1, 2.	M. 4078 ^d . Pl. XXXI. g. 3.	M. 4093 ^a . Pl. XXX. fig. 5.
	mm.	mm.	mm.	mm.	mm.	mm.
Full length of parts preserved.....	.....	.....	50	.....	.....	.....
Length of head-shield ...	29	33	.....	.....	.....	27
Breadth of do. ...	50	46	60	50	.....	40
Length of body .....	.....	.....	40	.....	27	.....
„ eight segments .....	.....	.....	.....	33	.....	.....
Breadth of third segment .....	.....	.....	40	36	24	.....
Length of spine of do....	.....	.....	22	20	20	.....
Length of telson visible...	.....	.....	.....	15	.....	.....

OLENELLUS GIGAS, sp. nov. (fig. 1, p. 667).

Fragments of a large species of trilobite with a strong genal spine and reticulated ornament were figured in a former paper (*op. jam cit.* pl. v. figs. 12, 12 a, 12 b). In the present collection a specimen occurs which gives most of the detail of the dorsal aspect of the head-shield: this 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 of carapace of *Olenellus gigas*, M. 1154^d:—

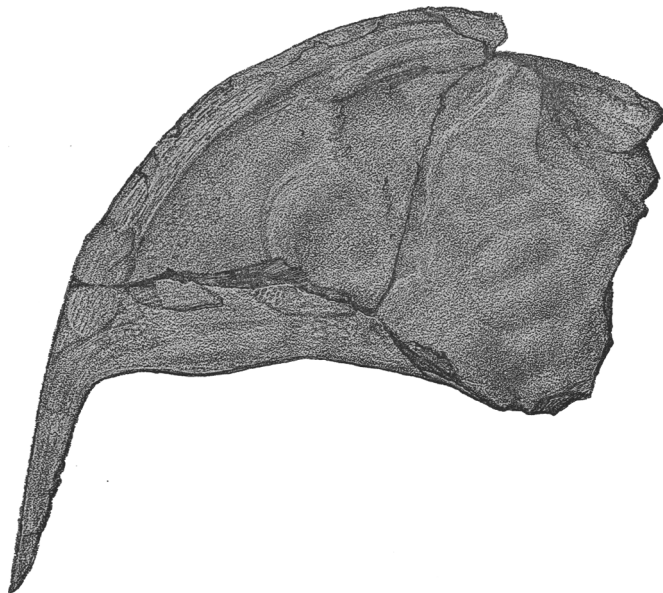
Length of head-shield 52 mm.
Breadth of do. 106 mm. = 4½ inches.

OLENELLUS INTERMEDIUS, sp. nov. (Pl. XXXII. fig. 7.)

This species is founded on a single head-shield, preserved in relief in a decomposing ochreous bed, and its counterpart. It is doubtfully

placed in the genus *Olenellus*. As it combines several of the features of the sub-genera of *Olenellus*, I have given it the specific name of *intermedius*.

Fig. 1.—*Olenellus gigas*, sp. nov. (Natural size.)



The head-shield is roughly hexagonal, the anterior and posterior sides of the hexagon being much the longest, so that the shield is wide compared with its depth. The anterior margin, which forms three sides of the hexagon, is divided into a long median section, which is slightly convex, bent round at obtuse angles and continued into the other two sides; these are straight and produced backwards into strong genal spines, the whole margin being strengthened by a well-rounded ridge. The posterior margin makes up the other three sides of the hexagon. The median portion, made up of the margin of the occiput and the edge of the cheeks as far as the pleural angles, is convex. At the pleural angles are placed two spines (Ford's 'interocular spines'). The margin between these and the genal spines is defined by almost straight lines, which form the remaining sides of the hexagon. It is thickened in the same manner as the anterior margin.

The cheeks are tumid and divided from the raised margin, the glabella, and the eye-lobes by a depression. A groove, continuous with that of the occipital groove of the glabella, is produced out towards the base of the spine upon the pleural angle. No free cheek nor facial suture has been observed. The glabella, which is highly embossed, extends from close upon the thickened anterior

margin to the posterior margin, is rounded in front, broadest at the base of the eye-lobes, and narrowest to just behind the second furrow. It then increases in breadth backward. It is divided into five lobes by furrows which are not so much bent backward in the middle as in *O. Lapworthi*. A small tubercle occurs on the occipital ring. The eye-lobes are reniform, and set out at more obtuse angles than in any of those already described; they extend back only so far as to be opposite to the second glabellar furrow. The area in the angle made by the glabella with the eye-lobes is tumid. The test is ornamented with the characteristic reticulate pattern.

Measurements:—

Length of head-shield	3 mm.
Breadth of do.	7.5 „
Length of genal spine	2.5 „

OLENELLOIDES, subgen. nov.

The collection of fossils from Meall a' Ghubhais contains numerous head-shields, and one specimen and its counterpart with head-shield and eight body-segments attached, of a peculiar, small, narrow trilobite armed with long spines at regular intervals. It is evident that it is nearly allied to *Olenellus*, in which genus I should prefer to allow it to remain; but though all the specimens may belong to only one species, yet the individuality of that species is so strongly marked that perhaps it would be better to place it in a separate sub-genus taking rank with *Holmia* and *Mesonacis* under *Olenellus*. The name that I have proposed for it is intended to show its strong likeness to some larval stages of other Olenellids.

Description. Small, elongated, and narrow in general outline, and set with long spines at regular intervals.

Head-shield roughly hexagonal, produced into long and strong spines at all the angles, and strengthened on all sides except the posterior one by a strong, rounded, raised margin, which is widest at the angles. Its greatest width is across from base to base of the mid-pair of marginal spines. The glabella, which occupies about half the area of the head-shield, is well embossed, almost cylindrical, divided into five distinct lobes, and extends nearly the whole length of the shield. It is rounded in front, slightly constricted near the second furrow, and widest at the occipital ring, which bears a small blunt tubercle in the mid-line. The eye-lobes are reniform, proceeding out from the frontal lobe just in front of the first furrow, and with their distal ends well set out from the glabella. The visual slits occupy nearly the whole length of the outward or convex edges of the eye-lobes. No free cheeks nor facial suture.

Number of body-segments unknown. The characters of the eight preserved show that the body was long and narrow, and that the segments are well trilobed, with highly embossed axes, which are wide compared with the pleura. The latter are marked off from the axial parts by a shallow furrow, have fulcral thickening in front, wide fulcral grooves, and end in short spines at the postero-lateral angles, except in the third and sixth segments, where the spines are

long and strong. The body suddenly narrows behind the sixth segment, and the pleura of the seventh and eighth segments are very small; hence it is inferred that it would require only a very few more segments to complete the body. Nature of telson unknown.

The characteristic features of this sub-genus are the great size of the axis of the body compared with the cheeks and pleura, the hexagonal head-shield with its angles set with spines, and the recurrence of larger pleura and highly elongated spines on the third and sixth body-segments.

OLENELLOIDES ARMATUS, sp. nov. (Pl. XXXII. figs. 1-6.)

The head-shield, which is hexagonal and set with long spines at the angles, is of about the same length as the first six body-segments and varies in proportion in different individuals as 1 : 1 and 4 : 3. It is bordered on five sides by a thickened, rounded margin, which is widest at the angles. The anterior margin between the first pair of spines is convex, and these spines are set forward at angles of about 30° to 35° to the general axis of the body. The margins between these and the lateral spines make almost straight lines, the head-shield being at its widest opposite the bases of these lateral spines, which are set backward at angles of about 50° to the axis of the body. Behind these spines the shield tapers rapidly at first and then more gradually, so that the margins between the lateral spines and the posterior ones are concave. The posterior spines are directed backward and set at an angle of about 30° to the long axis of the body; they are slightly curved inward towards their tips.

The posterior margin is convex, being made up of the posterior margin of the occiput, which constitutes $\frac{2}{3}$ of the whole, the remaining $\frac{1}{3}$ being occupied by the margins of the cheeks, which are marked off from the occipital part by deep notches. The glabella, which is nearly cylindrical and rounded in front, extends almost from end to end of the head-shield, and occupies the greater part of the cephalic area. It is divided into five lobes, wide in front, narrowing somewhat at the lobe behind the first furrow, and widest at the occiput. The furrows are nearly **M**-shaped, in consequence of which the frontal lobe is pear-shaped and the others are more or less cordate, the lobe immediately behind the first furrow being the smallest. The occipital lobe bears a small spine or tubercle in the mid-line. The eye-lobes are reniform, proceed out from the frontal lobe towards the outer margin, and terminate just behind the bases of the lateral spines opposite the third lobe of the axis, the ocular slit extending throughout the greater part of its outer or convex margin. The cheeks in front of the eye-lobes and glabella are hollow. A narrow ridge runs from the angle made by the eye-lobe and the glabella as far back as to opposite the third furrow; another ridge runs from this furrow to the base of the posterior spine. These ridges are separated from the glabella and eye-lobes by deep furrows. No free cheeks nor facial suture observed.

Body-segments, number unknown, eight only being preserved.

Each of these consists of a well-marked axis, very large in proportion to the pleura, from which it is marked off by shallow axial grooves, and bearing a tubercle or small spine in the mid-line near the posterior edge. The axis of the first segment is of about the same width as the occiput, and this width is maintained as far as that of the third segment. From this point they taper gradually backward to the sixth segment, behind which there is a comparatively sudden contraction, the seventh and eighth segments being much smaller than any of the rest. The pleura, which are almost quadrate in shape, have fulcral ridges and grooves, and spines on their postero-lateral angles. These are small and insignificant, except on the pleura of the third and sixth segments, which are long and strong, and set backward at almost the same angle as the posterior spines of the head-shield.

From the sudden tapering behind the sixth segment, and from the nature of the pleura of the seventh and eighth segments, which are especially small and set backward, it is inferred that the body never bore many more than those exhibited. The nature of the terminal segment or telson is unknown, though it was in all probability styliform.

Some of the specimens show that the test was ornamented with a reticulated pattern, as in *Olenellus* and other early trilobites.

TABLE OF MEASUREMENTS OF *Olenelloides armatus*.

	M. 4111 ^d . Pl. XXXII. figs. 1-3.	M. 4116 ^d . Pl. XXXII. fig. 4.	M. 4117 ^d . Pl. XXXII. fig. 5.	M. 4127 ^d . Pl. XXXII. fig. 6.
	mm.	mm.	mm.	mm.
Length of head-shield and eight segments, exclusive of spines	11			
Length of head-shield, exclusive of spines	5	4.75	3	4
Breadth of do.	4	4.5	2.5	4
Breadth at anterior margin	2	3	1.75	2.5
„ „ posterior do. ...	3	3.5	1.75	3
Average length of spines on head-shield	2.5	2.5	2.5	
Average breadth of axis of glabella	1.75	1.75	1.25	1.75
Breadth of 1st body-segment	3.5			
„ of axis of do.	1.75			
Depth of do.	1			
Breadth of third segment...	3.75			
„ of axis of do.	1.75			
Depth of do.	1			
Length of spine on do.	2.25			
Breadth of sixth segment...	2			
„ of axis of do.	1			
Depth of do. ....	.75			
Length of spine on do.	1.5			
Breadth of seventh and eighth segments	1			
Depth of axis of do. ....	.4			

Genus BATHYNOTUS, Hall.

BATHYNOTUS HOLOPYGIA? Hall.

Some fragments consisting of a portion of a glabella and fixed cheeks, and several slender spines of trilobites which cannot well belong to any known species of *Olenellus*, but which fairly answer to the description of parts belonging to *Bathynotus holopygia*, occur in the collection under review, and have been provisionally named as above till such time as further evidence regarding their nature is forthcoming.

III. THEORETICAL CONSIDERATIONS BASED UPON THE STUDY OF
THE REMAINS DESCRIBED.

Having described these trilobites, I may now proceed to compare them among themselves and with other known Olenellids, and endeavour to correlate their homologous parts. In all the Olenellids the glabella and eye-lobes are so similar, that no difficulty arises in correlating part with part. It is not so with the marginal spines of the head-shield. The spines upon the pleural angles of the posterior margin in *Olenellus intermedius*, Pl. XXXII. fig. 7, and so strongly pronounced in *Olenelloides*, Pl. XXXII. figs. 1-6, are represented in the other forms in the collection by the rounded-off pleural angles. They have been shown by Ford and Walcott to be present in young stages of the American *Mesonacis (Olenellus) asaphoides*, Pl. XXXII. fig. 11, and to disappear into the rounded pleural angles in the adult. They are present as spines in *Holmia (Olenellus) Kjerulfi*, Pl. XXXII. fig. 12, and in the other described species of this genus. A study of fig. 12 (after Holm) reveals that they are, in all probability, the pleural spines of a segment comparable with one of the free body-segments, the traces of the axis and pleura of which have not been obliterated by its fusion with the other segments of the head-shield.

The genal spines of most Olenellids occupy the postero-lateral angles of the head-shield. That this was not their original position is made almost certain by the researches of S. W. Ford and Walcott, who have shown that in some of the young stages of *Olenellus Gilberti*, Pl. XXXII. fig. 9, these spines may be produced in a line with the anterior margin, and that they travel round as the animal gets older, Pl. XXXII. fig. 10. In *Olenelloides*, Pl. XXXII. figs. 1-6, we have an adult form which shows these spines placed about halfway between the anterior and posterior margins. That they have travelled back from a more anterior position is rendered probable by the margin behind them being concave. If that be the case, the notch between the genal spines and the pleural angles in *Olenellus*, *Holmia*, and *Mesonacis* represents what has once been a lateral margin. This inference is supported by evidence gained from the study of the ornamentation on *Olenellus*. In the paper read before this Society in 1892 I pointed out that the polygonal pattern of the test becomes highly elongated on the thickened

margins, the elongation being more or less parallel with the outside edge. In *Olenellus reticulatus* and *O. gigas* this elongated pattern is continued inward beyond the genal spines, but ceases at the pleural angles, the pattern on the raised spaces between these latter points and the sides of the occiput being similar to that found on the pleura of the first free body-ring. If it has been shown that there is good reason to believe that what have once been lateral margins have become posterior, the difference between those trilobites whose facial sutures terminate upon the lateral and posterior margins respectively may be more apparent than real.

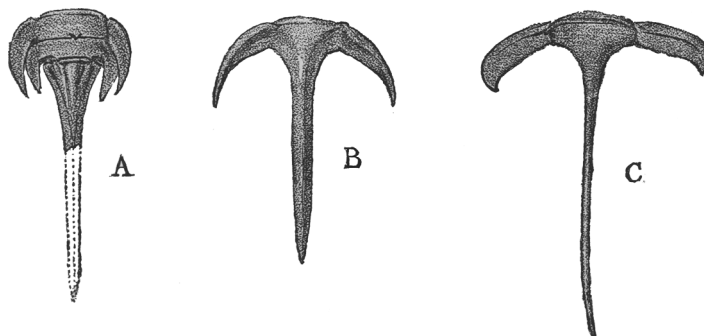
No exact homologues of the anterior spines in *Olenelloides* have been observed. It may be that the rounded anterior angles of *Olenellus intermedius*, Pl. XXXII. fig. 7, represent the places where such spines have disappeared. As I have already shown, the elongated spines recur at intervals of every third segment on the body of *Olenelloides*, Pl. XXXII. figs. 1-3, and there is a strong presumption in favour of the posterior spines of the head-shield being the representatives of the pleural spines. The idea suggests itself that the genal and even the anterior spines may represent such elongated pleural spines, in which case, if the intervals between them be the same as in the body, the head-shield may represent at least seven original segments. At first sight, it looks as if this arrangement of more pronounced spines at regular intervals were confined to *Olenelloides*, but there is a slight recurrence of the phenomenon in *Olenellus Lapworthi* and *O. reticulatus*, for while in them the pleura of the fourth and fifth segments are short and like those of the first and second, those of the sixth segment suddenly expand and bear longer recurved spines. Behind this latter segment the analogy ceases, for the sixth is followed by three or four similar segments.

So far as dorsal spines are concerned, it is an easy matter to correlate them, notwithstanding the fact that some are mere raised tubercles and others enormously-produced spines like those on *Holmia Bröggeri*, *Mesonacis asaphoides*, *M. vermontana*, and *M. Mickwitziae*. Keeping this in view, it is not difficult to see in the hastate telson of *Olenellus* the homologue of the small pygidium of *Holmia* and *Mesonacis*, each being a single segment. In the former case the dorsal spine has been enormously developed and the rest of the structure dwarfed, while in the latter case the corresponding spine is rudimentary. (See fig. 2, p. 673.)

The question naturally arises as to what could be the function of the spines. Concerning those that fringe the edge of the head and body, it is highly probable that they served to prevent the bearers from sinking into soft, flocculent sediment, and so being stifled. As the genital organs in annelids and most arthropods open well forward in the body, it may be that the function of the enormously-expanded pleura of the third body-segment in *Olenellus* was to provide space for enlarged genital glands about this region of the body, and, as suggested in the former paper, the form of the pleura and their spines may even denote sex.

The absence of faceted pleura shows that these Olenellids had not acquired the habit of rolling up, so that dorsal spines such as those found on *Mesonacis* and *Holmia* were probably protective. If so, one asks, what was the nature of the enemies from which these creatures had to defend themselves? We may infer that

Fig. 2.



- A = *Olenellus reticulatus*, last two body-segments and telson.
B = *Mesonacis Mickwitzia*, eighth body-segment. (After Schmidt.)
C = *Mesonacis asaphoides*, thirteenth body-segment. (After Walcott.)

they were large, for *Holmia Bröggeri* and *Mesonacis asaphoides* are of considerable size. That small enemies preyed upon them, living or dead, is made certain by the occurrence in the collection under review of *Olenellus*-spines which have been bored by some annelid or other animal before fossilization, Pl. XXXII. figs. 13-15. The strong spiniform telson may have been used by *Olenellus* for purposes similar to that fulfilled by the telson in the recent *Limulus*.

The study of these Olenellids plainly shows them to have been very primitive trilobites. They have all their body-segments free. Their glabella is long and cylindrical, and divided into lobes by well-marked furrows. Their eye-lobes are outgrowths from the glabella, and have not wandered far from the primitive axis of the body. There is good evidence for the belief that the occipital or nuchal ring has been once a free segment, and the last to be added to the head-shield, and that the genal spines have travelled back from a more anterior position.

Of all the Olenellids yet described *Holmia (Olenellus) Kjerulfi* is the most generalized. None of its body-segments are so specialized as to make it conspicuous among its fellows, nor are any of its spines, except the genal ones, more elongated than its neighbours. Its nuchal or occipital segment is much like one of its free segments, but it is fused to the preceding segment instead of being articulated with it. Its genal spines are intermediate in position between those of *Olenelloides* and *Olenellus*, in which respect it is not quite so primitive as the former. From it all the other forms as yet

described, except *Olenelloides*, could easily be produced by exaggeration or suppression of some of its spines, or by addition to or diminution from the number of its body-rings. From *Holmia* (*O.*) *Kjerulfi* (Linnarsson), as a central type, it would require a less amount of modification to produce the *H. (O.) Callavei* (Lapworth) of Shropshire than the *H. (O.) Bröggeri* (Walcott) of Newfoundland; and in like manner the *Mesonacis (O.) Mickwitzæ* (Schmidt) of Russia than the *M. (O.) vermontana* (Hall) or *M. (O.) asaphoides* (Emmons) of America. Further, the species of *Olenellus* found in the North-west Highlands of Scotland would require less modification than the *Olenellus Thompsoni* (Hall) or *O. Gilberti* (Walcott) of America. The consideration of these points makes it probable that the dispersal of the Olenellids was from the Old towards the New World.

EXPLANATION OF PLATES XXIX.—XXXII.

PLATE XXIX.

- Fig. 1. *Olenellus Lapworthi*. Underside, with imperfect labrum in place. Enlarged 2 diameters. From 'Furoid Beds,' Meall a' Ghubhais, Kenlochewe, Ross-shire. M. 4085^d.¹
- Fig. 2. *O. Lapworthi*. Enlarged 2 diameters. Same locality and formation. M. 4078^d.
- Fig. 2a. *O. Lapworthi*. Counterpart of fig. 2. M. 4078^{da}.
- Fig. 3. *O. Lapworthi*, var. *elongatus*. Enlarged 2 diameters. Same locality. M. 4080^d.
- Fig. 4. *O. Lapworthi*, var. *elongatus*. Enlarged 2 diameters. Same locality. M. 4089^d.
- Fig. 4a. *O. Lapworthi*, var. *elongatus*. Counterpart of fig. 4. M. 4089^{da}.
- Fig. 5. *O. Lapworthi*, var. *elongatus*. Enlarged 2 diameters. Labrum supposed to belong to this variety. Same locality.
- Fig. 6. *O. Lapworthi*, var. *elongatus*. Enlarged 2 diameters. Pleuron of third segment. Same locality.

PLATE XXX.

- Fig. 1. *Olenellus reticulatus*, nat. size. From 'Furoid Beds,' Meall a' Ghubhais, Kenlochewe, Ross-shire. M. 4076^d.
- Fig. 2. *O. reticulatus*, nat. size. Underside of head-shield. Same locality. M. 4104^d.
- Fig. 3. *O. reticulatus*. Portion of fig. 2, enlarged, to show nature of ornamentation.
- Fig. 4. *O. reticulatus*, nat. size. Same locality. M. 4161^d.
- Fig. 5. *O. reticulatus*, nat. size. Fragment of head-shield. Same locality. M. 4093^d.
- Fig. 6. *O. reticulatus*, nat. size. Underside of right pleuron of third body-segment. Same locality. M. 4103^d.
- Fig. 7. *O. Lapworthi*. Enlarged 3 diameters. Third body-segment. Same locality.
- Fig. 8. *O. reticulatus*. Last four segments enlarged, to show pleura and rudimentary spines on axes. Same locality. M. 4078^d.
- Fig. 9. *O. reticulatus*. Last three segments magnified, to show pleura and spines on axes. Same locality. M. 4109^d.
- Fig. 10. *O. reticulatus*. Body-segments from the tenth to the thirteenth inclusive, magnified to show pleura and spines on axes. Same locality. M. 4102^b.

¹ These are the registered numbers of the specimens in the List-books of the Geological Survey of Scotland. The M stands for Macconochie.

- Fig. 11. *O. reticulatus*. Detached body segment from posterior part of body, nat. size, to show rudimentary spine on axis.
Fig. 12. *O. reticulatus*, nat. size. Showing several body-segments and the nature of the articulation of the telson. Same locality. M. 4077^d.
Fig. 13. *O. reticulatus*, nat. size. Detached labrum, supposed to belong to an individual of this species. 'Fucoid Beds,' Allt an Bigh Jan, Dundonnell, Ross-shire.
Fig. 14. *O. reticulatus*. Portion of largest individual observed.

PLATE XXXI.

- Fig. 1. *Olenellus reticulatus*, nat. size. Shows the first two body-segments telescoped into the head-shield, the body being bent over at the eighth segment. Telson seen where the pleura of the left side have broken away, with counterpart. From 'Fucoid Beds,' Meall a' Ghubhais, Kenlochewe, Ross-shire. M. 4142^d.
Fig. 2. *O. reticulatus*, nat. size. Counterpart of fig. 1.
Fig. 3. *O. reticulatus*, nat. size. Distorted by the glabella being driven obliquely over the cheek. Same locality. M. 4078^d.
Fig. 4. *O. reticulatus*. Counterpart of fig. 3.
Fig. 5. *O. reticulatus*, nat. size. Same locality. M. 4091^d.
Fig. 6. *O. reticulatus*. Counterpart of part of fig. 5.
Fig. 7. *O. reticulatus*, nat. size. Left pleuron of third body-segment. Same locality.

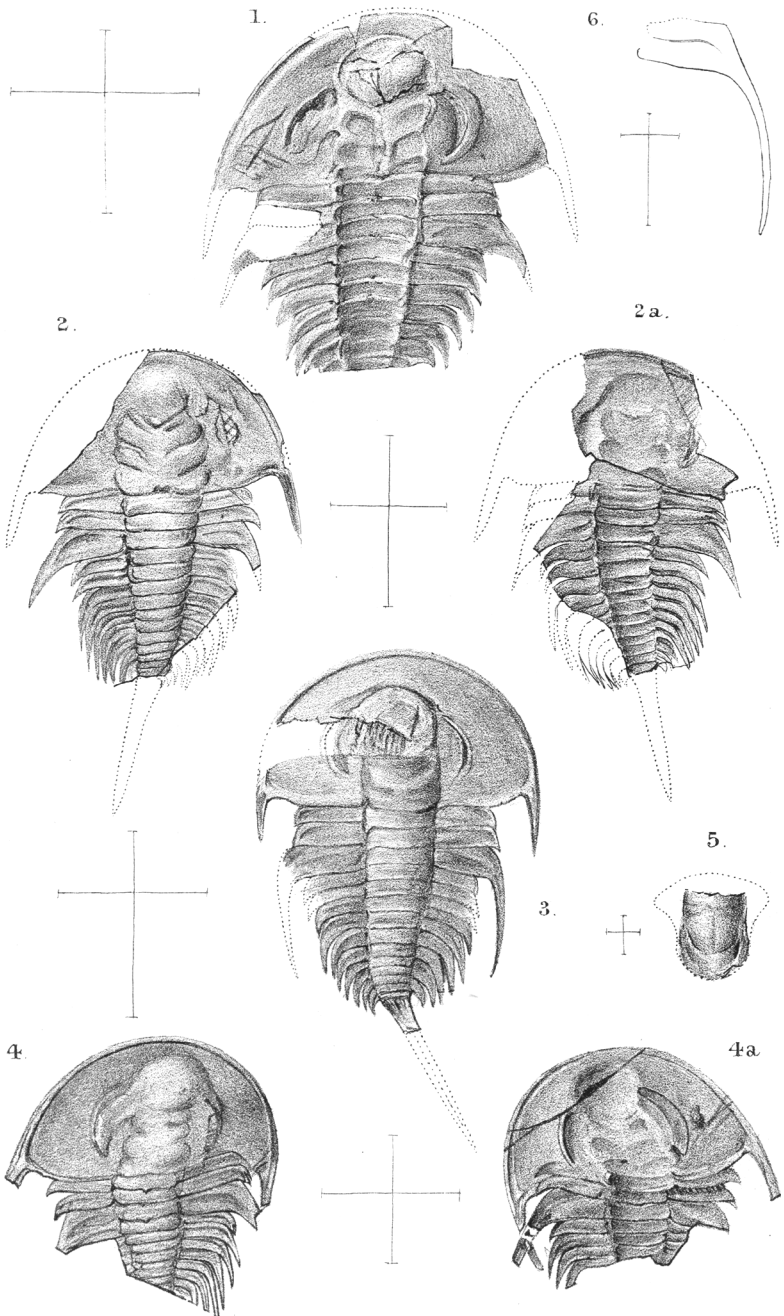
PLATE XXXII.

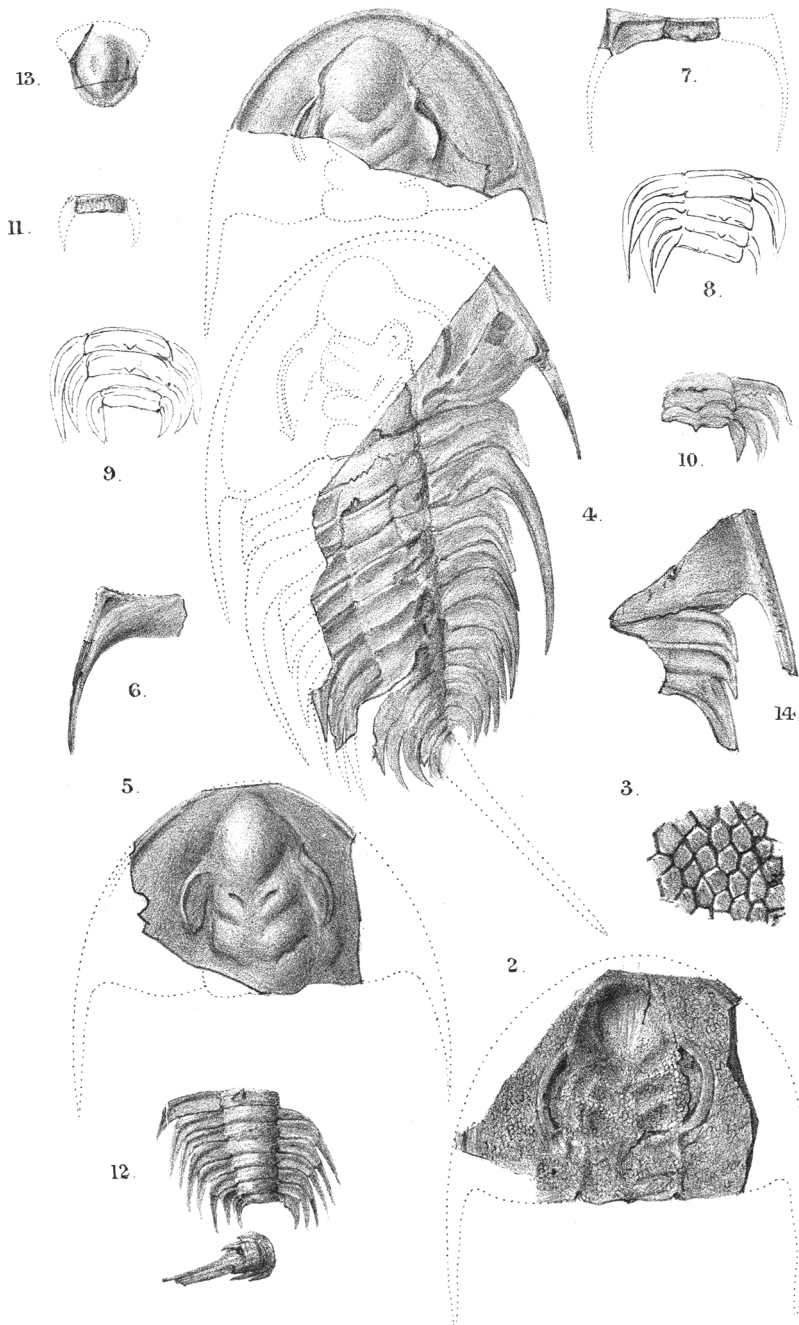
- Fig. 1. *Olenelloides armatus*. Enlarged 3 diameters, showing the outer side of the right half. 'Fucoid Beds,' Meall a' Ghubhais, Kenlochewe, Ross-shire. M. 4111^d.
Fig. 2. *O. armatus*. Enlarged 3 diameters, showing the inside view of the left side. Counterpart of fig. 1. M. 4111^{da}.
Fig. 3. *O. armatus*. Enlarged 3 diameters. Dorsal view of 1 and 2 combined.
Fig. 4. *O. armatus*. Enlarged 3 diameters. Broad head-shield. Same locality. M. 4116^d.
Fig. 5. *O. armatus*. Enlarged 3 diameters. View of inside of elongated head-shield. Same locality. M. 4117^d.
Fig. 6. *O. armatus*. Enlarged 3 diameters. Medium form of head-shield. Same locality. M. 4127^d.
Fig. 7. *Olenellus intermedius*. Enlarged 3 diameters. Head-shield. Same locality. M. 4149^d and 4149^{da}.
Fig. 8. *O. Lapworthi*, nat. size. Small head shield, to compare with figs. 4-7, showing that in this species the genal spine is at the posterior angles even in young individuals. Same locality.
Fig. 9. *O. Gilberti* (Walcott), after Ford and Walcott. Young stage, where the genal spines are placed far in advance, and given off in almost the same straight line as the anterior margin.
Fig. 10. *O. Gilberti* (Walcott), after Ford and Walcott. Young stage, in which the genal spines have travelled a little farther round than in fig. 9.
Fig. 11. *Mesonacis (O.) asaphoides* (Emmons), after Walcott. Young stage, in which the spines are still retained at the pleural angles.
Fig. 12. *Holmia (O.) Kjerulfi* (Linnarsson), after Holm, showing the head-shield and the first two free body-segments. Portion of the glabella is removed, to show the labrum in position beneath.
Fig. 13. Spine of *Olenellus gigas* bored by annelid? Nat. size. Meall a' Ghubhais, Kenlochewe, Ross-shire.
Fig. 14. Counterpart of fig. 13.
Fig. 15. Spine of *Olenellus*, bored by annelid? Nat. size. Same locality.

DISCUSSION.

Dr. HICKS said it was highly satisfactory to find that such important additions had been made to the *Olenellus*-fauna of the North-west Highlands. He would have liked to hear further details than could be given in the abstract just read, especially as to whether the new species marked distinct zones or whether they occurred together. In the *Paradoxides*-beds in South Wales, the new species did not occur together, but were separated by various thicknesses of beds. Where the deposits were sandstones the range was much greater than where they were made up of finer materials. The *Olenellus*-zone at St. David's was separated by over 800 feet of sandstone beds from the lowest *Paradoxides*-zone, and the latter by nearly 2000 feet of strata from the highest *Paradoxides*-zone. There were no less than five distinct zones, each marked by a new species. He had found it necessary from the first, more than 30 years ago, to mark the zones with great care, and it was by that means, when working afterwards in North Wales, that Mr. Salter, Mr. Homfray, and himself were able to correlate the various subdivisions with those at St. David's. He further said that in 1875 he prepared a map, which is published in the Quart. Journ. of the Society (vol. xxxi. pl. xxvii.). In that map he gave the distribution of the Cambrian and Lower Silurian faunas over the European area, and he stated in the paper which it illustrated that he thought the migrations were from the Atlantic in a north-easterly direction over Europe, and in a north-westerly direction over America.

Dr. G. J. HINDE also spoke.

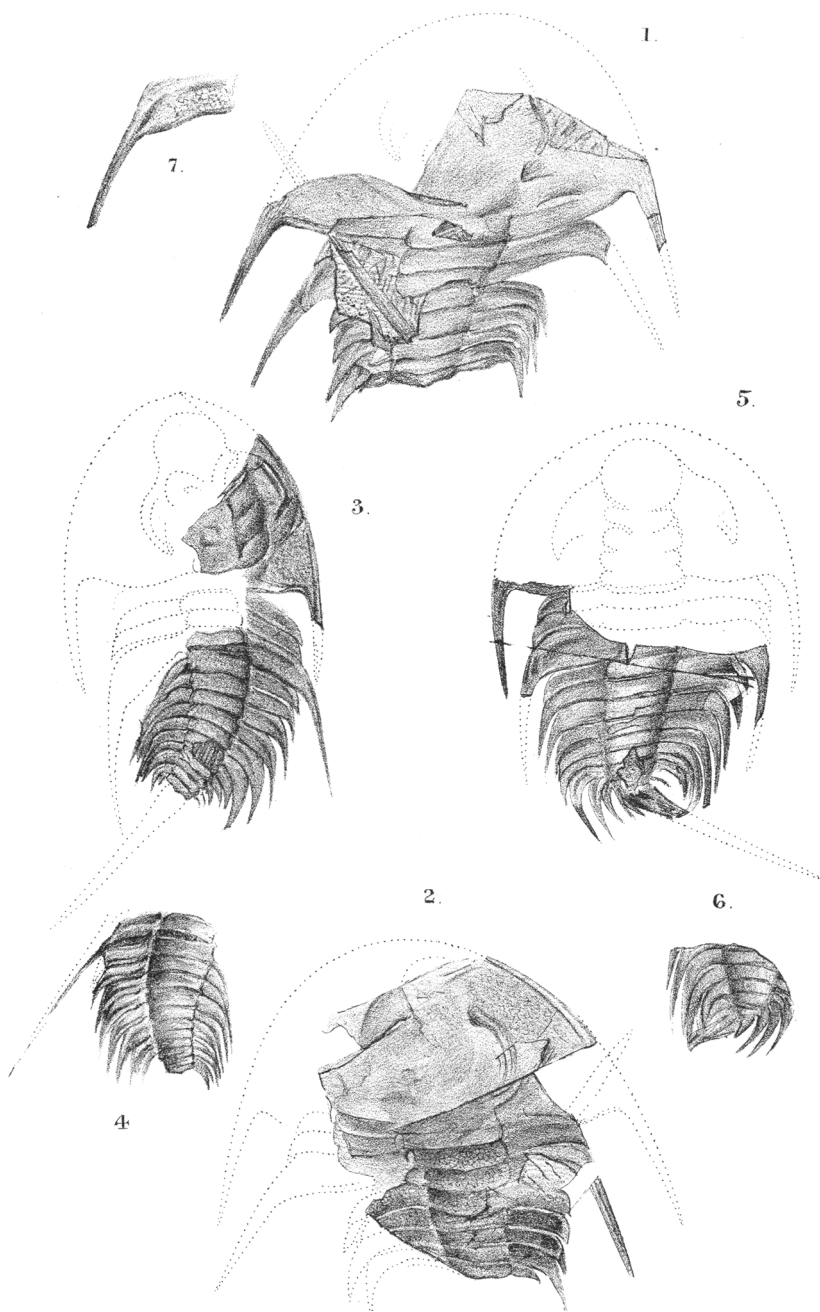




B.N.Peach del. F.H.Michael lith.

OLENELLUS RETICULATUS.
& O. LAPWORTH.

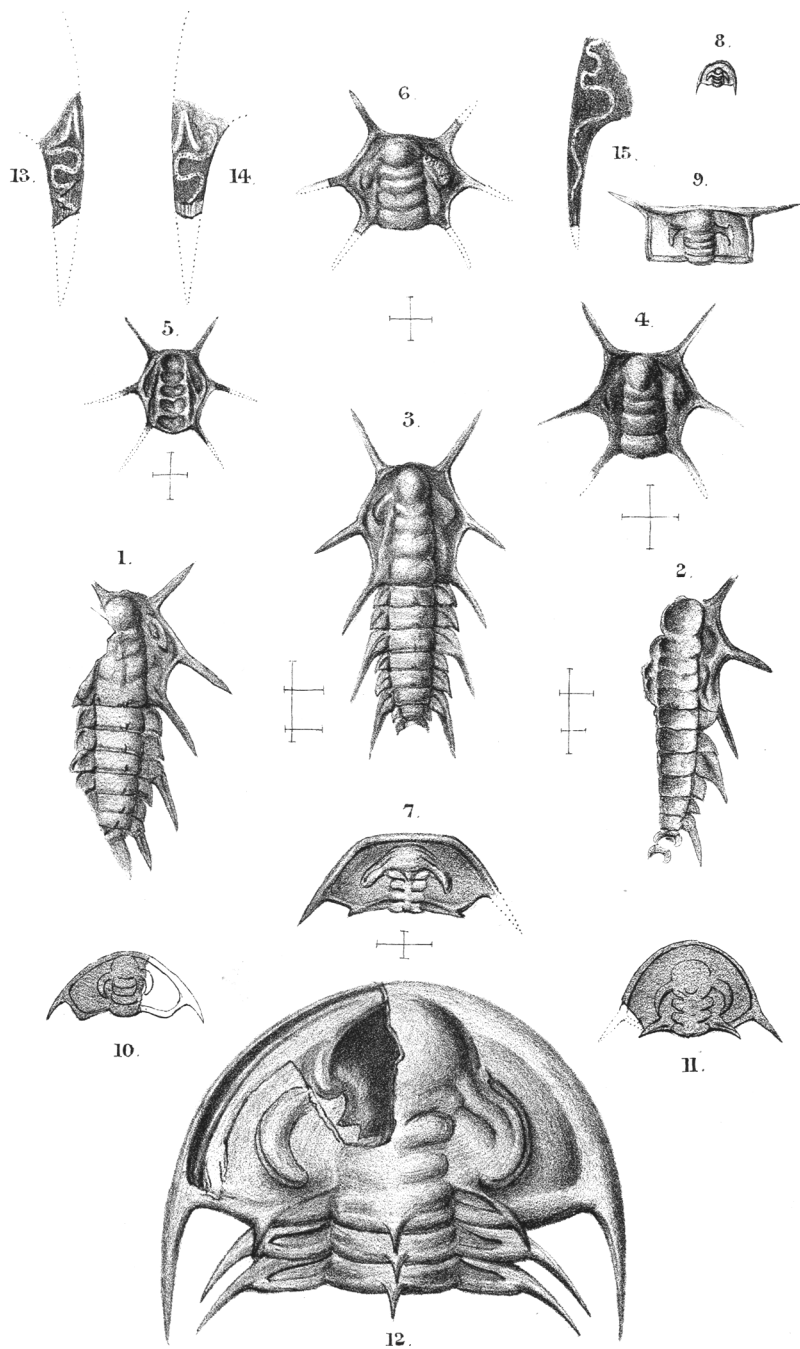
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Mintern Bros. imp.

OLENELLUS RETICULATUS.



B.N. Peach del. F.H. Michael lith.

Mintern Bros. imp.

OLENELLOIDES, OLENELLUS,
MESONACIS & HOLMIA.